Burges James Gadsden Provincial Park
Wetland Restoration Design Plan

Dragline bucket used to drain Moberly Marsh

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Contents

Executive Summary

The large natural wetland known as Moberly Marsh within Burges James Gadsden Provincial Park near Golden, BC is being drained by an extensive system of artificial dikes and ditches. The area of shallow, open water wetlands in Moberly Marsh has decreased by an estimated 93-percent since 1965. Historic water levels, wildlife, and vegetation within Burges James Gadsden Provincial Park may be restored by removing approximately 8.26 km of dikes, filling 14.70 km of ditches and borrow pits, reshaping and restoring natural levees along the Columbia River to restore flooding, and by returning flow from Moberly Creek into the Park. Habitat for up to 39 Species at Risk would be improved by restoring the wetlands. The project would greatly improve opportunities to view ducks, geese, herons, egrets, Bald Eagles and Osprey while traveling the TransCanada Highway.

Plan Objectives

BC Parks contracted with the British Columbia Wildlife Federation (BCWF) and the Fish and Wildlife Compensation Program to prepare a Wetland Restoration Design Plan for Burges James Gadsden Provincial Park with the following objectives:

1) Provide BC Parks with the detailed information needed to restore wetlands and streams within Burges James Gadsden Park that appear and function as natural ecosystems, and not require maintenance.

2) Identify wetlands and streams that may be restored to benefit Species at Risk by removing dikes, dams, filling ditches, canals, and removing soil used to fill wetlands.

3) Identify any additional inventories required to fully inform the restoration design plan and subsequent BC Parks Impact Assessment process.

4) Identify actions that may be taken to restore natural flooding along the Columbia River within Burges James Gadsden Park.

5) Involve First Nations in the planning process.

6) Identify actions for removing dams, dikes, ditches, canals, water control structures, pumps, and pipes installed by Ducks Unlimited Canada to meet current management objectives for Burges James Gadsden Park.

7) Identify estimated budgets for restoring wetlands, streams, and natural flooding along the Columbia River within Burges James Gadsden Park.
The BCWF contracted with the author to prepare this plan. The author examined Burges James Gadsden Provincial Park on the ground from May 4-11, 2019. Field examine involved walking throughout the Park identifying and mapping dikes, ditches, culverts, old roads, and fields using a hand-held GPS. The texture of soil and the presence or absence of groundwater was determined using a 122cm long tile probe, and a 274cm long open-face soil auger. Soil textures were determined in the field using the ribbon test. Elevations of dikes, water control structures, inlets, and outlets were determined using a laser level, tripod, and survey rod.

The following individuals assisted with the design process one or more days:

- Brian Amies (Spike Elk Farm)
- Suzanne Bayley, Ph.D. (Emeritus Professor of Ecology, University of Alberta)
- Rae Busse (BC Parks)
- Rachel Darvill (Goldeneye Ecological Services)
- Alana Higginson (BCWF)
- Brian Gustafson (Wildsight & Golden Rod and Gun Club)
- Megan Langley (Wildsight Golden)
- Sigi Liebmann (Spike Elk Farm)
- Chris McLean (BC Parks)
- Amanda Weber-Roy (BC Parks)

The BCWF held a public meeting at the Golden Rod and Gun Club on May 6, 2019 to discuss the wetland restoration design process for Burges James Gadsden Provincial Park on May 6, 2019. Notes taken at the meeting may be found in Appendix 1.

Figure 1. The Columbia River, shown here, once flooded Burges James Gadsden Provincial Park. The seasonal flooding was of critical importance to maintaining natural wetlands, and the animals and plants using them.

Figure 2. Natural ephemeral wetlands like the one shown may be restored in the Northern portion of Burges James Gadsden Provincial Park.

The author thanks the following individuals for providing valuable information used in preparing this plan:

- Suzanne Bayley, Ph.D. (University of Alberta, Emeritus Professor of Ecology)
- Rachel Darvill (Goldeneye Ecological Services)
- Brian Gustafson (Wildsight Golden & Golden Rod and Gun Club)
- Sigi Liebmann (Spike Elk Farm)
- Amy Waterhouse (Ministry of Forests, Lands and Natural Resource Operations)
- Amanda Weber-Roy (BC Parks)

Background

The Burges James Gadsden Provincial Park is located approximately 11 km West of Golden, British Columbia between the Trans-Canada Highway and the Columbia River. Totaling 404 hectares, the Park was established on June 24, 1965, and encompasses much of Moberly Marsh (British Columbia Parks, 2019). The cattail marshes which dominate the Park are visible from the Trans-Canada Highway.

Moberly Marsh is bordered to the South by Moberly Creek, North by Blaeberry River, East by the TransCanada Highway 1, and West by the Columbia River. The large marsh was historically supplied with water from Moberly Creek, and from the flooding of Columbia River. Floodwaters were trapped in Moberly Marsh by the natural-low elevation levees along the Columbia River. Moberly Marsh now only supplied with groundwater and from direct precipitation and snowmelt.

Water first entered Moberly Marsh by spilling over the banks of the Columbia River upstream at Moberly Creek, spreading out in a sheet-like pattern, and then flowing downhill over Moberly Marsh, returning to the Columbia River at the banks of Blaeberry River.

Burges James Gadsden Provincial Park is challenging for the public to visit. With no legal access the Park is bordered by the TransCanada Highway 1, two busy Canadian Pacific railroad tracks, deep ditches containing water, and the Columbia River. There are two wide places along the TransCanada Highway 1 where the public may park and view the James Gadsden Provincial Park. However, truck drivers often use these pull-offs, and there is great noise from traffic.

Figure 3. The pull-off for Burges James Gadsden Provincial Park along TransCanada Highway 1 contains this dated sign that does not describe the Park or Moberly Marsh. One sees cattails, willows and litter from the vantage spot.

Figure 4. This sign is difficult to read from the Highway pull off.

Figure 5. One sees an abundance of trash in ditches at the pull off.

The author has observed people visiting Burges James Gadsden Provincial Park over the past 3-years noticing they walk and stay on the constructed dikes; perhaps out of concern one will get wet or sink in the mud if they venture into the marsh. Consequently, one receives a false impression the marsh contains water because there are narrow channels of water along the base of the dikes. Getting off the dikes one will discover it is possible to walk almost anywhere without water going over their boots, showing how dry the large wetland has become.

The people who have owned Moberly Marsh since the 1800's worked to change Moberly Marsh to provide land for grazing cattle and horses, and for cutting hay to feed these animals. Moberly Marsh was a huge area of level land quite rare in British Columbia. Individuals started draining the marsh but fortunately did not finish the job.

Historically, Moberly Marsh looked much different than it does today. There were once numerous large wetlands containing open water and an abundance of ducks, geese, wading birds, and shorebirds. The marsh was a mosaic of open water and ephemeral wetlands, mudflats, sedges, with some cattails. Now, there significantly more cattails, trees, and shrubs growing in the Park.

Moberly Marsh contains streams that appear different than how streams appear in the mountains. The streams in Moberly Marsh are wide, shallow, with low banks. The banks of the streams are typically only 10cm high, channels are about 5-meters wide, and the water in the channels is approximately 20cm deep. The streams form long ribbons of meandering wet-meadow wetlands.

Figure 6. The Southern two-thirds of the Park historically contained large, perennial, shallow open-water wetlands, as shown here. This wetland is located near the town of Golden, BC.

Figure 7a. This open-water wetland containing beaver lodges is the most visible feature in Moberly Marsh when traveling the TransCanada Highway. Beaver made the pond by building a dam across two ditches dug after 1965.

Figure 7b. Few natural streams, like the one shown here, remain in the Park. Most were turned into ditches for draining wetlands.

Figure 8. 1948 photo of Moberly Marsh showing the Harry Cooper's home during a flood (Blaeberry Homesteaders book page 85).

Figure 9. May, 2019 match of Moberly Marsh showing where Harry Cooper's home once stood. Stones were found from the home's foundation.

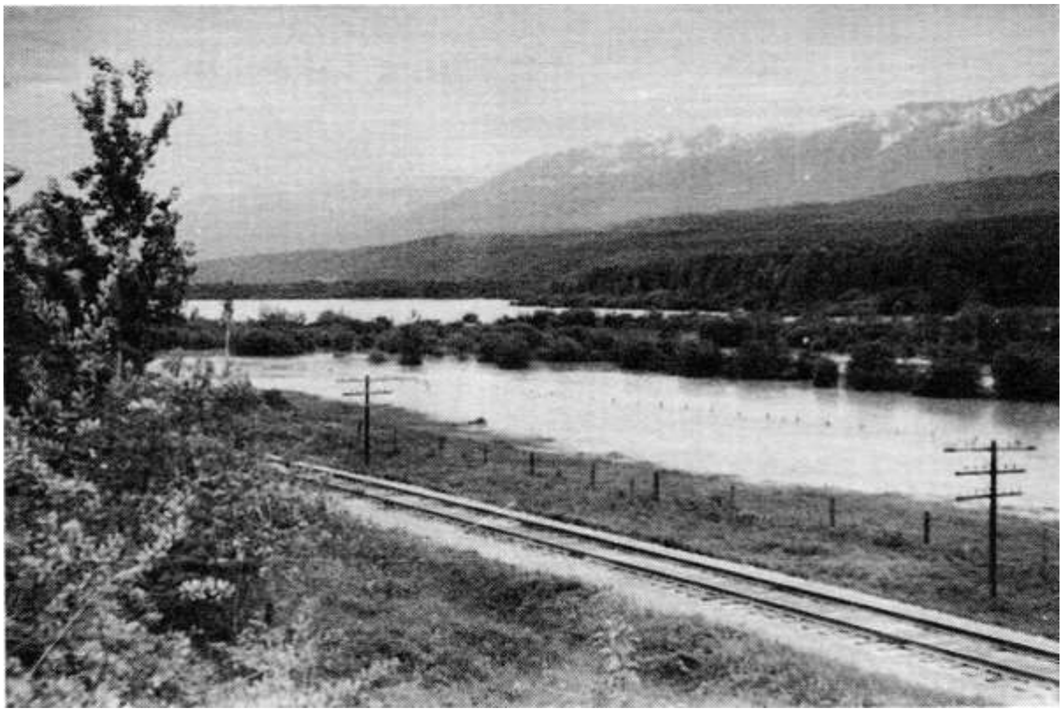


Figure 10. 1948 photo showing Moberly Marsh flooded (Blaeberry Homesteaders Book page 85).

Figure 11. May, 2019 match of the photo on page 85 of the Blaeberry Homesteaders Book. Note the wetlands recently restored in the field.

Figure 12. Boys swimming in ditch within Moberly Marsh. Blaeberry Homesteaders Book page 99. The author says the ditch was dug in the 1920's. The photo appears to have been taken in the 1940's.

Figure 13. Approximate match of the photo showing the boy's swimming on page 99 of the Blaeberry Homesteaders Book. Photo taken in May, 2019.

Figure 14. 2001 (left) and 1949 (right) aerial photos showing Moberly Marsh and Burges James Gadsden Provincial Park.

Shallow Open-Water Wetlands

Approximately 157-hectares of shallow, open-water and drained open water wetlands were visible on aerial photographs of Moberly Marsh taken before 1965. Aerial photographs from 2017 show approximately 11-hectares of shallow, open-water wetlands in Moberly Marsh. This represents a 93-percent reduction in shallow, open water wetlands since Burges James Gadsden Provincial Park was established.

The Northern one-third of the Park likely contained wetlands that dried in the Summer due to soils high in gravel from the Blaeberry River. The Southern two-thirds of the Park contained an abundance of open water wetlands containing water all year due to deep clay soils.

The analysis of shallow-open water wetlands was completed by the author, who has interpreted wetlands on aerial photographs for over 40-years, has assisted in the drainage of hundreds of wetlands, and has restored over 2,250 wetlands across North America.

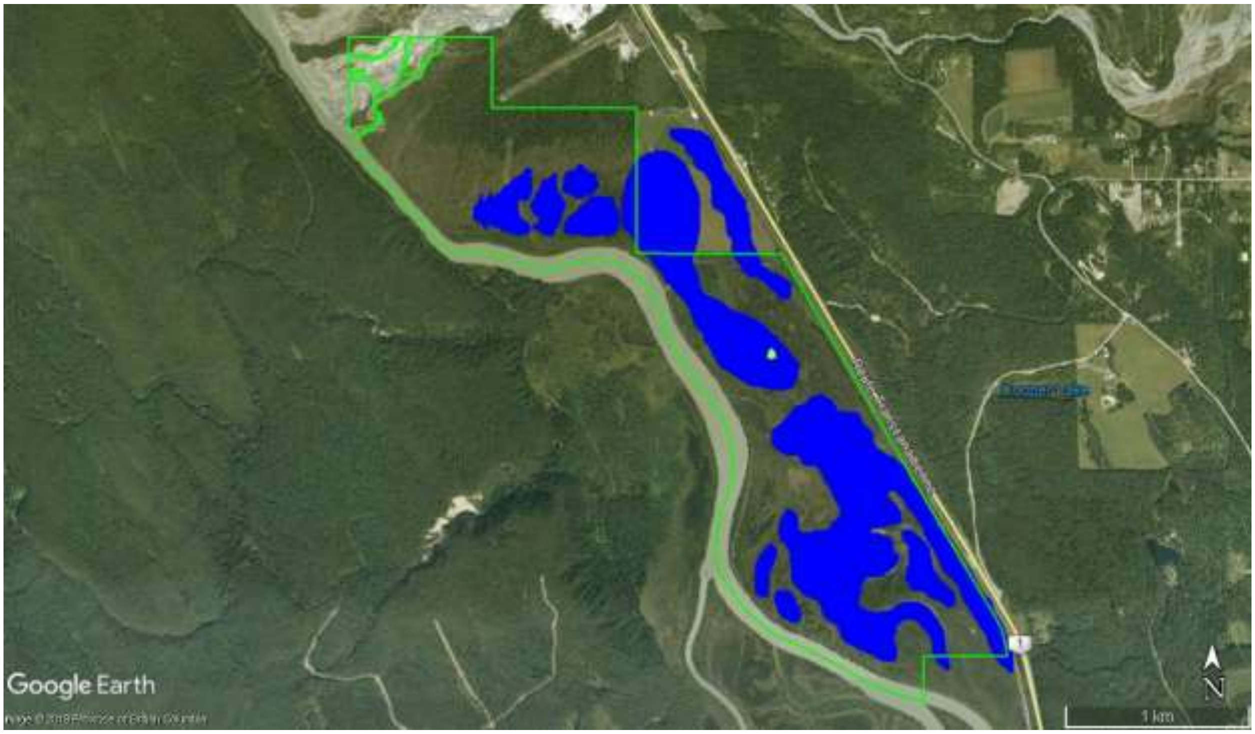


Figure 15. Approximately 157-hectares of shallow-open water wetlands (blue) are visible on aerial photographs prior to 1965 in Moberly Marsh.

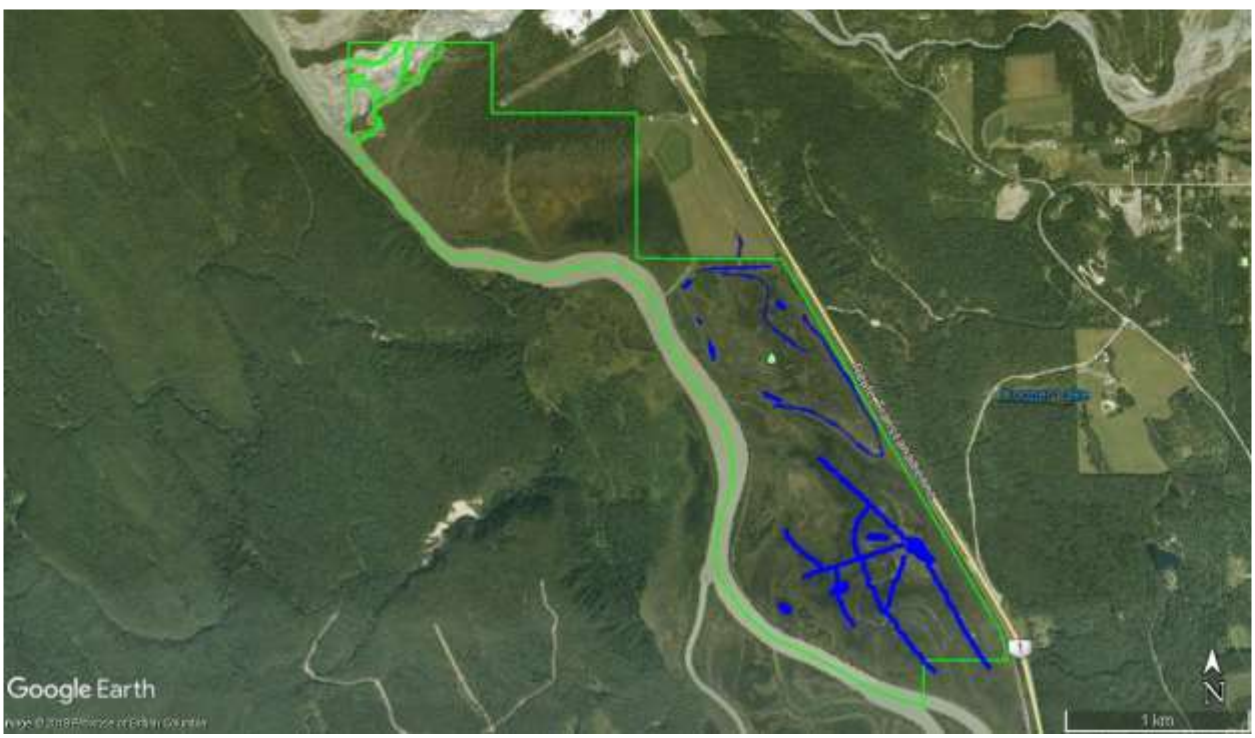


Figure 16. Approximately 11--hectares of shallow-open water wetlands (blue) are visible within Moberly Marsh on this 2017 aerial photograph.

Figure 17. Constructed ditches like the one shown here are draining Moberly Marsh. Note the change in vegetation on either side of the ditch. The cattails growing in the foreground on higher ground show that more water is present compared to sedges and grasses growing on the other side of the ditch. The ditch is moving water out of the wetland.

Figure 18. A dense growth of bulrushes grows where there was once a large wetland containing open water within Burges James Gadsden Provincial Park.

A portion of Moberly Marsh was drained by the construction of ditches and a dike prior to designation as a Park. Moberly Creek was channeled and diverted to avoid entering Moberly Marsh. Trees and shrubs were also cleared along the banks of Moberly Creek to create farmland.

Ducks Unlimited Canada (DUC) under permit from BC Parks completed significant modifications to James Burges Gadsden Provincial Park since its designation by constructing an extensive network of dikes and ditches. Dikes were built to prevent the Columbia River from flooding Moberly Marsh, new ditches were dug and existing ditches were deepened and lengthened.

The dikes, ditches, and water control structures within Burges James Gadsden Provincial Park are managed by Ducks Unlimited Canada, according to the terms of a 10-year Permit issued by BC Parks in 2019.

Wetlands are among the most biodiverse ecosystems in the world, and the most economically valuable. The loss of wetlands continues, despite our knowledge of their tremendous value. The Wetland Extend Trends Index developed by the UN Environment World Conservation Monitoring Centre showed a 35% decline in marine, coastal and inland natural wetland areas studied between 1990 and 2015 (Gardner, 2018). This rate of loss for wetlands is 3 times the global average annual rate of the loss of natural forests (Gardner, 2018).

Wetlands have tremendous value for wildlife, biodiversity, carbon storage, recreation, and beauty. Of the many types of ecosystems where restoration investments are being made, restored wetlands provide 10 times the return on investment in terms of the value of ecosystem services provided compared to all other types of restored ecosystems (Dodds, 2008).

Definitions

The natural features and human modifications found in Burges James Gadsden Provincial Park are called a variety of names. The following definitions are used to describe these features in this plan:

Breach: A gap in a dam, dike, or levee. A breach is formed when water flows over or through a dam, or a ditch is cut through a dam. Breaches may be caused by beaver digging a canal or borrow through a dam, or a human using heavy equipment to dig a channel in a dam. A breach rapidly triggers head-cuts to form, causing massive erosion and eventual drainage of the majority of wetlands and streams in the watershed.

Dike: Long and high ridge of soil constructed to control flooding and to impound water. The same as a dam, dyke, levee, or berm. Dikes are generally made from soil that is high in clay and compacted. Ducks Unlimited Canada built dams at Burges James Gadsden Provincial Park to create large impoundments of deep water, and to prevent the Columbia River from flooding these impoundments. The dikes also provide motor vehicle access into Moberly Marsh.

Ditch: Long and narrow excavation constructed for drainage and/or flooding. Similar to a canal or waterway. Ducks Unlimited Canada built ditches in Burges James Gadsden Provincial Park to remove water from constructed impoundments, and to add water to impoundments. Ditches were also dug to drain wetlands for farming. Ditches provide poor quality habitat for fish and wildlife because their water levels change rapidly, they lack large woody debris, contain steep eroding banks, and have few if any pools or riffles.

Head-cut: A head-cut is similar to a small waterfall, being a vertical drop-off in a stream or ditch. A head-cut is an erosional feature that moves uphill, following the drainage in which it is located. A head-cut causes great erosion by widening and deepening a stream channel. Head-cuts drain wetlands by removing standing water, and causing a lowering of the elevation of groundwater. Head-cuts may form gulley's and canyons unless they are controlled. Head-cuts have formed in the natural outlets associated with wetlands along the Columbia River near Golden. Head-cuts form when a dike is breached, and/or when ditches are dug downstream in the same watershed.

Natural levee: Higher elevation ground found along the banks of the Columbia River. Formed by sand and gravel being deposited by floodwaters over time. The high elevation of the natural levee is generally equal to the elevation of ground nearest the base of closest old cottonwood tree growing along the river.

Inlet: Location where water from the Columbia River flows over the natural levee and into Moberly Marsh. An inlet is not a stream. Natural inlets appear to range from 3-10 meters wide, are approximately 50cm lower in elevation than the base of old cottonwood trees growing on the bank of the river. An inlet does contain a valley like an outlet. Inlets are typically found along the outside bend in the river. They can be identified by seeing cattails when boating on the river. One generally does not see erosion associated with a natural inlet. Head-cuts typically do not form in inlets. Water appears to flow in an inlet only under flood conditions.

A natural inlet to a wetland was identified and measured on the West side of the Columbia River, opposite Burges James Gadsden Provincial Park. The elevation in the bottom of the inlet was approximately 27cm lower than the bank on either side. The high bank on either side of the inlet was the same as the elevation found at the base of large old cottonwood trees growing on the natural levee. The inlet was located in an outside bend of the river, and entered the wetland at a shallow angle to the river. The inlet directed water from the river into a wetland containing open water, cattails, sedges, and willow. The total width of the inlet was approximately 14.8-meters. There was no valley or erosion between the inlet and the river, showing that water from the river enters but does not leave the wetland via the inlet.

Outlet: Location where water flows out of from Moberly Marsh into the Columbia River. An outlet is a stream that may flow all or part of a year. Natural outlets range from 4-16 meters wide where they enter the Columbia River near Moberly Marsh. The elevation of the entrance of the outlet is the same as water or cattails in a marsh. An outlet contains a valley where water flows out from the marsh on higher ground down to the river. The elevation at the entrance of the outlet controls the water level in the wetland. Outlets form the spillway for wetlands. One typically sees erosion associated with a natural outlet. Head-cuts may also form in outlets.

A natural outlet to a wetland was identified and measured on the West side of the Columbia River, opposite Burges James Gadsden Provincial Park. The outlet was located along a straight section of the Columbia River, and looked like a valley cutting through the banks of the river. The angle of the outlet was opposite that of inlets. Water flows out in a path that parallels the river. The outlet drained a wetland containing open water and cattails. The elevation where water first enters the outlet is the same as the elevation of water and cattails in the wetland being drained by the outlet. The entrance to the outlet was approximately <u>2.35 meters higher</u> than the elevation of the river. The mouth of the outlet was the same elevation as the river.

Beaver may maintain the elevation of the entrance to a natural outlet at a high elevation by building dams across the outlet. Their dams may also control head-cuts from advancing and draining wetlands. However, the beaver is generally not allowed to control the elevation of artificial outlets associated with water control structures, as water levels may not be adjusted when pipes are blocked by beaver debris.

The elevation of the entrance to the outlet controls the elevation of water in the wetland, regardless of the size of the wetland. The outlet serves as a spillway for the wetland.

One natural outlet was identified for Moberly Marsh by examining historic aerial photos, and by investigating areas on the ground. The outlet is labeled “Outlet 2” on Figure 37. The outlet appears to carry water seasonally. It most likely carried water year-round before the dikes and ditches were built.

Two constructed outlets were identified for Moberly Marsh. These are labeled “3-way control” and “4-way control on Figure 37.” The elevation of the constructed outlets is significantly lower than the natural outlet.

Changes Prior to 1965

Aerial photographs from 1949 and 1951, the Blaeberry Homesteaders book (Seward, 1982), interviews with residents, and field examination were used to identify human caused impacts to Moberly Marsh prior to the designation of Burges James Gadsden Provincial Park in 1965.

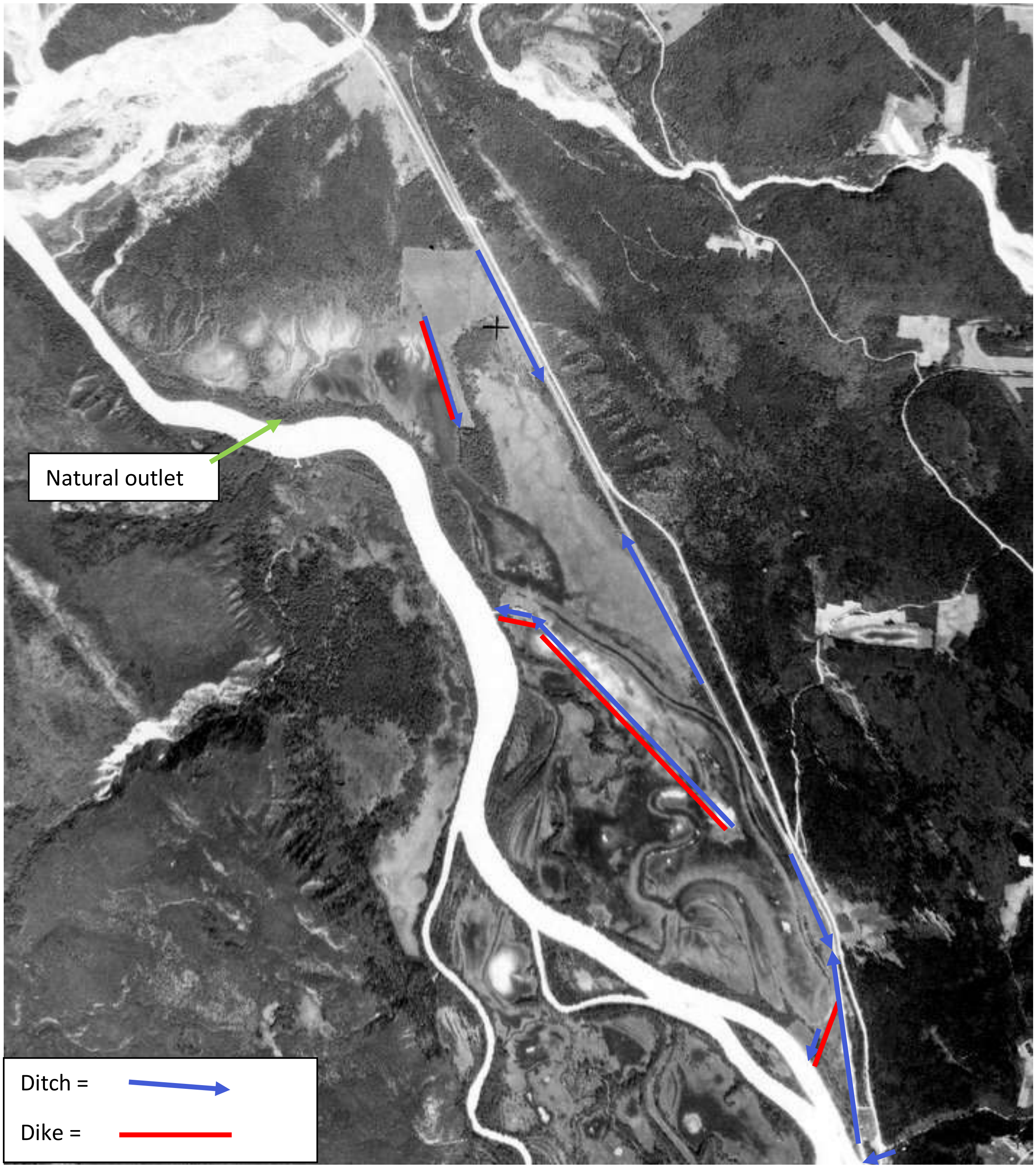


Figure 19. Changes made to Moberly Marsh are shown on this 1949 aerial photograph. The Canadian Pacific Railroad and TransCanada Highway are not marked in this figure.

Ditches

Ditches were dug to divert Moberly Creek and to create farmland from the wetland. The ditches removed standing water and lowered the elevation of groundwater. Examination of historic aerial photos shows that the ditches that were dug were effective at reducing the area of open water in Moberly Marsh. One can see white color indicating exposed soil surrounding the longest ditch shown on the 1949. This ditch was probably dug in 1948 or 1949.

A field was created by draining the Northeast portion of Moberly Marsh on private land beginning in the 1920's. A.G. Seward describes how "the old channel that was dug to drain the slough became our favorite swimming hole" (Seward, 1982). Drainage of the field was completed after 1965. The field is still being managed for hay.

Outlets

The construction of a long ditch in the center of Moberly Marsh created a new and deep outlet for draining large areas of wetland. Examination of historic aerial photos and ground surveys indicate that Moberly Marsh may have had only one outlet prior to this ditch being dug around 1949, this outlet is labeled "Natural Outlet" on Figure 19.

The main step taken in draining a wetland involves identifying the natural dam or levee, and then breaching this levee by cutting a ditch through it. Natural outlets for Moberly Marsh were significantly higher in elevation than the ditches dug for drainage. Thinking of a swimming pool is a good analogy, digging a ditch through a natural levee is like using a knife to cut a deep "v" notch in the side of plastic swimming pool full of water.

Dikes

The soil removed from digging the ditches was generally used to build dikes. The soil placed in the dikes was then shaped to form roads, and the base for the railroad and highway.

Figure 20. The red line marks a section of a dike built before 1965. The blue arrow marks a ditch dug at the same time. The dike was built using soil removed from digging the ditch, and helped prevent water from the Columbia River from flooding a portion of Moberly Marsh.

Figure 21. The fence posts show that portions of the Park were farmed and used for pasture. The ridge of trees on the right is a road and dike constructed across Moberly Marsh years ago.

Stream channeling

Moberly Creek appears to have historically flowed into Moberly Marsh. The stream was likely moved and straightened so that it would flow into the Columbia River at a right angle, and not enter Moberly Marsh. The stream may have been moved and channeled to create farmland, and too facilitate the construction of the railroad and TransCanada Highway 1.

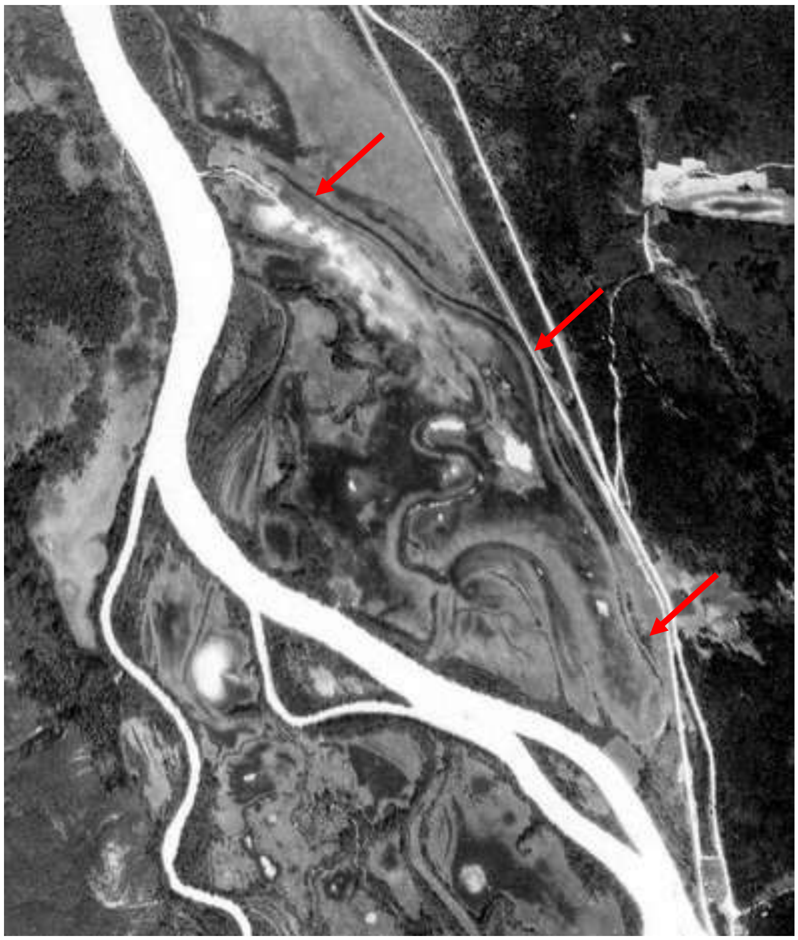


Figure 22. Arrows point to the probable historic channel of Moberly Creek on this 1949 aerial photo (GeoBC, 2019)

Moberly Marsh looked very different when Moberly Creek used to enter it. Beaver were able to build dams and create a diversity of wetlands. Waterfowl and geese could nest on the beaver and muskrat houses in the beaver ponds. Muskrats living in the wetlands would be able to control cattails. The year-round flow of water from the stream would maintain water levels in the marsh.

Figure 23. It is very possible the rows of willows are growing on the banks of Moberly Creek, before it was diverted from entering Moberly Marsh.

Figure 24. The red arrow points to a beaver dam across a stream entering a natural wetland along the Columbia River, South of Golden. The stream flows through a culvert under the railroad tracks. Moberly Marsh may have appeared like this when Moberly Creek entered the large wetland.

On page 81 of his book Seward describes how a ditch was dug from Old Man Creek to Wiseman Lake. A steel culvert was installed under the road and water was channeled away from its intended course. The stream dried up and was no longer used by spawning Cutthroat trout. (Seward, 1982)

The moving, straightening, and channeling of streams in British Columbia was a common practice. Streams were moved to create farmland, homesites, roads and railroads. The author found where a small stream was moved and channeled in Moberly Marsh on private land to create a large 81-acre field.

Figure 25. This topographic map shows that Moberly Creek once flowed into Moberly Marsh. (GeoBC, 2019)

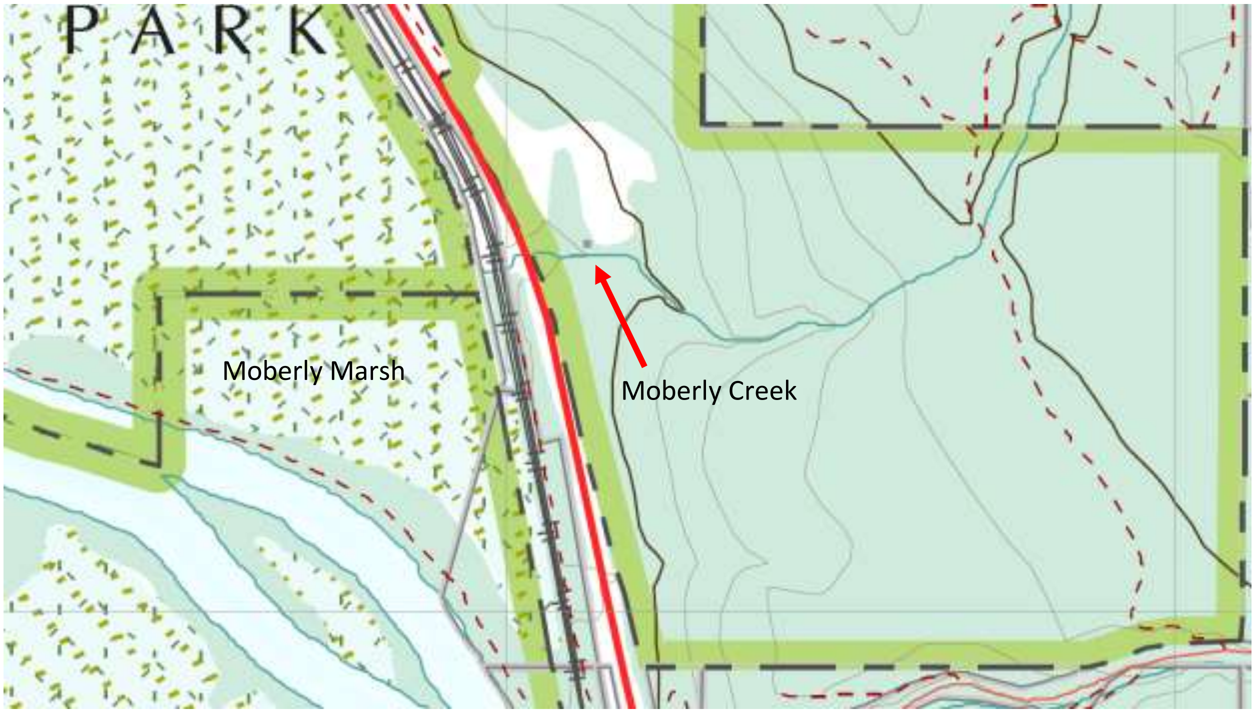


Figure 26. The arrow points to Moberly Creek where the stream was moved and straightened. Note the building and open land shown on the map near the section of straightened stream. This is probably a home and farm field created after the stream was moved. (GeoBC, 2019)

A Ducks Unlimited Canada Plan from 1978 shows Moberly Creek being redirected into Moberly Marsh. The drawing labels Moberly Creek being placed in a drainage ditch. The stream historically was moved less than 100-meters so it would not enter Moberly Marsh. Moberly Creek was not moved into Moberly Marsh by DUC.

The author walked the length of the abandoned channel of Moberly Creek. The stream was ditched and channeled in near the TransCanada Highway 1 and the railroad, and near the 3-way water control structure.

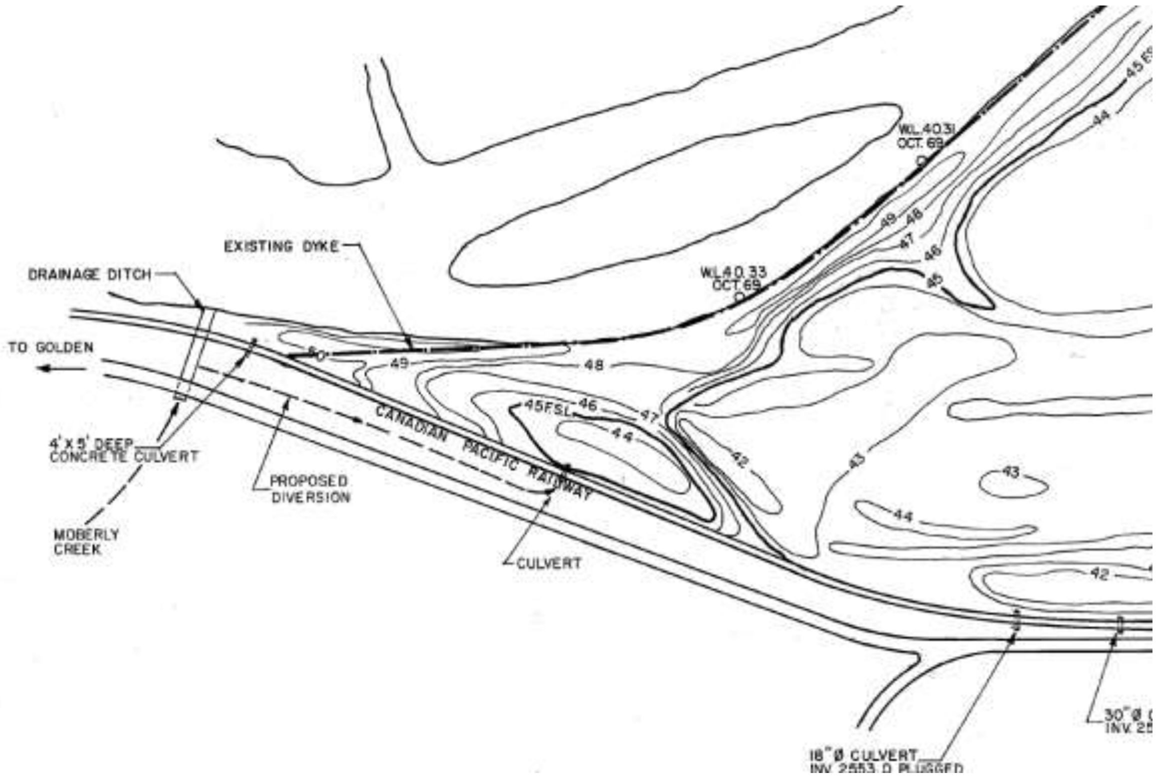


Figure 27. General and Detail Plan for Moberly Marsh, Ducks Unlimited (Canada), May 1978.

Farmland

Large areas of Moberly Marsh were cut for hay and used for pasture prior to 1965. The presence of square corners, light-colors, and even textures on historic aerial photos indicates where hay was being cut. Low and rough ridges typical of decomposed trees and shrubs piled from land clearing were found by the author along the Southeast edge of Moberly Marsh.

A.G. Seward writes “Cooper and Gadsden ran their wild cattle out on the sloughs. They grew as wild as a herd of elk and had to be rounded up into the corrals on horseback. I remember when some of kids surprised a herd and they watched us as it were the first time, they had ever seen humans. They would advance a few steps and then race away as if frightened for their lives.” (Seward, 1982).

Reed canary grass and the nonnative plant Mullein was found growing on the land that was once farmed. A livestock feeder was found in the Northern part of Burges James Gadsden Provincial Park, showing the wetlands were used for pasture.


Figure 28. Mullein and reed canary grass grow in old fields once part of Moberly Marsh.


Figure 29. Wood fence posts and woven wire once bordered farmed fields within Moberly Marsh.

Railroad

The construction of the Canadian Pacific Railroad impacted Moberly Marsh by diverting runoff and by filling the Eastern edge of the wetland. Long sections of the railroad bed were built by filling portions of Moberly Marsh. Deep and long ditches were dug along the upper and lower sides of the tracks. These ditches captured runoff and intercepted groundwater. The ditches contain standing and flowing water. Few culverts were installed in the railroad bed. The author observed where a number of the culverts are plugged. A large amount of the water in the ditches along the railroad is being diverted into a deep ditch dug in the Park to drain the large field on private land. The runoff from the railroad is generally down the ditch into the Columbia River, and is not supplying Moberly Marsh. The water in the ditches along the railroad tracks does not appear clean. Coal dust and oil covers the ground, and the air near the track's smells like creosote.

Figure 30. Ditches located between the TransCanada Highway 1 and The Canadian Pacific railroad divert runoff from entering Burges James Gadsden Provincial Park.

Figure 31. The majority of runoff that once entered Moberly Marsh is being diverted by ditches along the TransCanada Highway 1 and the Canadian Pacific railroad. This is why restoring floodwaters from the Columbia River and filling ditches is especially important to the health of Moberly Marsh.

Figure 32. Few culverts are located along the Canadian Pacific railroad to carry runoff into Moberly Marsh. None were flowing water at the time of the survey.

Figure 33. The railroad and associated access roads block the majority of runoff from entering Moberly Marsh.

Impoundment Construction

The techniques used for building wetlands to provide habitat for waterfowl were different in the 1960's and 70's than they are today. The author was taught to construct large impoundments containing deep water to improve habitat for ducks and geese while majoring in Wildlife Management at the University of Minnesota in the 1970's. Here are the main points taught about managing wetlands and waterfowl:

1. Nesting success for waterfowl may be improved by constructing dams to control seasonal flooding from rivers and streams.
2. Large impoundments should be built by surrounding fields, forests, and existing natural wetlands with dikes. The dikes should be high with steep sides to lower construction costs.
3. It is too costly and there is no need to dig deep core trenches under dikes and dams to prevent leaking.
4. Water control structures and pumps should be installed so that moist soil management may be practiced. This involves removing water from the impoundment in the Spring and returning it in the Fall.
5. Canals should be built so that water may be diverted from rivers to fill wetlands in the Fall.

6. Streams and rivers may be diverted in ditches to fill impoundments.
7. Natural wetlands should be connected with ditches so that they may be drained to remove carp and filled in the Fall for hunting season.
8. Fields should be created within impoundments and planted to corn or wheat so they may be flooded in the Fall.

Historic Impoundment Construction Techniques

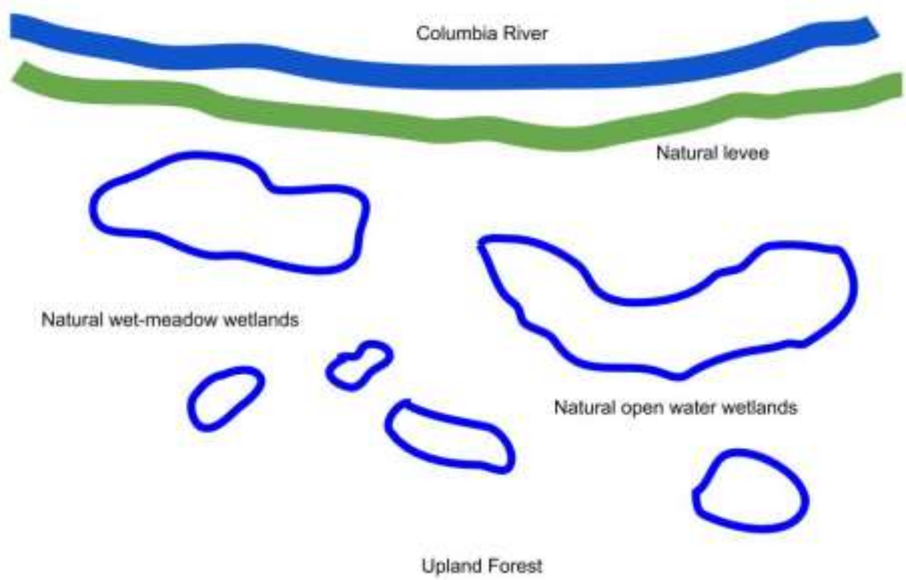


Figure 34. Natural river and floodplain before construction.

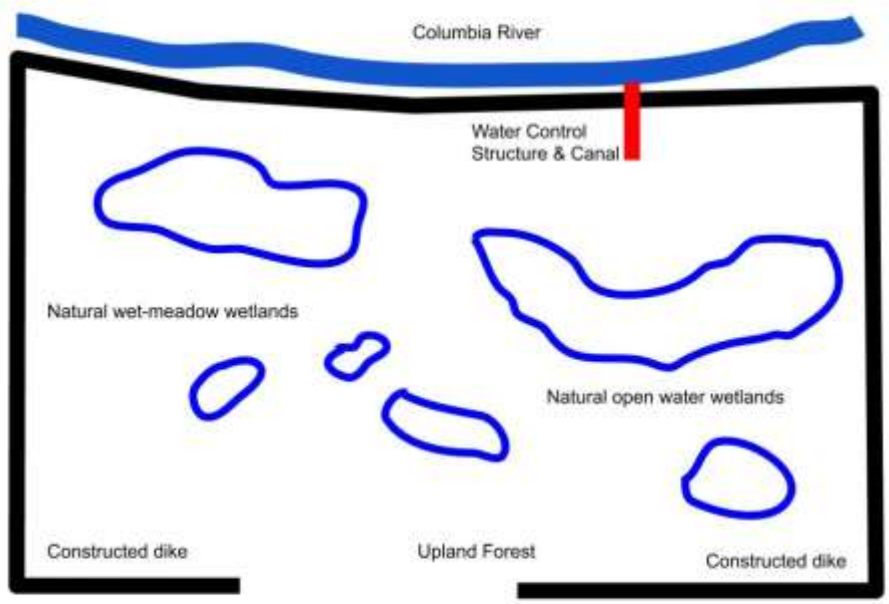


Figure 35. Dike and water control structure constructed to form impoundment.

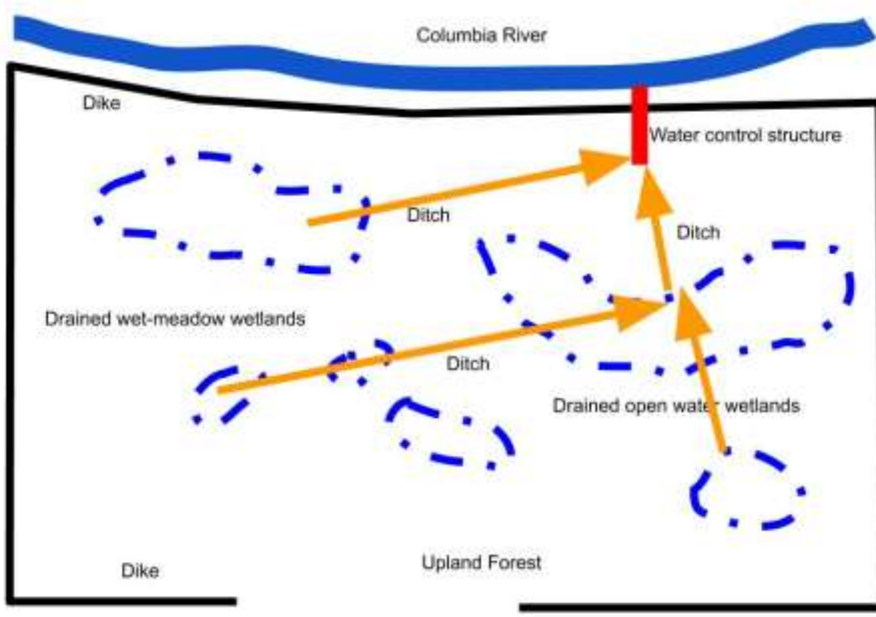


Figure 36. Ditches are dug to connect natural wetlands within the impoundment.

The way the impoundments or compartments were built at Burges James Gadsden Provincial Park mirrors techniques used in the 1970's. Examination of historic aerial photos and discussions with longtime residents indicate the constructed impoundments do not hold water as planned. The author has determined that the dams were built with permeable soils, and were placed on permeable foundations. Water is leaking from the impoundments by traveling under the dikes, around and through water control structures. Muskrats and beaver have also dug numerous burrows into the dams, causing them to leak.

A dragline was used to build the dikes. A dragline bucket may be observed on private land adjacent to the Park. The long and narrow areas where soil was removed to build the dams are the main places that contain water within the Park. This is because the excavations were deep enough to expose groundwater.

Highly effective techniques have now been developed for restoring wetlands to improve habitat for waterfowl and a diversity of animal and plant species that include:

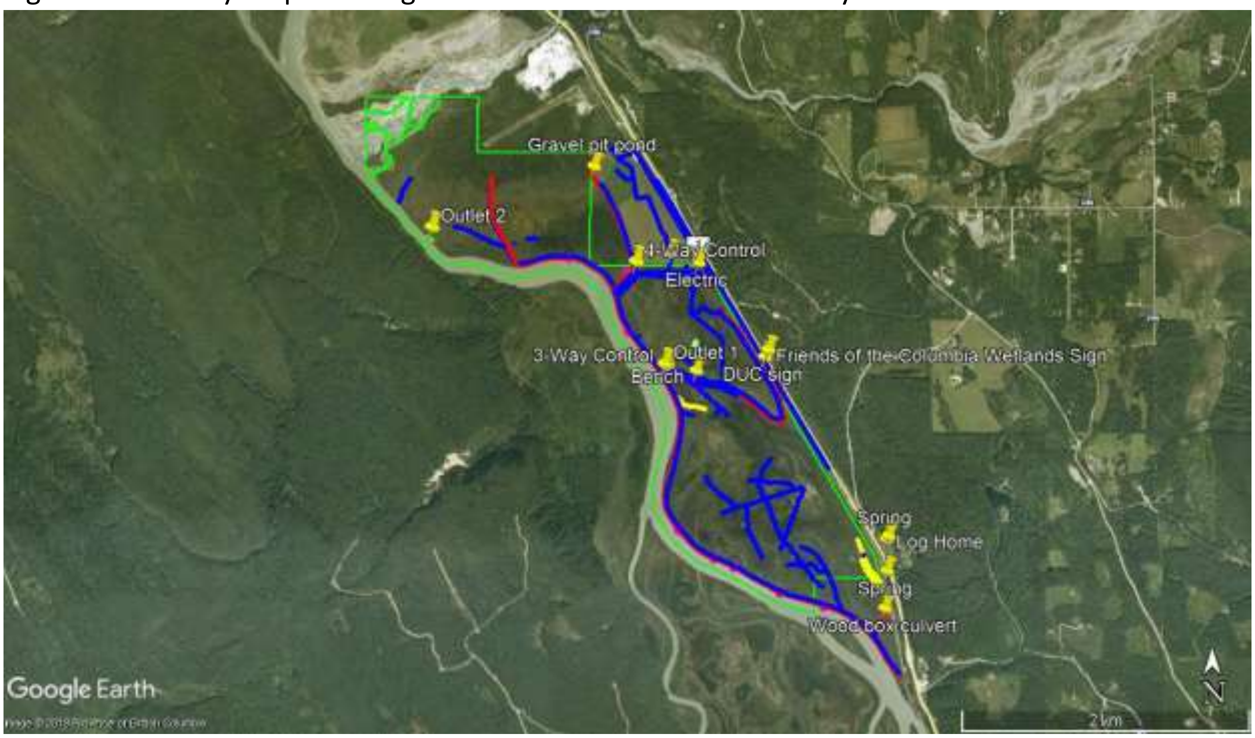
1. Restoring seasonal wetlands because of their critical importance to migrating waterfowl and shorebirds. Wetlands that dry and fill naturally produce a high diversity of plants and invertebrate's waterfowl and shorebirds use for food.
2. Waterfowl make great use of shallow water wetlands for feeding and nesting.
3. Deep-water wetlands generally contain fish, often nonnative fish. The fish will eat ducklings and directly compete with waterfowl for food.
4. Dikes, dams, water control structures, pipes, pumps, and canals require frequent and expensive maintenance. Agencies and private landowners generally do not have the money or skills needed to maintain impoundments.
5. It is critical to dig deep core trenches across ditches that are based on bedrock or clay and filled with soil that is high in clay and compacted so that restored wetlands will develop intended hydroperiod.
6. It is very expensive, difficult, and unnecessary to create, maintain, plant, and flood planted fields for waterfowl.
7. Impoundments appear unnatural and are generally not accepted by the public.
8. Head-cuts will develop in ditches dug to divert streams and rivers causing great erosion and drainage of wetlands and streams.

Changes after 1965

Ducks Unlimited Canada began a major construction program under a long-term permit issued by BC Parks for the newly established Burges James Gadsden Provincial Park.

Aerial photographs taken in 1967, 1976, 1990, and 1992 were used to identify ditches and dikes built within Moberly Marsh following the designation of Burges James Gadsden Provincial Park. In addition, the report prepared by DUC *Application for Renewal of Park Use Permit for Burges James Gadsden Provincial Park Moberly Marsh* (Ducks Unlimited Canada, 2016) was used to identify ditches, dikes, and water control structures. Lidar images were also used to identify ditches and dikes. The author examined Moberly Marsh on the ground in July 2017, August 2018, and May, 2019 to confirm the presence of ditches and dikes visible and not visible on aerial photographs.

Figure 37. Vicinity map showing ditches and dikes within Moberly Marsh.



Green line = Burges James Gadsden Provincial Park Boundary
Blue line = ditch
Red line = dike
Yellow = Piled soil

The following describes the modifications made by DUC to Moberly Marsh after 1965:

Dikes

Moberly Marsh was historically flooded seasonally by the Columbia River. Beginning in 1965 an extensive system of dikes was built to prevent water from the Columbia River from entering Moberly Marsh. The dikes were placed along the banks of the Columbia River, and were made using soil onsite. The project was very effective at keeping floodwaters from entering Moberly Marsh. Only one location was identified where floodwaters from the Columbia River may have flowed over the dike along the Southern edge of Moberly Marsh.

The suggested actions described in this plan would reconnect the Columbia River with Moberly Marsh, restoring wetlands and proving conditions for native plant species to recolonize the Park. “The dikes must be removed to restore the hydrologic connectivity” (Bayley, 2019). The constructed dikes do not look or function as natural levees found along the Columbia River. Dikes are built high, with steep sides and flat tops, and are compacted. The compacted dikes provide poor conditions for plants to grow.

Dams known as “Interior” dikes were built to flood large portions of Moberly Marsh with deep water. The dikes were constructed to contain water added by pumping and from pipes connected to the Columbia River. The dikes did not impound water as planned. Generally, the only open water found in impoundments is where soil was removed to build the dikes. Most of the photos taken of Moberly Marsh show the narrow strips of open water along the dikes.

The construction of dikes was not successful in creating large areas of open water. Examination of aerial photos clearly shows that the area of natural, open water wetlands in Moberly Marsh significantly decreased following the construction of dikes and ditches.

The dikes did not impound water. One normally would see water within 30 cm of the top of the dikes within the impoundments, a high-water mark along the inside slope of the dikes, or a mud line lacking terrestrial vegetation if the dikes are holding water as planned. Instead, terrestrial vegetation is growing on the entire inside slope of the dikes, showing the dikes did not flood Moberly Marsh.

The dikes were built on permeable foundations containing organic soil and roots, and subsurface layers of gravel, sand, and silt. DUC design drawings show core trenches to be dug to a depth of 2-feet as a foundation for the dikes. The core trenches were not dug deep enough to block water from moving under the dike. The core trenches should have been dug deeper than the bottom of the borrow pits on either side of the dike to control leaking. The bottom of the borrow pits exposed permeable layers of soil, and these provided a conduit for water to travel to the river under the dike. The dikes were also built on the natural levee along the river, which is high in sand.

Deep ditches are located along one and sometimes both sides of the dike. These ditches were formed when soil was removed to build the dike. The dikes look higher than they are because of where the soil was removed along the base of the dike to build the dike. A large dragline was used to build the dikes that obtained the soil needed to build the dikes by digging deep and long pits along the base of the dikes. These ditches are named “borrow pit ditches.”

The borrow pit ditches resulting from construction of the dikes surrounding the Braul Compartment at the Northern edge of the Park have gravel in the bottom. The ditches based in gravel opened up a massive drain. This dike combined with the borrow pit ditches have dried a major and unique portion of Moberly Marsh.

The elevation of the constructed dikes was measured at numerous locations in relation to the base of old cottonwood trees growing on the banks of the Columbia River at Moberly Marsh. Dr. Bayley suggested using elevations measured at the base of cottonwood trees 100-years and older growing on the banks of the Columbia River at Moberly Marsh to indicate the approximate elevation of natural levees along the river before they were changed by dike construction (Bayley, 2019). The dikes were built an average of 119cm (3.9-feet) higher than the elevation of natural levees along the Columbia River.

The impoundments are not holding water as planned due to the following factors:

1. Water flows under the dikes via permeable layers of organic soil, tree roots, sand, and gravel layers.
2. Water flows through and under the dikes via muskrat and beaver burrows.
3. Moberly Creek does not enter the impoundments.
4. Water control structures were leaking.

The impoundments are now dominated by cattails with little open water.

The dikes have not breached or washed out since they were built. They are very difficult to inspect for burrows dug by muskrat and beaver because their steep slopes have not been mowed.

Figure 38. Large areas of Burges James Gadsden Provincial Park are covered by dense growths of cattails. Historical aerial photos show these areas containing large wetlands with open water.

Figure 39. This photo shows a dragline working to move soil. Draglines were used to dig the ditches and build the dikes in Moberly Marsh.

Figure 40. The dikes greatly reduced the quantity of large woody debris entering Moberly Marsh. The logs are of great importance to waterfowl for loafing.

Figure 41. Dikes were built on the banks of the Columbia River to prevent seasonal flooding of Moberly Marsh. This dike was built for the Bergenham Compartment. The top of the dike is being mowed by a volunteer.

Figure 42. This deep and wide ditch was formed by the dragline when it removed soil for building the adjacent dike. The area where soil was removed is called a borrow pit, and this is a borrow pit ditch. The ditch moves surface water and groundwater downhill towards the water control structure. Water also soaks into the ground and flows under the dike into the Columbia River.

Figure 43. Many of the borrow pit ditches are dry like the one shown.

Figure 44. Interior dikes within Burges James Gadsden Provincial Park are riddled with beaver burrows. This photo shows a typical section of the dam on the Sime Compartment breached by a beaver.

Figure 45. The holes are collapsed muskrat burrows in an interior dike on the Sime Compartment. Muskrat and beaver burrowing activity have caused breaching and failure of interior dikes.

Figure 46. This photo shows the Southern end of the dike built for the Bergenham Compartment. Sections of dike that are growing desirable plants would not affect restoration of the wetlands would not be disturbed or removed by the project.

Figure 47. Restoring Moberly Marsh will return a diversity of wetlands to Burges James Gadsden Provincial Park similar to what is shown here. These wetlands are located within the Sime Compartment. Water in the wetlands is not being maintained by the constructed dikes, and the wetlands would not be dried by removing the dikes. The author knows this based on removing over 300-dams to restore wetlands across North America.

Figure 48. Numerous small wetlands like the one shown may be restored by removing the dikes and associated borrow pit ditches.

Ditches

A number of new ditches were dug throughout Moberly Marsh after 1965. Ditches dug prior to 1965 were deepened, widened, and lengthened. Ditches were generally dug to follow natural streams, and cut through the natural levees of natural wetlands.

Ditches were dug to allow managers to remove the majority of water from Moberly Marsh to practice Moist Soil Management. Moist Soil Management involves draining water from impoundments in the Spring, allowing annual plants to grow in moist soils all Summer, and then flooding the impoundment in the Fall to attract waterfowl.

Ditches were dug to connect large natural open-water wetlands within Moberly Marsh. These ditches were designed to both drain natural wetlands, and to add water to natural wetlands. Because the dikes and water control structures that were installed are not holding water as planned, the ditches connecting natural wetlands have drained the natural wetlands.

Temporary ditches were also dug to facilitate the construction of dikes, drying saturated soils so heavy equipment operators may shape and compact soils, and not get stuck. These construction ditches were left open when the dikes were finished.

Figure 49. The red arrow shows a long and narrow ditch dug to dry natural wetlands and a stream within the Park. Notice the difference in vegetation on either side of the ditch.

Figure 50. Ditches may be filled to restore small wetlands surrounded by trees like the one shown. This wetland is located on private land within Moberly Marsh.

Borrow Ditches

The extensive system of dikes was built using a dragline. The dragline has a long boom with a large bucket at the end attached to cables. The bucket is swung out from the machine and pulled back using a system of cables and pulleys. The soil needed to build the dikes was obtained next to the dike being built. The dragline ends up digging a deep channel or ditch parallel to the dike being built. Dozers were most likely used to shape and compact the soil into a dike. The long ditch where soil was removed is called a borrow pit. The borrow pit can be dry, hold water seasonally, or year-round.

The water entering the borrow pit is drawn in from surrounding saturated soils. The dikes were not built on level ground, and neither were the borrow pits. Therefore, the borrow pits inadvertently became large drainage ditches by collecting and moving groundwater out of the wetland. The groundwater moved downhill in the borrow pit ditches until it disappeared in a gravel layer, flowed under the dike in a permeable layer, or entered the Columbia River via a leaking water control structure.

Occasional dams are observed that were built across the borrow ditches. This was done to slow water flowing in the ditches. Beaver have also built dams across the borrow ditches, showing that a considerable amount of water is flowing in the borrow ditches towards the leaking water control structures. There was no active beaver activity in the borrow pit ditches in May, 2019 largely because the ditches and wetlands were dry.

The borrow pit ditches were dug deep enough to expose permeable layers of organic material, sand, and gravel. A large quantity of water in Moberly Marsh now enters the borrow pit ditches from Moberly Marsh, flowing underground into the Columbia River. This is because the elevation of Moberly Marsh is typically over two-meters higher than waters in the Columbia River.

Figure 51. This drainage ditch was dug prior to 1965 near the Southern end of Moberly Marsh. The ditch was blocked by a dike built for the Bergenham Compartment. Water is soaking into the ground and flowing under the dike.

Figure 52. This photo shows where soil was removed to build a dike for the Bergenham Compartment. The area where soil was removed is called a borrow pit. Borrow pits parallel dikes, and slope downhill towards water control structures and pipes. The borrow pits formed ditches that are draining Moberly Marsh.

Figure 53. Here is another borrow pit ditch located along a constructed dike. The majority of the borrow pit ditches are dry because water is soaking into the ground and flowing under the dike towards the Columbia River in organic, sand, and gravel layers. The borrow pit ditches remove standing water and lower the elevation of groundwater over the entire Burges James Gadsden Provincial Park.

Level Ditches

Level ditches were built with throughout Moberly Marsh. Level ditches are designed to provide standing open water in dense cattails, and not drain. However, field examination by the author finds that the majority of level ditches are draining, removing water from Moberly Marsh. Because the ground surface in Moberly Marsh is sloped, ditches that were dug for any purpose remove water from a wetland unless they are successfully blocked at their outlet. Some of the level ditches in Moberly Marsh have been dammed by beaver, creating small open water wetlands. Many of the level ditches are not blocked at their end. Surface and groundwater are being drawn into the level ditches, moving downhill, and then leaving the wetland by traveling under the dam and past water control structures. The level ditches were also built across and in natural streams, interrupting and diverting their flow.

Figure 54. Natural streams were wide and shallow, like the one shown here in the Park. Many were dug into wide and deep ditches with curves in them after 1965, using the “level ditch” technique.

Water Control Structures

Two major ditches were dug to create outlets and inlets for draining and filling the impoundments. Water control structures, valves, pipes, and pump were installed for filling the impoundments, and for draining wetlands and the large field on private land. The water control structures were named the 3-way and the 4-way control.

The water control structures and ditches were also designed to remove a majority of water from Moberly Marsh for maintenance purposes. This would allow dikes, water control structures, and the pump to be repaired above and not below water.

The elevation of the ditches/canals built to fill and drain the impoundments and the large hayfield were dug to be the same as the Columbia River. These ditches established new and significantly lower elevation outlets for Moberly Marsh. Examination of natural, unmanaged wetlands on the West side of Moberly Marsh shows that the entrance elevation of outlets is significantly higher than the entrance elevation of outlets in ditches associated with the 3-way and 4-way water control structures.

The author examined each water control structure, recorded water elevations on the Columbia River, inside impoundments, and within actual water control structures. The invert of the pipe and valve on the 3-way control structure is approximately 88cm *below* the elevation of water in the Columbia River. In comparison, the elevation of the natural inlet measured on the West side of the river was 235cm *higher* than the river. The water control structure is currently draining Moberly Marsh. Removing the water control structure and pipes combined with restoring the elevation of the natural levee would return historic water levels to the Park.

Beaver and muskrat have dug burrows into the dikes surrounding flashboard riser water control structures. The water control structures are leaking, and water is likely leaking around the pipes connecting the water control structure. The flashboard riser type water control structures are not holding water. The leaking can be expected to be much worse when water levels are higher in Moberly Marsh due to greater hydraulic pressure.

The valves, pipes, and flashboard riser water control structures are made of steel which will rust over time. The leaking water control structures combined with the low elevation ditches associated with the 3-way and the 4-way water control structures are draining Moberly Marsh.

Figure 55. This long ditch was dug for the Bergenham Compartment as part of the 3-Way Control Structure. A flashboard riser water control structure was installed at the end of the ditch. The ditch was started before 1949, then deepened, widened, and lengthened after 1965. The flashboard riser and surrounding dike are leaking and not holding water. The elevation of water in the flashboard riser water control structure was the same as the elevation of water in the river. Removing water control structures, filling ditches, and restoring the elevation of natural levees along the Columbia River would restore water levels in Moberly Marsh.

Farmland

A significant action affecting Moberly Marsh involved the creation of an 81-acre field on private land adjacent to Burges James Gadsden Provincial Park. Historic aerial photos show the field was once part of Moberly Marsh. The ditch system leading to the 4-Way control was designed to drain the field. The high dikes built around the field were designed to keep out the Columbia River. The pump that was installed was designed to remove water from the field when the level of the Columbia River was high. The elevation of the field is lower than the elevation of the Columbia River. The field was historically wetland that flooded regularly by the Columbia River.

The private landowners who own the field cooperate with BC Parks and DUC to adjust the 4-way control structure to flood a portion of the field in early Spring, and drain the field in time for grass to grow.

The owners of the large hayfield worked in partnership with the Fish and Wildlife Compensation Program, British Columbia Wildlife Federation, the author, and others to restore 6 wetlands in the hayfield in 2018. The wetlands are being used by a diversity of ducks, geese, wading birds, and shorebirds. Shallow water wetlands surrounded by mowed grass provide a unique and valuable habitat to a diversity of wildlife species.

Figure 56. This large 81-acre hayfield on private land was made by draining a significant portion of Moberly Marsh after 1965. The field was surrounded by a high dike to keep out the Columbia River. Numerous ditches were dug and water control structures with a pump were installed within the Burges James Gadsden Provincial Park to keep the field from flooding. The field receives use by a high diversity and number of bird species during migration.

Islands

Twenty-eight islands were built in Moberly Marsh. The islands were formed by pushing surrounding soils towards the center of an oval into a mound. The islands appear to be large piles of soil surrounded by narrow moats of water; unlike features one would see in a natural wetland.

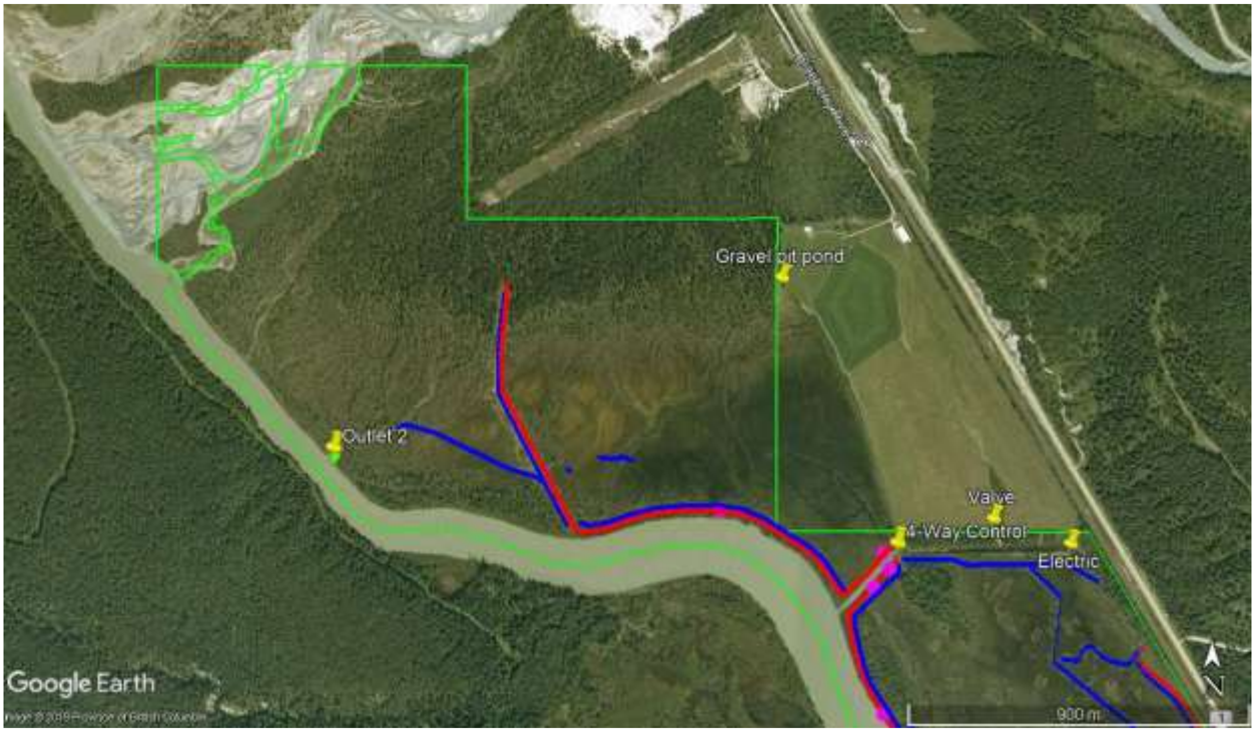
Summary of DUC Actions

The following is a summary of DUC construction activities within the Park: (Ducks Unlimited Canada, 2016).

> DUC constructed dikes to prevent river water inflow during critical nesting periods, approximately 10 feet high throughout[1]. DUC added a water control in 1972. A cross dike was constructed in 1978 to separate two wetland compartments (‘Sime’ to the north, ‘Bergenham’ to the south) along with a new 2-way water control. Internal channel creation and nesting islands were undertaken in 1979 in the Sime compartment, and a pumping station with an electrical source was added in 1986. In 1988 the ‘Braul’ Marsh compartment was added using donated land, a new dike, and a control.
>
> The project consists of three wetland compartments: the Sime, Bergenham and Braul compartments. Together, they include 246 hectares of wetland habitat, and 132 hectares of ‘upland’ habitat. (Note that the area of the Bergenham compartment includes some area not covered by Park Use Permit.) The original 30-year Park Use Permit, signed in 1984, included the following:
>
> - 6.3 km of perimeter diking (All compartments)
> - 3.2 km of internal diking (All compartments)
> - 3.0 km of internal ‘level ditching’ (All compartments)
> - One 3-way inlet/outlet water control (controls river flow to/from Sime/Bergenham)
> - One 4-way inlet/outlet water control with electric pumping unit and associated culverts and stoplogs (controls river flow to/from Sime/Braul/Hayfield)
> - 28 nesting/loafing islands constructed using excavated material (Sime/Bergenham)
> - 10 elevated nesting structures (Braul)
> - One water license (no expiration date; issued in 1971 to the Provincial Minister of Recreation and Conservation).

[1] The average height of constructed dikes as measured by the author is less than 4-feet.

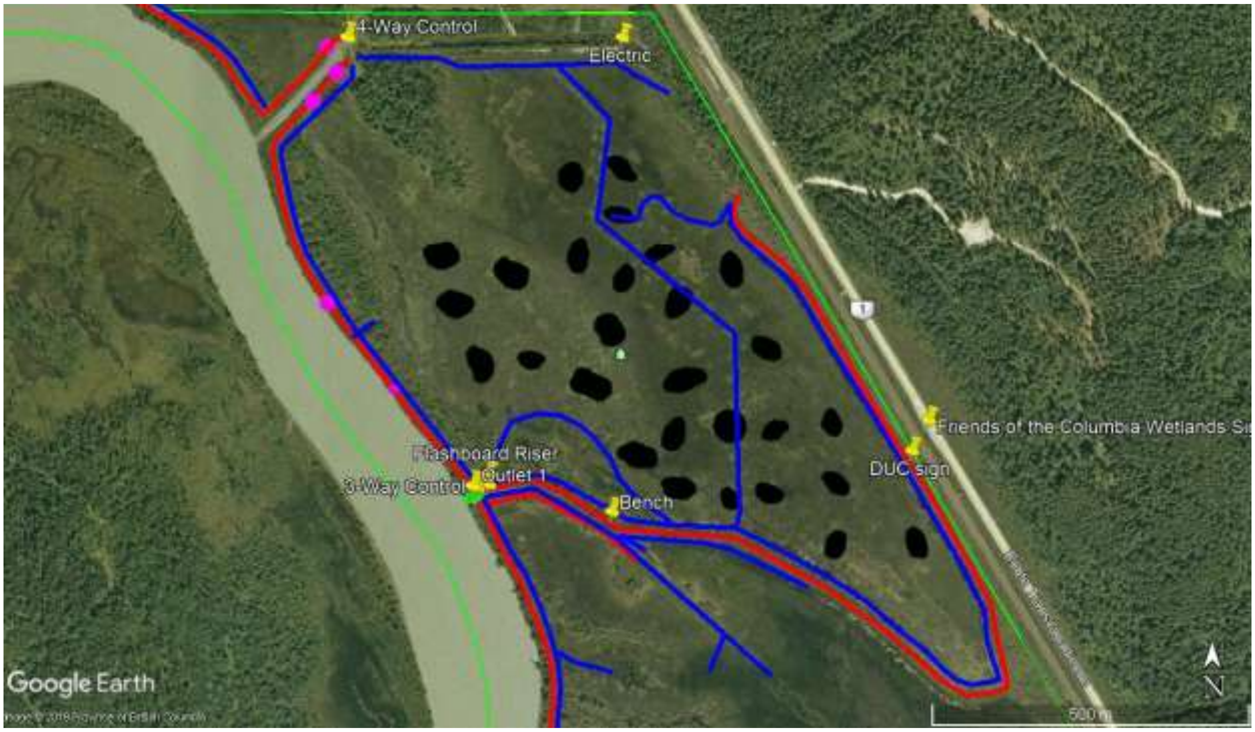
Figure 57. Modifications made to Burges James Gadsden Provincial Park after 1965[2]
Braul Compartment (Northern)



Green line = Burges James Gadsden Provincial Park Boundary
Blue line = ditch
Red line = dike
Pink Dot = Planned Inlet

[2] Determined by the author from field examination, review of historic aerial photos and Lidar images, and interviews with community residents.

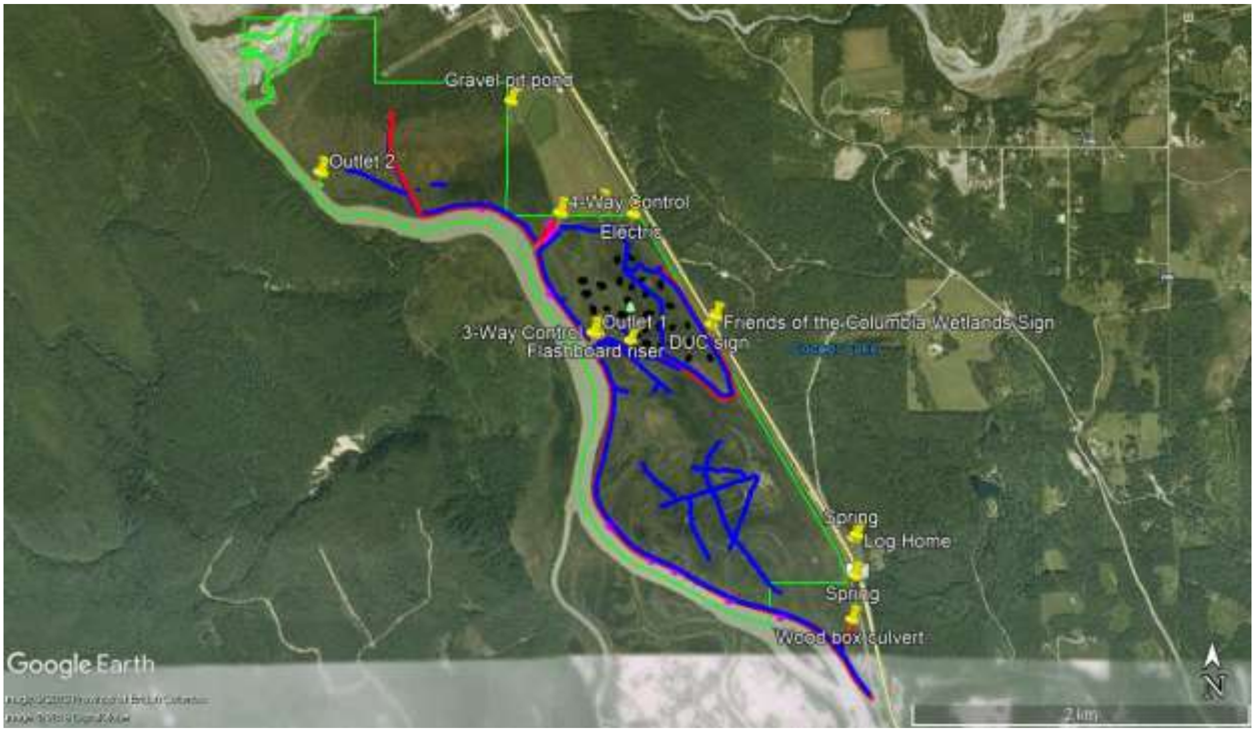
Figure 58. Modifications made to Burges James Gadsden Provincial Park after 1965.[3]
Sime Compartment (central)



Green line = Burges James Gadsden Provincial Park Boundary
Black polygons = Nesting Islands
Blue line = ditch
Red line = dike
Pink Dot = Planned Inlet

[3] Determined by the author from field examination, review of historic aerial photos and Lidar images, and interviews with community residents.

Figure 59. Modifications made to Burges James Gadsden Provincial Park after 1965.[4]
Bergenham Compartment (Southern)



Green line = Burges James Gadsden Provincial Park Boundary
Black polygons = Nesting Islands
Blue line = ditch
Red line = dike
Pink Dot = Planned Inlet

TransCanada Highway 1

The TransCanada Highway 1 impacted Burges James Gadsden Provincial Park by diverting runoff and by filling the Eastern edge of the wetland. The construction of the highway involved filling portions of Moberly Marsh. Deep and long ditches were dug along both sides of the highway. These ditches capture runoff and intercept groundwater. The ditches contain standing and flowing water. Few culverts were installed under the highway. The runoff from the highway is being directed into the ditches along the railroad. The ditches are filled with trash and the water that does not appear clean.

[4] Determined by the author from field examination, review of historic aerial photos and Lidar images, and interviews with community residents.

Figure 60. Photo showing a spring located on the East side of TransCanada Highway 1. Waters from the spring enter the Park.

Restoration Objectives

Wetlands may be restored in Burges James Gadsden Provincial Park to accomplish a variety of objectives including:

- Improving habitat for Species at Risk
- Improving habitat for ducks, geese, wading birds, shorebirds, elk, and deer
- Increasing wildlife viewing opportunities along the TransCanada Highway 1
- Reducing the need for maintenance
- Returning Culturally important plants
- Controlling nonnative plant species
- Restoring flood connectivity with the Columbia River
- Returning a sheet-pattern flow of floodwaters over Moberly Marsh
- Restoring a diversity of wetland types

Restoration efforts are likely to provide direct habitat for the following Species at Risk (Darvill, 2019):

1. Western Grebe (staging habitat)
2. Horned Grebe (staging and possibly breeding habitat)
3. Eared Grebe (staging and possibly breeding habitat)

4. Tundra Swan (staging)
5. American Bittern (breeding habitat)
6. Great Blue Heron (feeding areas)
7. Painted Turtle
8. Western Toad

These additional at-risk species may also benefit as they have been recorded in the park previously as well as in other areas of the Columbia Wetlands, and they could benefit from increased feeding and/or breeding opportunities due to restoration activities (Darvill, 2019):

1. Rough-legged Hawk
2. Bank Swallow
3. Long-billed Curlew
4. Surf Scoter
5. American White Pelican
6. California Gull
7. Peregrine Falcon
8. Bobolink
9. Common Nighthawk
10. Swainson's Hawk
11. Lewis's Woodpecker
12. Black Swift
13. White-throated Swift
14. American Avocet
15. Double-crested Cormorant
16. Red-necked Phalarope
17. Broad-winged Hawk
18. Short-eared Owl
19. Evening Grosbeak
20. Prairie Falcon
21. Peregrine Falcon

The Northern leopard frog, a Species at Risk, was historically found in Moberly Marsh (Adama, 2017).

Techniques developed and published by the author may be used to restore the wetlands and streams in Burges James Gadsden Provincial Park so they appear and function as natural ecosystems, requiring little if any maintenance. Wetlands and streams may be restored without the use of dikes, dams, diversions, ditches, canals, pipes, pumps, or water control structures, all of which require maintenance.

The actions identified in this plan were designed specifically not to affect the TransCanada Highway 1, local roads, the Canadian Pacific Railroad, private land, and the adjoining 81-acre field on private land.

Figure 61. Areas of gravel on higher ground within Burges James Gadsden Provincial Park near the Blaeberry River appear to provide the Common Nighthawk with suitable nesting sites.

Figure 62. Restoration actions would restore wetlands like this one within the Park.

Restoration Actions

Historic water levels in wetlands and streams along with a diversity of native animals and plants may be restored in the Park. This may be accomplished by taking action to restore the elevations of natural levees, filling of ditches, and returning natural runoff from streams. These improvements would require little, if any maintenance. The following is a detailed description of recommended actions for restoring wetlands and streams within the park:

Restoration of natural levees

Natural levees may be restored along the Columbia River. This involves lowering and reshaping all of the constructed dikes along the Columbia River, and the interior dikes within Moberly Marsh. Floodwaters would then flow over the restored natural levees into Moberly Marsh every year.

People would continue to have walking access along the Columbia River after the dikes are removed. The restored natural levees would be wider than the dikes, and be on high ground that is well-drained. Trees and shrubs would grow on the restored natural levees because their soils would be loosened and not saturated.

The borrow pit ditches along the dikes may be filled to control leaking, and reshaped to form a diversity of naturally appearing and functioning wetlands and streams. The flow of water in the ditches may be blocked by digging core trenches along the length of the ditch, and filling these core trenches with clay that is compacted. Small wetlands may be restored along the length of the ditch, and the soil generated from building these wetlands and from lowering the dike used to fill the ditch. Naturally appearing streams, wetlands, muskrat houses, beaver lodges, and ridges may be formed from the borrow pit ditches.

Historically, floodwaters would have flowed over Moberly Marsh in a wide, sheet-like pattern. Therefore, interior dikes built within Moberly Marsh would be removed to avoid blocking the flow of floodwaters over the wetland, and directing floodwaters into ditches.

The dikes along the river and the interior dikes are not maintaining water in the constructed Braul, Bergenham, and Sime Compartments. Water from Moberly Marsh is flowing under the dikes via permeable layers of organic material, sand, and gravel. Water is flowing through the dikes via muskrat and beaver burrows, and in and around water control structures and valves that are leaking. Removal of the dikes would greatly increase the area of open-shallow water wetlands within Moberly Marsh.

Naturally appearing inlets and outlets would be formed in the restored levees along the Columbia River. The inlets would allow floodwater from the Columbia River to enter the wetlands each year. The outlets would match the elevation of natural outlets, restoring historic water levels in the Park.

Excavating narrow and deep channels through dikes would cause significant erosion and irreversible damage to remaining wetlands in the Park. Head-cuts form when dikes are breached. Head-cuts will advance upslope in ditches and natural streams, causing a deepening and widening of ditches and stream channels. Head-cuts begin with minutes of a dike being breached. The author has examined thousands of wetlands that have been destroyed when narrow channels were dug through a dam or levee. The head-cuts are very difficult and very expensive to control.

Table 1. Constructed Dike Elevations in relation to wetland features.

DUC Compartment	Top of constructed dike elevation	Base of old Cottonwood on natural levee (cm)	Base of willow near dike in Compartment (cm)	Base of cattails near dike in Compartment (cm)	Elevation of water in Compartment (cm)
Sime	0	-116	-152	-161	-177
Bergenham	0	-122	-216	-256	-305
Average	0	-119	-184	-208	-241

Figure 63. The elevation of dikes would be lowered to approximately the same elevation as the base of large old cottonwood trees growing between the dike and the Columbia River.

Figure 64. The orange ribbon shows a typical location for building an inlet. The inlet would be built between the trees at an elevation slightly lower than the elevation of the base of old cottonwood trees growing between the dike and the Columbia River.

Figure 65. The tape measure spans the width of a natural inlet to a wetland opposite Moberly Marsh. Note the narrow and low ridge of grass between the river and cattails.

Figure 66. The red arrow marks the center of a natural inlet to a wetland along the Columbia River opposite Moberly Marsh. The green grass with cattails growing in the background are typical of natural inlets.

Figure 67. The red arrow marks the center of a natural inlet to a wetland along the Columbia River opposite Moberly Marsh. The green grass with cattails growing in the background are typical of natural inlets. Note the high elevation of the inlet, and that there is no gully between the wetland and the river.

Figure 68. Natural outlet draining from a natural wetland along the Columbia River opposite Moberly Marsh. A stream is flowing in the outlet from the wetland.

Figure 69. Natural outlet draining from a natural wetland along the Columbia River opposite Moberly Marsh. No stream is flowing in the outlet.

Figure 70. Planned Outlet #2 for Moberly Marsh. This natural outlet has become dry from the construction of dikes and ditches that have drained the wetlands it once served. Beaver have dug a channel up the bottom of the outlet.

Figure 71. Wetland adjacent to natural outlet along the Columbia River opposite Moberly Marsh. Beaver built a dam across the outlet just before it drops to the river. The elevation of the outlet controls the depth of water in adjacent wetlands. The natural elevation of outlets is the same as the water level in wetlands along the floodplain, which is significantly higher than the river.

Figure 72. Natural stream as it approaches a natural outlet along the Columbia River, opposite Moberly Marsh. The stream is wide, level, and at a high elevation above the river. A short and steep valley exists where the stream drops to the river.

Recommended specifications for restoration:

Dikes along the Columbia River as shown by Figure 59 will be changed to appear and function as natural levees by reducing their height, widening their base, and loosening compacted soils.

The elevation of dikes will be lowered to approximately the same elevation as the base of the closest old cottonwood tree growing between the river and the dike. The elevation of the top of the restored levee can be expected to change along the Columbia River. The Contract Representative will monitor and mark planned elevations along the length of the dike being removed as construction is taking place. The goal is to restore a naturally appearing levee along the banks of the river containing dips, ridges, and loosened soil for trees and shrubs to grow.

Gradual slopes no steeper than 10-percent will be formed on both sides of the dike using soil removed from lowering the dike. Soil will generally not be piled over trees and shrubs growing on the river side of the dike.

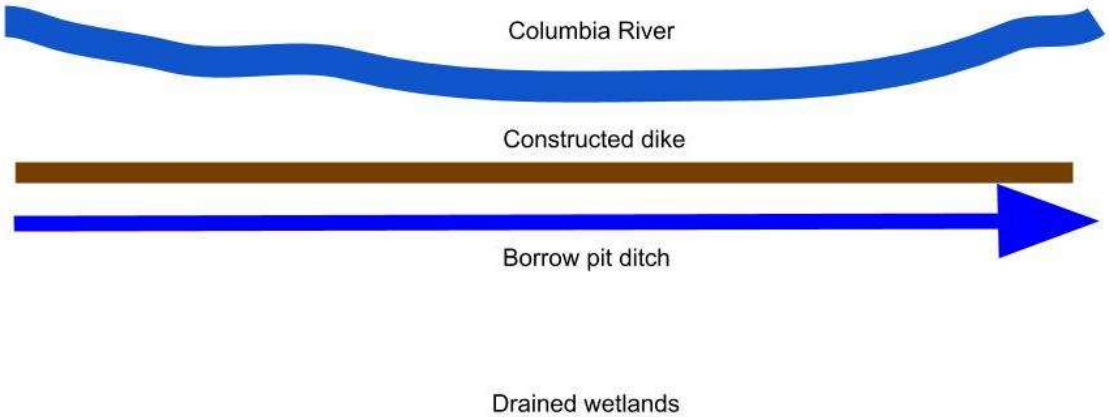


Figure 73. Existing constructed dike and borrow pit ditch (typical plan view).

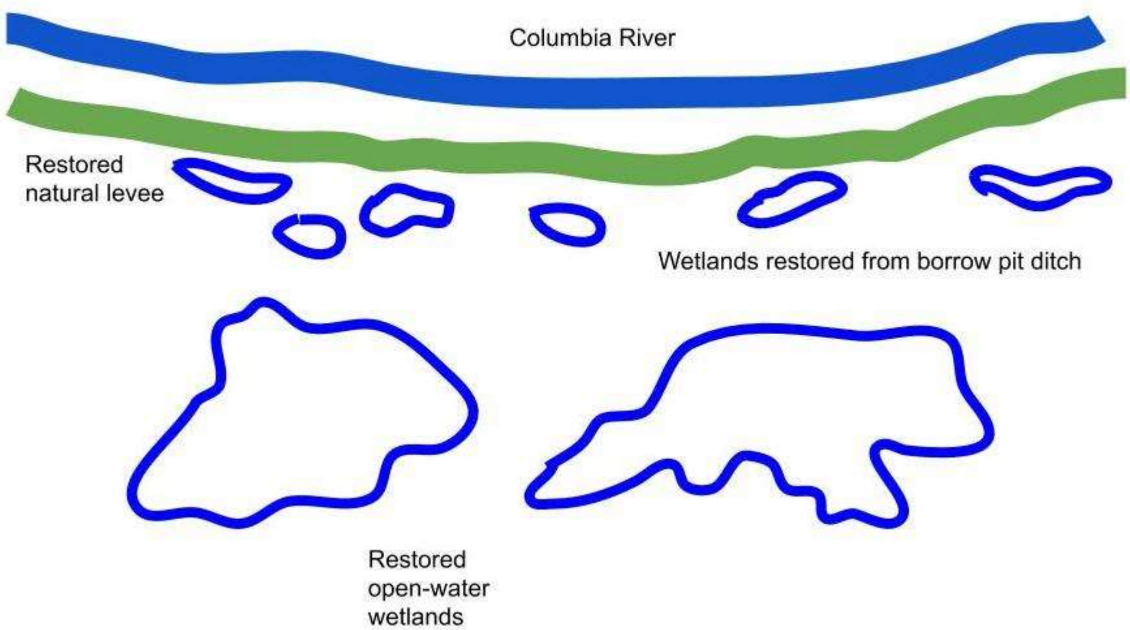


Figure 74. Restored natural levee (typical plan view).

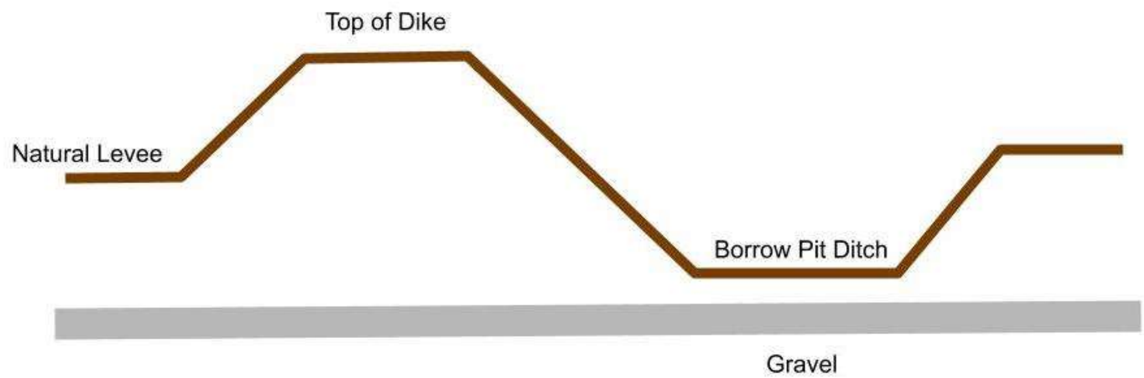


Figure 75. Constructed dike and borrow pit ditch (typical profile view).

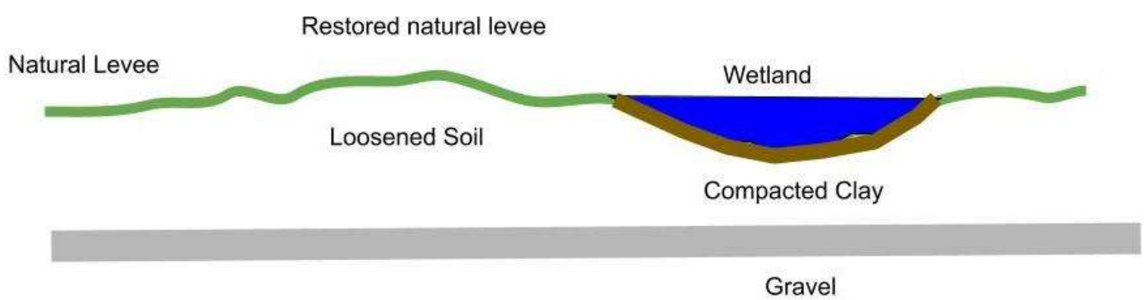


Figure 76. Natural levee and wetland restored from dike and borrow pit ditch (typical profile view A).

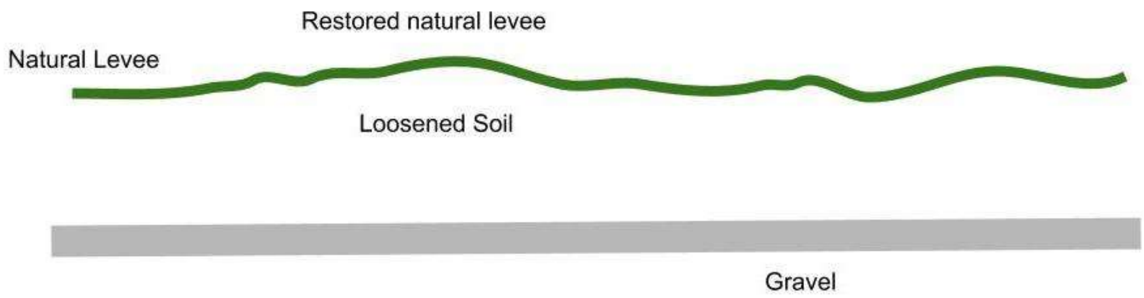


Figure 77. Natural levee restored from dike and borrow pit ditch (typical profile view B).

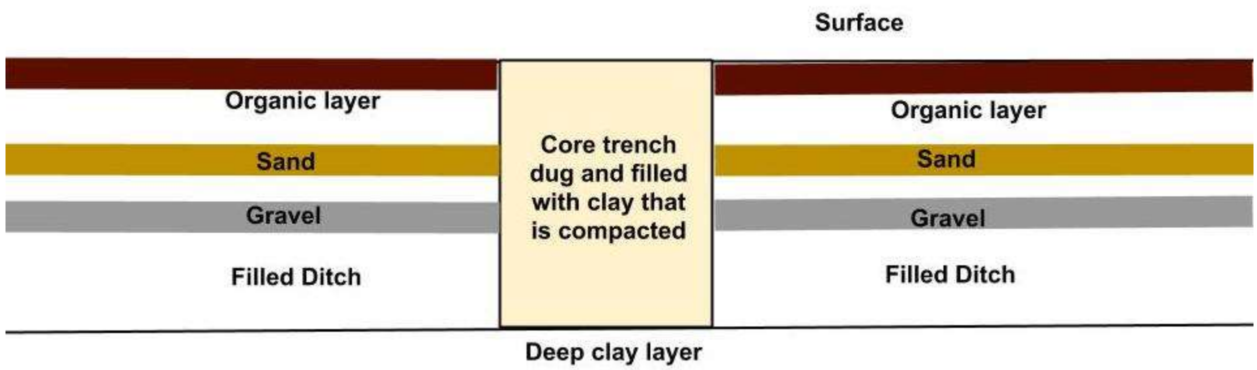


Figure 78. Core trench filled with clay that is compacted to block subsurface water flow in borrow pit ditch or drainage ditch (typical profile view).

Water will be prevented from flowing along borrow pit ditches by filling and blocking the borrow pit ditches with soil. To prevent water from flowing in the borrow pit ditches underground once they are filled, core trenches will be dug perpendicular and across borrow pit ditches approximately every 30-meters. The core trench will be deep enough to cut through organic soil and permeable layers of soil. Soil that is high in clay will be placed in the core trench in layers, with each layer being compacted by the excavator.

The soil removed from lowering the dike would generally be placed in the borrow pit along the edge of the dike. Soil removed from lowering the dikes would be used to shape wetlands having a diversity of sizes, depths, and shapes.

Patches of gravel will be spread on higher ground when uncovered during restoration activities to create nesting habitat for the Common Nighthawk.

Heavy equipment or vehicles are not to be allowed to travel on the levees once they are restored. Work must be planned where it is not necessary to travel over restored natural levees and wetlands once they are finished. Soils will be loosened and the marks of heavy equipment removed from areas traveled by heavy equipment and vehicles.

Interior dikes not along the Columbia River will generally be lowered to an elevation equal to the base of wetland vegetation on either side of the dike, generally cattails or sedges. The soil removed from lowering interior dikes will be shaped into naturally appearing wetlands, ridges, and mounds. Compacted soils in shaped ridges and mounds will be loosened to a depth of 1-meter using the bucket of an excavator.

Small wetlands of various sizes, shapes, and depths will be shaped along the length of the borrow pit ditches being filled. Areas of gravel or sand uncovered in wetland basins being formed will be covered with soil high in clay that is compacted to a thickness of approximately 70cm.

Trees of various diameter obtained onsite will be placed on the restored natural levees and in and around the restored wetlands as large woody debris to improve wildlife habitat. Trees will be anchored by burying approximately ½ of the trunk in the ground.

Native aquatic plants, shrubs, and small trees will be transplanted where possible. This may be accomplished by using the excavator to remove desirable clumps of plants from areas being disturbed and immediately transplanting them on areas where heavy equipment recently finished work. The Contract Representative will work closely with the excavator operator to mark clumps of plants to be removed and transplanted as work progresses.

Sections of dikes that appear natural, are supporting desirable plants, and as designated by the Contract Representative may be left undisturbed to provide habitat for wildlife.

Figure 79. Straight borrow pit ditches like the one shown may be restored to naturally appearing and functioning wetlands.

Figure 80. This canal on the Sime Compartment would be transformed by giving it natural irregular edges including points, peninsulas, ridges, bays, and islands, with large woody debris.

Figure 81. Dikes and borrow pit ditches will be restored to provide habitat for waterfowl and a diversity of wildlife species. This photo is an example of how the restored dikes and ditches will appear within 5-years of construction.

Figure 82. Interior dikes including this one on the Sime Compartment may be removed to restore floodwaters from the Columbia River over all of Moberly Marsh.

Figure 83. This photo shows how a restored borrow pit ditch can be expected to appear within 5-years of restoration.

Figure 84. Dikes would be restored to natural levees and borrow pit ditches reshaped with natural edges similar to the wetland shown in this photograph.

Figure 85. Borrow pit ditches would be reshaped to appear like natural wetlands.

Figure 86. This photo shows one of many large wetlands in the Braul Compartment that was drained by ditches, borrow pit ditches, and dikes since 1965.

Figure 87. This photo shows one of many large wetlands in the Braul Compartment that was drained by ditches, borrow pit ditches, and dikes since 1965.

Figure 88. This photo shows one of many large wetlands in the Braul Compartment that was drained by ditches, borrow pit ditches, and dikes since 1965.

Figure 89. Cattails grow in the deepest part of a historic natural wetland drained by ditches, borrow pit ditches, and dikes in the Braul Compartment since 1965.

Figure 90. The borrow pit created by building the dike (red line) is draining the entire Northern portion of Moberly Marsh. Gravel lenses exposed in the ditch are carrying water under the dike into the Columbia River.

Figure 91. Willows are beginning to grow in the drained wetland basin. The borrow pit created by building a long dike is draining the wetland. Water is flowing down the borrow pit ditch, into exposed gravel layers, and then into the Columbia River.

Figure 92. Note the gravel in the ditch that is draining the large wetland.

Figure 93. The construction of dikes and ditches in the Braul Compartment has greatly shortened the hydroperiod of natural wetlands within Moberly Marsh. The crustaceans shown in this photo died because the wetland dried prematurely due to drainage.

Figure 94. This ditch was constructed to move water into and out of a large natural wetland within the Braul Compartment. The ditch now only drains the wetland. The wetland no longer holds water due to the permeable substrate exposed in the ditches.

Locations for restoring inlets were identified using one or more the following criteria:

1. Possible inlet visible on historic aerial photos.
2. Suggested by Dr. Suzanne Bayley
3. Along an outer bend in the Columbia River
4. Erosion taking place along the river bank and dike
5. Strategic location for floodwater inflow as identified in the field
6. Suggested by DUC personnel

Inlets will be formed at designated locations as listed by Table 2. The inlets will allow floodwaters from the Columbia River to enter the wetlands annually without erosion. They will generally be oriented to the river at an angle as shown in Figure 95.

Table 2. Planned Inlet and Outlet Locations.

Inlet Number		
1	51.390669	-117.035164
2	51.391565	-117.039719
3	51.392494	-117.042625
4	51.392823	-117.043435
5	51.39321	-117.044557
6	51.3933783	-117.046622
7	51.395637	-117.050238
8	51.395727	-117.05041
9	51.407315	-117.054027
10	51.408602	-117.055633
11	51.41242	-117.055632
12	51.412032	-117.055412
13	51.411602	-117.055994
14	51.413204	-117.061827
Outlet Number		
1 (at 3-Way Control)	51.405690	-117.052231
2 (mouth at river)	51.414614	-117.076572
2 (uphill entrance)	51.415392	-117.073505

The inlets to be constructed may range from 3-10 meters wide, and be approximately 50cm lower in elevation than the base of the closest old cottonwood tree growing on the bank of the river. The actual elevation of each inlet will be based on a ground survey, and consultation with a Hydro-Technical Engineer. The elevation of the inlets will be set so the Columbia River will flood the wetlands each year, and not become outlets or ditches that will drain the wetlands. The inlets will not contain valleys leading to the river like an outlet.

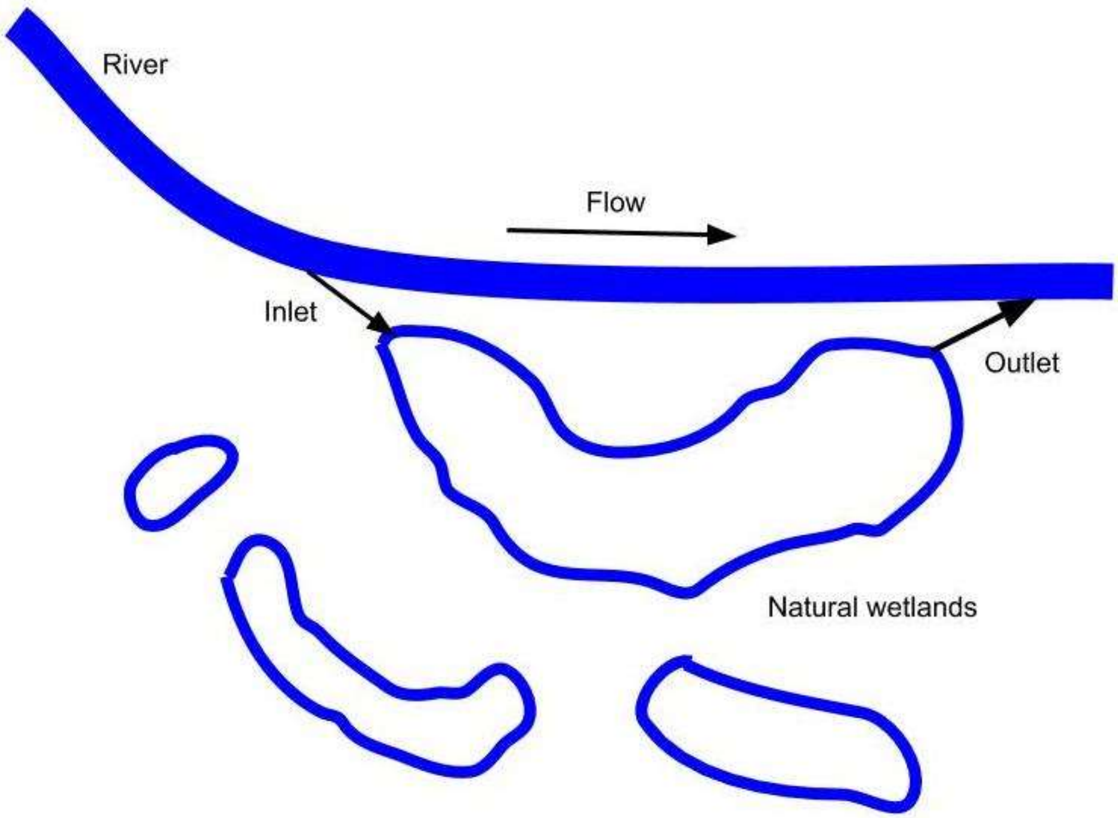


Figure 95. Location of wetland inlet and outlet in relation to the river (typical plan view).

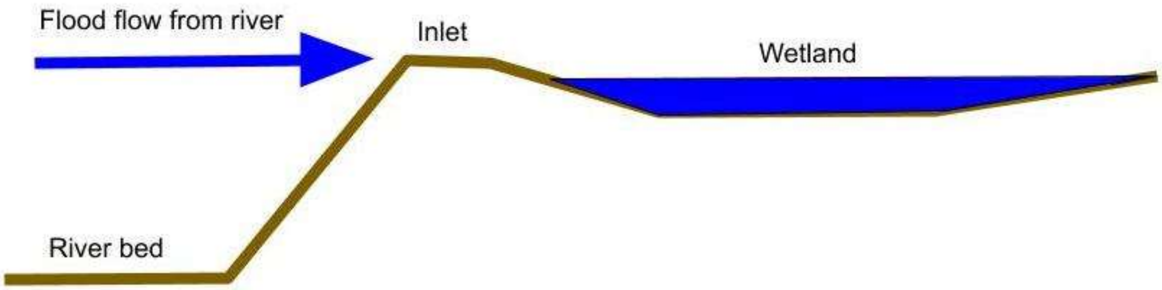


Figure 96. Inlet (Side profile view).

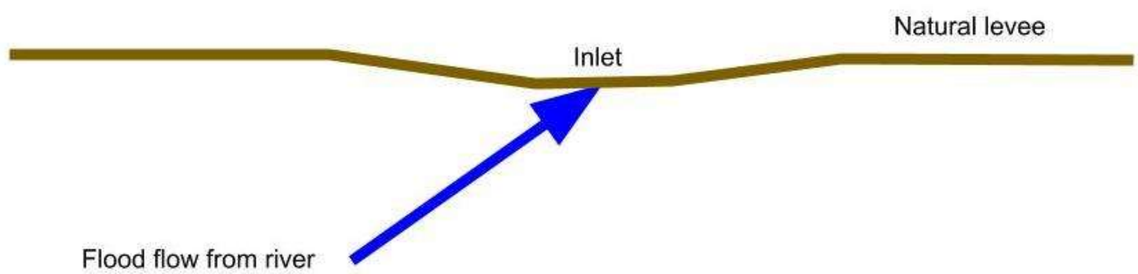


Figure 97. Inlet (Front profile view).

Locations for building outlets were identified using one or more the following criteria:

1. Suggested by Dr. Suzanne Bayley
2. Existing natural outlet visible on historic aerial photos and Lidar images
3. Existing constructed ditch forming an artificial outlet at a low elevation
4. Along a straight stretch of the Columbia River
5. Strategic location for an outlet Identified in the field
6. Suggested by DUC personnel

Two outlets will be constructed (Figure 57 and Figure 58). The outlets will be shaped to appear as natural valleys with gradual slopes that cut through the river bank. The entrance of the outlet will be approximately 50cm-lower than the lowest elevation measured along the length of the restored levee. The Contract Representative will determine the final elevations of the entrance and mouth of each outlet during construction. Outlets will be shaped like a natural spillway, and be approximately 12-meters wide. Rock from 30 to 60cm in diameter will be used to armor the mouth of the outlet, starting at the river and extending inland approximately 50-meters. The armoring will control erosion and reduce the possibility of head-cuts forming.

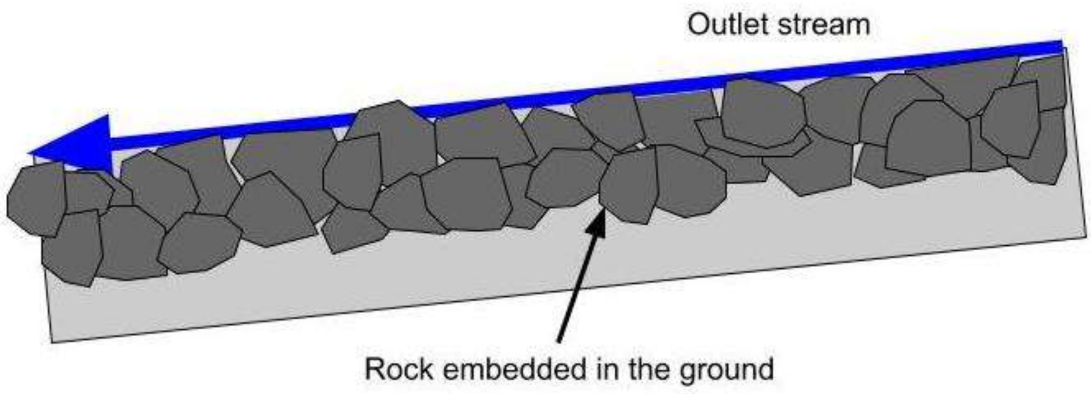


Figure 98. Constructed Outlet (Side profile view).

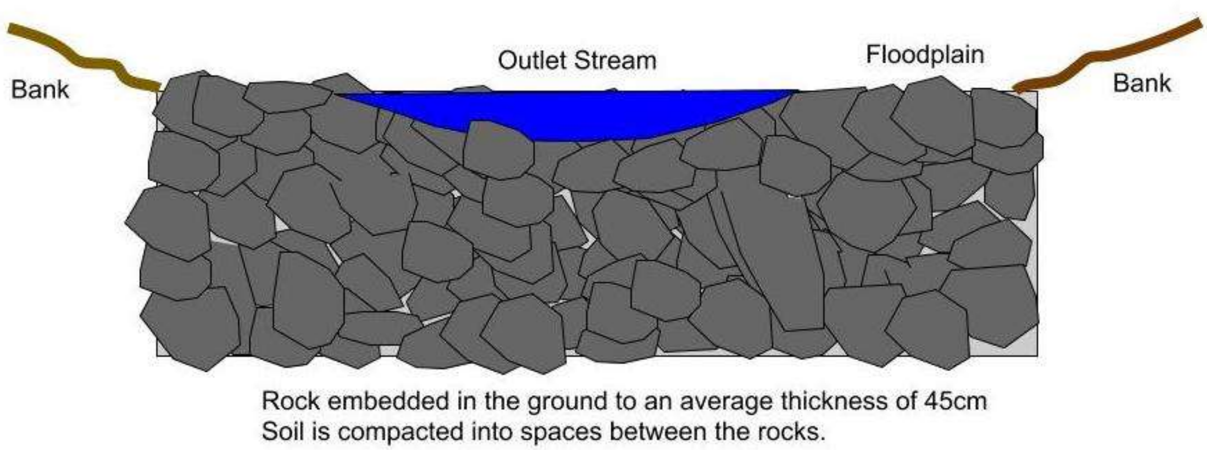


Figure 99. Constructed Outlet (Front profile view).

Filling of ditches

Natural streams and wetlands may be restored by filling and reshaping ditches, and by removing water control structures to return historic water elevations within the Park. Ditches will be filled and shaped to control drainage and to restore naturally appearing wetlands and streams.

Recommended specifications for restoration:

Ditches will be filled with soil from the old spoil piles and from adjacent dikes. Naturally appearing wetlands of various shapes, sizes, and depths will be restored along ditches where adequate soil needed to fill ditches is not available.

Ditches will be filled with soil to an elevation equal to surrounding undisturbed ground. An attempt will be made to fill ditches with the same texture soil and at the same compaction rate as neighboring undisturbed land.

Core trenches filled with soil that is compacted will be used to prevent water from flowing underground in the filled ditch. The core trench will be dug perpendicular and across the width of the ditch, extending into original ground on either side approximately 3-meters. The core trench will be dug deep enough to cut through organic soil and permeable soil layers. Soil that is high in clay will be placed in the core trench in layers, with each layer being compacted by the excavator. A core trench will be placed at the outlet of the ditch, and every 30-meters along the length of the ditch.

Naturally appearing streams and wetlands will be restored along the length of the ditch. These will be separated by ridges of soil and core trenches to prevent water from flowing down the ditch.

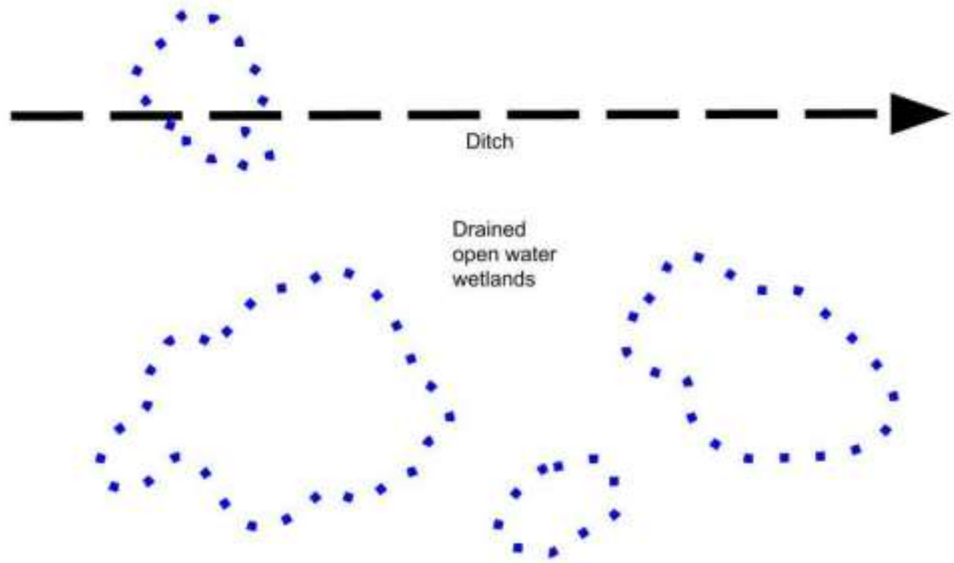


Figure 100. Ditch and drained wetlands (typical plan view).

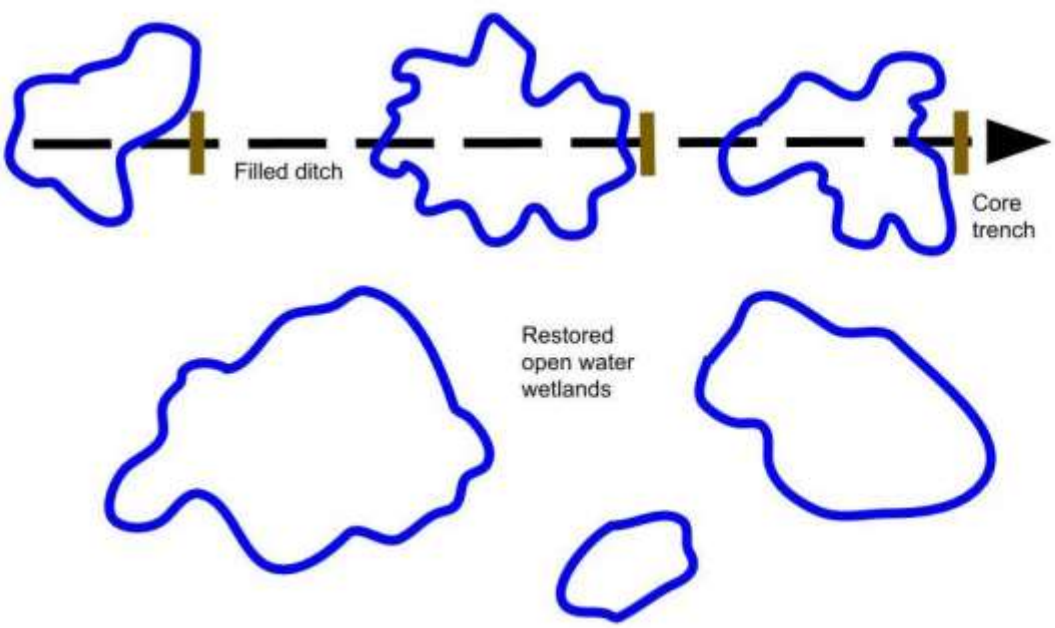


Figure 101. Filled and restored ditch (typical plan view).

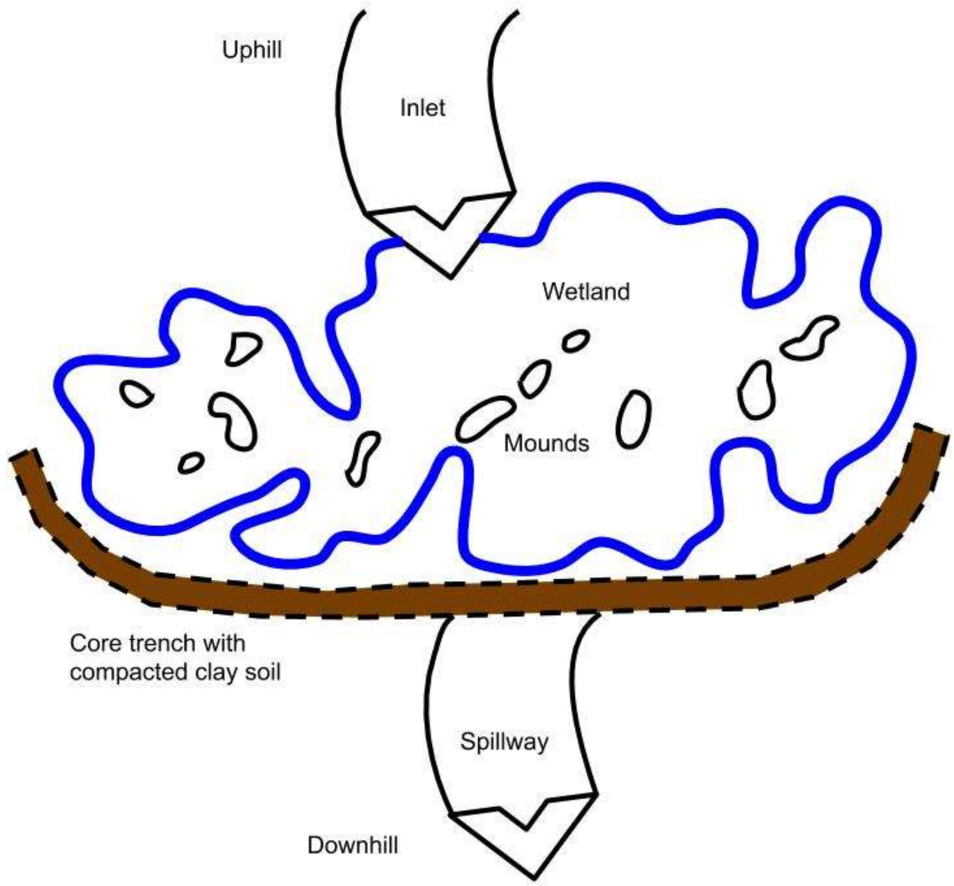


Figure 102. Wetland restored from drainage ditch or borrow pit ditch (typical plan view).

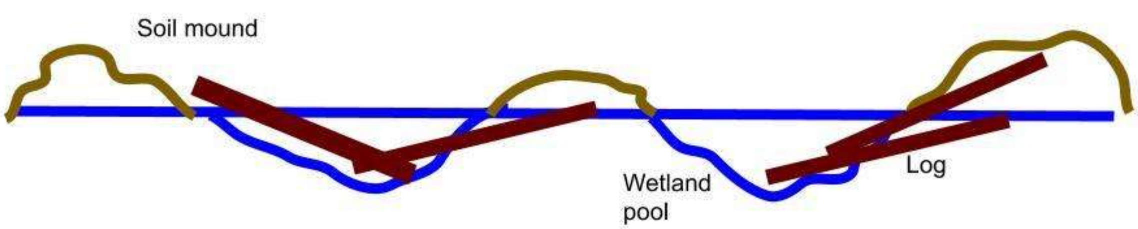


Figure 103. Wetlands and mounds in filled and restored ditch (typical profile view).

Heavy equipment or vehicles are not to be allowed to travel on the filled ditches once they are restored. Work must be planned where it is not necessary to travel over restored areas once they are finished. Soils will be loosened and the marks of heavy equipment removed from areas traveled by heavy equipment and vehicles. Compacted soils in shaped ridges and mounds will be loosened to a depth of 1-meter using the bucket of an excavator.

Trees of various diameter obtained onsite will be placed in and near the restored wetlands and streams as large woody debris to improve wildlife habitat. Trees will be anchored by burying approximately ½ of the trunk in the ground.

Native aquatic plants, shrubs, and small trees will be transplanted where possible. This may be accomplished by using the excavator to remove desirable clumps of plants from areas being disturbed and immediately transplanting them on areas where heavy equipment recently finished work. The Contract Representative will work closely with the excavator operator to mark clumps of plants to be removed and transplanted as work progresses.

Sections of ditches that appear natural, are supporting desirable plants, and as designated by the Contract Representative may be left undisturbed to provide habitat for wildlife.

Figure 104. This photo shows one of many large wetlands in the Braul Compartment that was drained by ditches and dikes since 1965.

Figure 105. This photo shows the transition where a natural stream was turned into a drainage ditch within the Braul Compartment after 1965.

Figure 106. A diversity of wetlands may be restored by filling ditches. The restored wetlands would provide for waterfowl and for Species at Risk.

Figure 107. Ditches may be restored with small open water wetlands that resemble beaver ponds.

Figure 108. Mounds resembling muskrat houses may be formed in the restored wetlands.

Figure 109. Ditches may be restored to natural streams like this one in Moberly Marsh.

Figure 110. Natural streams like the one shown may be restored by filling and reshaping ditches.

Figure 111. Ditches, borrow pit ditches, and level ditches may be restored to appear as the wetland in this photo with points, peninsulas, bays, and ridges.

Restoration of Level Ditches

Level ditches may be reshaped so they appear as natural wetlands and streams within the Park. This would involve widening and sloping sections of level ditches so they appear as beaver ponds along a natural stream. The natural streams and beaver ponds present within the Park may serve as a guide to restoring the level ditches.

Figure 112. Level ditches may be restored to natural streams like the one shown.

Figure 113. Wetlands that resemble beaver ponds may be restored from level ditches.

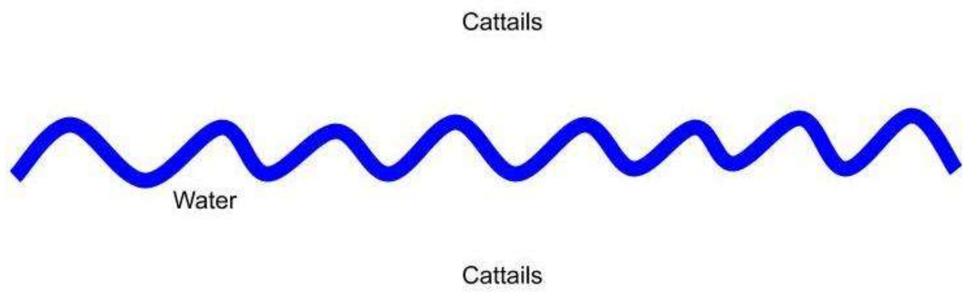


Figure 114. Existing level ditch (plan view).

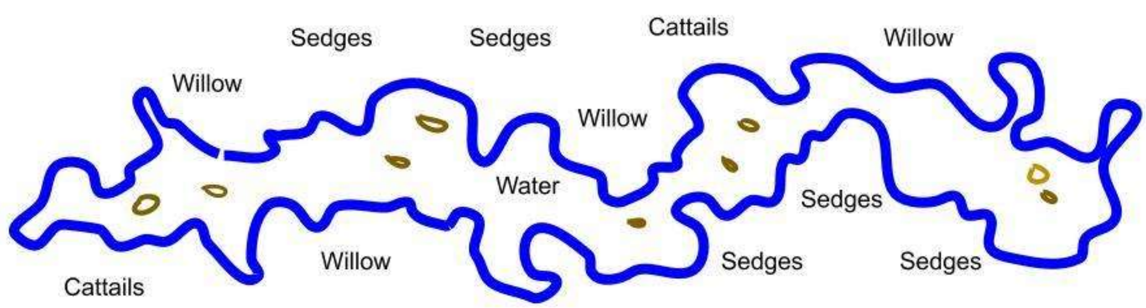


Figure 116. Restored level ditch (plan view).

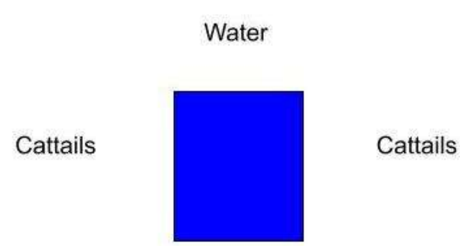


Figure 115. Existing Level Ditch (front profile view).

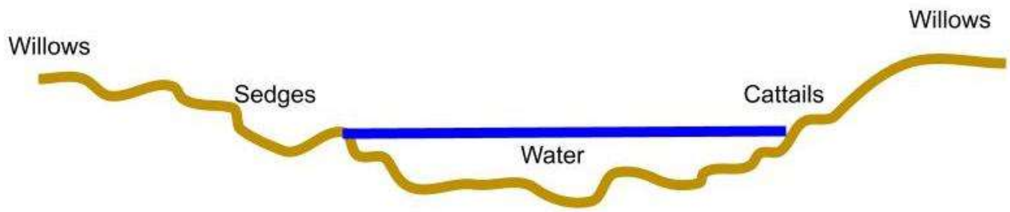


Figure 117. Restored level ditch (front profile view).

Water Control Structure Removal

Water control structures may be removed to restore water levels in the Park. The author assumes that only the water control structures associated with the 3-way control would be removed, as the 4-way control is used to prevent flooding of the 81-acre field on private land.

Construction drawings prepared by DUC may be used as a guide to locate and remove the water control structures and pipes. There are three separate water control structures associated with the 3-way control. The main structure uses a valve, the other two structures use flashboard risers.

A large excavator will be needed to remove the water control structures and pipes. A cutting torch will be needed to cut long pipes. A pump may be needed to remove water from holes being dug to ensure all pipes are found. An attempt should be made to block ditches with compacted soil to prevent water from rushing in the holes being dug.

It is critical to the success of this project that all of the pipes and water control structures are removed, and that soils high in clay, which are compacted, be used to fill trenches and holes left from the removal of the structures and pipe.

The pipe and water control structures are to be hauled off site. The site where the 3-way control is located will be modified to a naturally appearing outlet with an entrance at a higher elevation.

Figure 118. The walkway for the 3-Way Control Structure may be removed.

Figure 119. All pipes associated with the 3-Way Control Structure may be removed.

Figure 120. The ditch leading to and from the 3-Way Control Structure would be changed to a naturally appearing and functioning outlet at a much higher elevation for Moberly Marsh.

Figure 121. Leaking valves on water control structures are draining Moberly Marsh.

Figure 122. The flashboard riser and pipes for the Bergenham Compartment may be removed. Water levels would be near the top of the structure if the dike and water control structure were holding water.

Figure 123. The red arrow points to the flashboard riser and pipes for the Sime Compartment that may be removed. The water control structure has been covered by beaver.

Restoration of Moberly Creek

Moberly Creek may be restored so it enters Burges James Gadsden Provincial Park. A General and Detail Plan prepared by DUC for Moberly Marsh dated May, 1978 shows that Moberly Creek was planned to be diverted into a ditch between the TransCanada Highway 1 and the Canadian Pacific Railroad, entering Moberly Marsh through an existing culvert in the railroad grade. This part of the plan was not implemented.

The restoration of Moberly Creek was not designed for this plan. Perhaps the design and project may be completed as part of the reconstruction of the TransCanada Highway 1 from 2 to 4-lanes of traffic. The reconstruction of the TransCanada Highway 1 will likely involve filling more of Moberly Marsh. Restoration of Moberly Creek could serve as mitigation for filling wetlands.

Nesting islands

An excavator may be used to restore natural contours where each island is located. The islands may be reshaped to appear as small beaver ponds, with naturally looking mounds of soil that resemble beaver lodges and muskrat houses. The work may be done when the ground is frozen to avoid disturbing plants traveling to each island location.

Table 3. Island Sizes

Island Number	Size (m^2)
1	1,203
2	1,511
3	963
4	1,494
5	1,115
6	1,000
7	1,672
8	1,648
7	1,672
8	1,648
9	1,437
10	2,045
11	1,937
12	2,417
13	1,944
14	1,976
15	2,074
16	1,839

17	962
18	2,010
19	1,559
20	2,233
21	961
22	1,050
23	1,120
24	1,110
25	1,219
26	1,344
27	1,589
28	801
Total	45,553
Average	1,627

Figure 124. The red arrow points to one of 28 constructed islands.

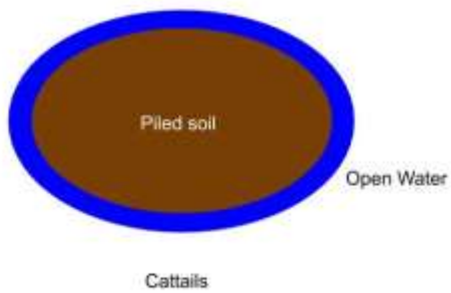


Figure 125. Constructed nesting island (typical plan view).

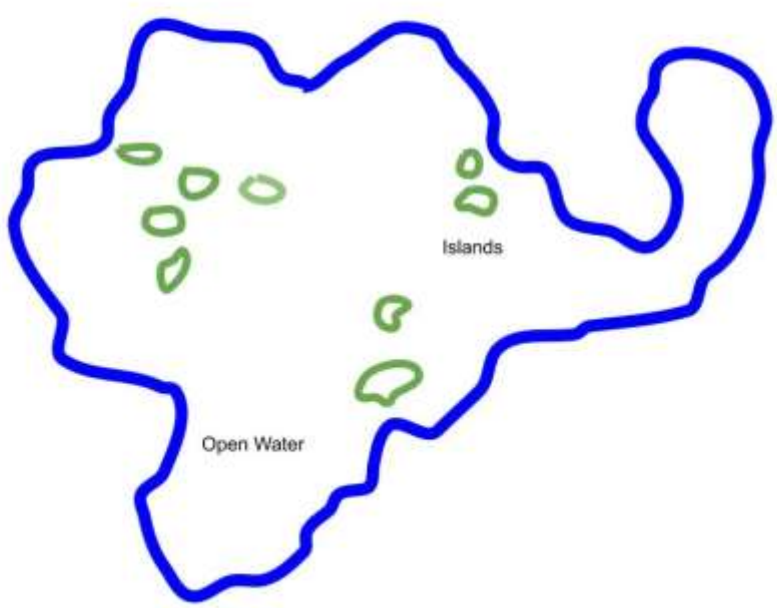


Figure 126. Restored nesting island (typical plan view).

Figure 127. Nesting islands may be reshaped to appear like this open water wetland in the Park.

Figure 128. Nesting islands may be reshaped to restore naturally appearing areas of open water like what is shown here.

Restoration of Culturally Important Plants

Plants of cultural importance may be established within and around the wetlands that may be restored. These plants include aquatic and terrestrial species. The plants may be seeded or planted following restoration. Many of these plants will grow without seeding and planting.

Here's a partial list that may be evaluated for seeding and planting for the restoration project: (McCoy & Keefer, 1999)

- Cattail
- Choke Cherry
- Oregon Grape
- Paper Birch
- Saskatoon

The following plants are of importance to the Yaqan Nukiy near Creston, BC. These may also be propagated as part of the project:

- Bulrushes
- Horsetail
- Sedges
- Wapato

Nonnative plants

Minimizing the spread of invasive species is a key concern during implementation of designed projects because of the areas of soil that are exposed may create conditions for non-native plants to become established. The following measures may be taken to control invasive species:

1. Heavy equipment operators would clean machines to prevent the introduction of non-native species to the site.
2. Heavy equipment operators would avoid using their bucket or blades while moving equipment to the site to minimize exposing soil between access routes and the restoration sites.
3. An excavator may be used to pull non-native shrubs and trees out by the roots within project areas. Non-native shrub plant material may be disposed of off-site or deeply buried to prevent re-growth.
4. The top layer of non-native grasses and associated soil/ seedbank may be scraped off and buried onsite. Although this takes extra time during the restoration project, it would greatly decrease the establishment of non-native plants.
5. Thick layers of weed-free mulch (1 bale of barley or wheat straw/10 m^2) may be used to suppress weeds and retain moisture for new plantings.

6. Dense plantings of native plants both in the restored wetland and adjoining upland areas where soil is spread may be used to control non-native plants.

Actions may be taken to prevent cattails, reed canary grass, and phragmites from dominating the restored wetlands. These techniques may be used to prevent any one plant from taking over a restored wetland:

1. Heavy equipment may be used to remove nonnative plants as part of construction.
2. Nonnative plants may be buried onsite or removed so they do not spread.
3. The bottom of wetlands would contain uneven elevations with pits, mounds, and depressions.
4. Compacted soils would be loosened within and around the restored wetlands.
5. Ridges, mounds, tufts, and scrapes would be created within the wetlands.
6. Exposed soils would be seeded to a diversity of sedges, rushes, and wheat, the same day the wetland is completed.
7. Exposed soils that are above the water level would be mulched using straw, not hay.

The restored wetlands may be monitored for nonnative plant and cattail colonization following construction. Cattails and nonnative plants that begin growing in and near the wetlands may be removed each month following construction. This action would facilitate the establishment of an attractive diversity of native aquatic plants in the new wetlands.

Mosquitoes

The wetlands to be restored can be expected to lower mosquito populations in the community where they are located. The dragonfly larvae, damselfly larvae, water boatman, water striders, frogs, toads, and salamanders living in the wetlands can be expected to control mosquitoes in as little as one year. Swallows, bats, and adult dragonflies flying near the wetlands would consume adult mosquitos. The wetlands can be expected to become population “sinks” for mosquitoes.

Figure 129. Salamander larvae can be expected to control mosquitoes in the restored wetlands.

Figure 130. Dragonfly larvae living in the restored wetlands can be expected to control mosquito larvae.

Heavy Equipment

Heavy equipment with skilled operators is recommended for completing this designed project. Each piece of heavy equipment should be operated by an experienced individual who is interested in building wetlands to help the environment.

A Service Contract is recommended for hiring the heavy equipment and operators to restore the wetlands and streams. Under a Service Contract, the machines and operators are hired by the hour to build the projects. The award of the contract is based on a combination of factors that include: ability to provide the required heavy equipment, performance operating heavy equipment, experience restoring wetlands and stream, and price. The heavy equipment should be the size and type needed for restoring wetlands. The author is available to help manage the designed projects, which can include preparing a Request for Price (RFP) Service contract package.

Engineering Design

The author designed the wetland and stream restoration actions described in this plan. The project is ready for implementation. Unfortunately, there may be individuals who ask that an engineer prepare a separate design for the same project, and that the project be implemented using a Construction Contract. This traditional practice has its problems. The greatest being that costs will be from 10 to 100 times higher for building wetlands when first paying for a separate engineering design, and then using a construction contract for implementation.

Contractors are paid by the job according to an engineering design when using a construction contract. In comparison, heavy equipment operators are paid by the hour for completing the work under a Service Contract. A skilled Contract Representative is on site full-time supervising the wetland project when using a Service Contract.

Here are some advantages and disadvantages of preparing an Engineering Design and using a Construction Contract to build wetlands:

Advantages
1. Provides detailed scale drawings of how the wetlands and streams would appear.
2. Can be used as the basis for obtaining bids for a Construction Contract.
3. Profits the people preparing the Engineering Design.

Disadvantages
1. Greatly increases the cost of designing and building wetlands and streams.
2. A land survey takes time and is expensive. The land survey generally includes an area much larger than the wetlands being restored. The land survey can miss key features important to wetland construction, such as ditches, head-cuts, buried drainage structures, clay texture soil and wetland plant inclusions.
3. Does not guarantee the success of a wetland project. Many factors critical to wetland construction are often missed in the Engineering Design because one cannot see underground (i.e. buried drainage structures, subsurface permeable layers, inclusions of permeable soils and clay soils).
4. One must pay for an Engineer to mark the Engineering Design on the ground using stakes prior to and during construction.
5. One must pay an Engineer to remark the project during construction. Grade stakes can be difficult to find in dense vegetation and are removed daily during construction of the wetlands.
7. No matter how many soil test holes are dug in advance, there would always be surprises when construction begins. It is often cheaper to build the wetlands than to dig enough test holes to avoid unknowns during construction.
8. The Engineering interpretation of soil test hole data is often based on road and building construction. Wetland construction is different, one needs to know the presence of groundwater, soil texture, subsurface permeable layers, compaction, and buried drainage structures to be successful.
9. One must hire someone who knows how to use AutoCAD to prepare the Engineering Design. Expect changes to be needed to the Engineering Design before and during construction, these changes take time and are expensive.
10. The person who prepares the Engineering Design rarely has experience with wetlands and wetland restoration techniques. The author has reviewed engineering designs prepared for restoration projects and always identifies major errors that must be corrected.

11. The process of preparing and reviewing the Engineering Design takes time and is expensive.
12. The Engineers planning the wetland project must visit the site numerous times to measure features critical to construction.
13. The persons planning the wetland project is often given a false sense of security because the planned wetland is drawn by an Engineer, when the key to building a successful wetland is to work closely with heavy equipment operators to build the wetlands.
14. Regardless of how complete the Engineering Design may appear, expect critical details to have been missed, and not addressed in the engineering design.
15. It can be difficult, time consuming, and expensive to change the Engineering Design to respond to changing site conditions while the project is underway.
16. The Engineering Design does not prevent the need for making changes while the wetland project is being built. One cannot see underground, and one cannot predict where buried drainage structures and permeable layers would be found during construction. Changes must be made to any project while a wetland is being built to be successful. Making changes to the Engineering Design and Construction Contract takes time, costs money, and causes longer delays compared to having someone onsite working with the contractors to build a wetland using a Service Contract.
17. The Final Engineering Design can be expected to contain mistakes and incorrect techniques. These mistakes may be caused by incorrect elevation readings, lack of test hole data, and the fact they were prepared by individuals who are not familiar with the site.
18. The majority of contractors have trouble understanding engineering plans and taking elevations during construction. Mistakes are often made because engineering plans are left in the vehicle.

Construction Monitoring

Regardless of whether a Construction Contract or a Service Contract is used to build the wetlands, someone who is familiar with wetland and stream construction techniques should be on the site at all times serving as a Contract Inspector/Representative to monitor the completion of designed projects. This person must have knowledge of wetland and stream construction, be dedicated, and communicate effectively with the contractor and heavy equipment operators. Another great value in having the Contract Inspector/Representative on the site is that they can meet and talk with people who would likely visit and ask questions during construction.

An onsite Contract Inspector/Representative would monitor soil texture, groundwater elevations, surface elevations, slopes, and compaction during construction. This person’s judgment would be critical in deciding if and how to modify the design based on what is found when the equipment begins working. Having the best Engineering Design and Construction

Contract in the world does not excuse the critical need of having a person who knows how to build wetlands on site monitoring the construction of the project. The rewards of having a highly experienced Contract Inspector/Representative onsite supervising the wetland project are great. Not only is a significant amount of money saved, but a much higher quality project is built.

The author has taught graduate-level courses to engineers about wetland and stream restoration techniques at three Universities for over 10-years. He is available to serve as the Contract Inspector/Representative for this project.

Buried Utilities

From a safety perspective, a check for buried utilities prior to construction should be conducted prior to implementation. All buried utilities in the area must be marked so they can be avoided. The project should not take place over buried electric, gas, phone lines, or water lines.

Climate Change

The wetlands and streams to be restored would sequester carbon by tying up large quantities of organic material in the saturated soils of restored wetlands. The author has found trees, shrubs, leaves, and grasses in the saturated soils that have been buried and preserved for thousands of years when working to restore wetlands. The organic material buried in restored wetlands may be sequestered for as many years as the wetland is present on the landscape.

The project would restore a diversity of native flowing plants that would benefit pollinators such as bees, butterflies, hummingbirds, and moths. These pollinators would help insure the survival of a diversity of plants that covert carbon dioxide into oxygen.

Large quantities of nonnative plants and roots would be buried in soils that would become saturated, sequestering their carbon indefinitely. This new soil would also capture and hold phosphorus.

The wetlands to be restored can be expected to replenish groundwater. This groundwater would provide cool water to stream and rivers under low flow conditions. The projects would naturally capture runoff and inject this water into the ground.

Project Implementation

The author is available to assist with the implementation of the designed project. It is best to contact him early to reserve dates for implementation, as he typically schedules projects months in advance.

Agency personnel and community members would be welcome to observe and participate in the restoration project, learning first-hand about restoration techniques. Students and volunteers may participate in steps where it is safe for them to be involved.

The actual restoration of a portion of the wetlands and streams may be accomplished as part of *Hands-on Wetland Restoration Workshops* instructed by the author and the BC Wildlife Federation. Tom Biebighauser would work in partnership with agencies and organizations to instruct practical training sessions where participants learn about wetlands and how to restore them by becoming actively involved in the construction and planting of wetlands. The training program has proven effective at encouraging individuals across Canada and the United States to initiate wetland restoration programs in their communities.

Inventories

The author was asked to identify if any additional inventories would be needed before implementing this project. These comments address this request:

Archeology: The restoration actions described in this plan would take place on lands greatly modified by the construction of dikes, ditches, and installation of water control structures. Vehicle access would take place by driving on top of constructed dikes. Areas of land that were well-drained and not wetland would not be disturbed by the project. There appears to be little chance that cultural resources would be disturbed by this project.

Biology: The restoration actions described in this plan are designed to improve habitat for Species at Risk. This project is unlike the construction of a parking lot or mining operation that may destroy habitat. Construction activities would take place on constructed dikes containing compacted soils, and in ditches. These areas are generally considered to be marginal habitats for wildlife and plant species. A detailed report describing wildlife species and habitat restoration for Moberly Marsh was prepared by Douglas Adama in 2017 (Adama, 2017).

Engineering: The final elevations for inlets and outlets to be restored may be determined in consultation with a Hydrotechnical Engineer familiar with the Columbia River. Actual target elevations may be marked on the ground by an experienced surveyor.

Budget

An estimated budget was prepared for this project. The project may be funded in total or part over one or a number of years.

Figure 131. Estimated Budget

Project	Length (m)	Area (m²)	Production rate per hour/per machine (m²)	Total Excavator Hours	Excavator 1 Hours	Excavator 1 Cost	Excavator 2 Hours	Excavator 2 Cost	Rock Needed (dump truck loads)	Rock Cost	Wheat 50lb bags	Wheat cost	Native Species Plant & Seed Cost	Labor cost for planting & nonnative plant control	Heavy Equipment Contract Supervision Hours	Heavy Equipment Contract Supervision Cost	Total Cost
Braul Compartment Restoration																	
Dike & borrow pit ditch removal	1683	42075	80	526	263	$59,168	263	$59,168		$0	84	$3,366	$12,623	$13,148	263	$52,331	$199,804
Ditch removal	533	10660	80	133	67	$14,991	67	$14,991		$0	21	$853	$3,198	$3,331	67	$13,258	$50,622
Inlet construction (2)				10	5	$1,125	5	$1,125		$0	0	$0	$0		5	$995	$3,245
Outlet construction (1)				20	10	$2,250	10	$2,250	33	$26,400	0	$0	$0		10	$1,990	$32,890
subtotal	2216	52735		689	345	$77,534	345	$77,534	33	$26,400	105	$4,219	$15,821	$16,480	345	$68,574	$286,560
Sime Compartment Restoration																	
Dike & borrow pit ditch removal	2824	70600	80	883	441	$99,281	441	$99,281		$0	141	$5,648	$21,180	$22,063	441	$87,809	$335,262
Ditch removal	1037	20740	80	259	130	$29,166	130	$29,166		$0	41	$1,659	$6,222	$6,481	130	$25,795	$98,489
Level ditch restoration	907	22675	70	324	162	$36,442	162	$36,442		$0	45	$1,814	$6,803	$8,098	162	$32,231	$121,830
Inlet construction (4)				20	10	$2,250	10	$2,250		$0	0	$0	$0		10	$1,990	$6,490
Outlet construction (1)				20	10	$2,250	10	$2,250	33	$26,400	0	$0	$0		10	$1,990	$32,890
Water control structure (3-Way) removal & disposal				30	15	$3,375	15	$3,375		$0	0	$0	$0		15	$2,985	$9,735
Nesting Island Removal (28)		45553	90	506	253	$56,941	253	$56,941		$0	91	$3,644	$13,666		253	$50,361	$181,554
subtotal	4768	159568		2042	1021	$229,705	1021	$229,705	33	$26,400	319	$12,765	$47,870	$36,642	1021	$203,161	$786,249
Bergenham Compartment Restoration																	
Dike & borrow pit ditch removal	3753	93825	80	1173	586	$131,941	586	$131,941		$0	188	$7,506	$28,148	$29,320	586	$116,695	$445,551
Ditch removal	866	17320	80	217	108	$24,356	108	$24,356		$0	35	$1,386	$5,196	$5,413	108	$21,542	$82,248
Level ditch restoration	3372	84300	70	1204	602	$135,482	602	$135,482		$0	169	$6,744	$25,290	$30,107	602	$119,826	$452,932
Inlet construction (8)				40	20	$4,500	20	$4,500		$0	0	$0	$0		20	$3,980	$12,980
subtotal	7991	195445		2634	1317	$296,280	1317	$296,280	0	$0	391	$15,636	$58,634	$64,840	1317	$262,043	$993,712
Survey & HydroTechnical Engineer Consultation																	$10,000
Section 11 Water Act Permit Application Process																	$5,000
Archeology Review & Monitoring																	$5,000
Biological Review & Monitoring																	$5,000
Log purchase & delivery																	$6,000
Volunteer Supervision																	$0
Contingency Fund																	$0
Administration/Overhead																	$0
subtotal																	$31,000
																Grand Total	$2,097,521

Burges James Gadsden Wetland Restoration Project Budget

The prices listed are estimates based on similar projects that have been completed in the area. It will be necessary to receive prices from local contractors to be more accurate.
This budget is not "padded" nor does it contain a contingency fund.
Estimated average finished width of restored dike & associated borrow pit ditch = 25 meters
Estimated average finished width of restored ditches = 20 meters
Estimated average finished width of restored "level" ditches = 25 meters
Estimated area of each restored nesting island = 2,000m²
Costs may be added for Volunteer Supervision, Laborers, Contingency Fund, and Administrative Overhead
Rock for outlets should contain sharp edges and be from 30 to 60cm in diameter..
Average quantity of rock/dump truck load is 9 m³ and would cost an estimated $800.00/load delivered to site.
Outlet 1 Rock Needed = (50m long) x (15m wide) x (0.4m thick) = 300m³/9m³ per dump truck = 33 dump truck loads
Outlet 2 Rock Needed = (50m long) x (15m wide) x (0.4m thick) = 300m³/9m³ per dump truck = 33 dump truck loads
The Production Rate per machine applies to finished area excavated, and is based on similar wetland projects that have been completed in British Columbia.
Total Heavy Equipment Hours Needed = Area to be excavated/production rate per machine
Excavators are equivalent to a Caterpillar 329E, 67,000lbs or greater, 215HP or greater, bucket 1.6yards³ or greater. Two excavtors with operators would be working at the same time.
The main purpose of the logs is to provide floatation for the excavator. The logs may be placed in restored wetlands to improve habitat when the project is finished.
Wheat = (Area excavated) ÷ (500m²), (Wheat is packaged in 50lb bags, 1-50lb bag/500m² wetland built.
Native plant cost = Total Wetland Area m²/10,000m² x $3,000.00 (native seed may be collected onsite in advance of construction to lower this cost)
Heavy Equipment Contract Supervision Hours = Total Excavator Hours/2
Heavy Equipment Contract Supervision Cost = (# Heavy Equipment Contract Supervison Hours) x ($199.00/hour), includes all costs, i.e. salary, airfare, lodging, car rental, meals, & survey equipment.
The costs listed for native species of plants and seed purchase (grasses, sedges, aquatics, trees, shrubs) may be adjusted.

Summary

The area of open water wetlands within Burgess James Gadsden Provincial Park has been reduced by approximately 93-percent since 1965. Over 8.2km of constructed dikes and 14.7km of dug ditches dug within the Park portion of Moberly Marsh have significantly reduced the area of shallow water wetlands, natural streams, and corresponding biodiversity. The natural complex of wetlands lost their main sources of water after being separated from the Columbia River and from Moberly Creek. Ditches, borrow pits, and leaking water control structures now allow water rapidly flow underground from wetlands into the Columbia River. Dense cattails dominate where historically a mosaic of attractive wetlands teaming with waterfowl, shorebirds, wading birds, muskrat, and beaver were present.

Fortunately, highly effective techniques may be used to restore water levels, groundwater elevations, and seasonal flooding to the Park. A natural mosaic of wetlands and streams may be restored that provide critical habitat for Species at Risk, waterfowl, wading birds, and shorebirds. Wetlands and streams may be restored without the use of dikes, dams, pipes, or pumps that require maintenance. The restored wetlands would be beautiful to look at, support an abundance of wildlife, and provide tremendous viewing to thousands driving the TransCanada Highway each day.

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About the Author:

Tom Biebighauser is a Wildlife Biologist and Wetland Ecologist who has restored over 2,250 wetlands and streams and designed over 6,000 wetland and stream restoration projects across Canada, in 26-States, New Zealand, Puerto Rico, and Taiwan since 1979. He retired in 2013 after working 34-years for the USDA Forest Service as a Wildlife Biologist, where he initiated wetland and stream restoration programs on National Forests across the United States. Tom has served as an instructor for the British Columbia Wildlife Federation Wetlands Institute for 16-years, and has restored over 200-wetlands across British Columbia since 2003. Having designed, built, and repaired over 1,400-dams, he has since decommissioned over 300 -dams. Biebighauser has extensive experience controlling and preventing head-cuts that destroy wetlands and streams. He has studied drainage and irrigation for 36-years, learning from contractors who spent their lives destroying wetlands. Tom has developed highly effective and low-cost techniques for building wetlands and stream for rare species across North America. The wetlands he restores require little, if any maintenance, and do not involve the use of diversions, dams, dikes, pipes, or pumps. He teaches practical, hands-on workshops where participants learn how to restore wetlands by becoming involved in the design and construction of naturally appearing and functioning wetlands. Tom has written 4-books about wetland restoration, and instructs online college and field courses on the topic. He received the United States National Wetlands Award for Conservation and Restoration in 2015.

References

Dodds, W. K. (2008). Comparing Ecosystem Goods and Services Provided by Restored and Native Lands. *Bioscience*, 837-845.

Gardner, R. C. (2018). Global Wetland Outlook: State of the world's wetlands and their services to people. *Ramsar Convention Secretariat*.

Government, B. (2018, December 8). *Wetlands in BC*. Retrieved from https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-planning-strategies/wetlands-in-bc

Kadlec, R. H. (2016, June 7). Wetland Management Services. *Water*, 36.

Kostel Jill, P. (2015). *How Exactly Do Wetlands Remove Nutrients?* Retrieved February 15, 2019, from http://www.wetlands-initiative.org/nutrient-removal/

Linnaea. (2019, February 23). *Linnaea*. Retrieved from http://linnaeafarm.org/about/

Miller, B. K. (1990). *Department of Forestry and Natural Resources*. Retrieved February 15, 2019, from http://www.extension.purdue.edu/extmedia/WQ/WQ-10.html

Appendix

Notes from Moberly Marsh Meeting: May 6, 2019 at the Golden Rod and Gun Club. Prepared by Alana Higginson.

Attendees of the Meeting:

1. Alana Higginson (BCWF)
2. Tom Biebighauser (Wildlife Biologist and Wetland Ecologist, Contractor with BCWF)
3. Mark Thomas (Councilor on the Shuswap Indian Band)
4. Catherine Parent (GRGC/Botanist/volunteer with Wildsight Golden)
5. Brian Gustafson (GRGC/Contractor with Wildsight Regional)
6. Chad Parent (VP of GRGC/Board member of East Kootenay Wildlife Association)
7. Russel Wagner (GRGC)
8. Chris McLean (BC Parks Sr. Park Ranger -18 protected areas)
9. Rachel Darvill (Wildsight/Biologist/Golden Eye Ecological/Columbia Wetland Stewardship Partnership)
10. Bryan Kelly-MacArthur (Naturalist and Plant Surveyor)
11. Brian Amies (adjacent landowner- Spike Elk Farm)
12. Sigi Liebmann (adjacent landowner- Spike Elk Farm)
13. Keri Sculland (from the local newspaper The Golden Star)

Mark Thomas of the Shuswap Indian Band began the meeting with an opening statement of welcoming to the group. As well, he shared a story about Coyote and how salmon spread through the rivers and why there are no salmon in the Kootenay areas. Mark has a fisheries background and has been working to restore salmon to the area for the last 20 years and has the 8th annual Salmon Festival in September. He is currently developing the Shuswap Creek into a poster child for future creeks to develop it into a fish bearing stream that has been restored. He advocates for the restoration of Moberly Marsh as long as it does not further damage the ecosystem.

Following this, Chris McLean gave a description of the park. It was donated to the province in the 1960's with the purpose to preserve a small portion of the Columbia Wetlands and to provide recreational opportunities that are non-obtrusive. There are access challenges to the park as it can only be accessed through private property (Spike Elk Farm-Brian and Sigi's land), the Columbia River or CP Rail Private land. There are two long term surveys being conducted within the park boundaries, both are ecological monitoring projects with one focused on amphibians and one for waterfowl. In the 1970's, Ducks Unlimited Canada (DUC) put in dikes (dams) to increase waterfowl numbers in the area, but they now want to remove their structures as the goal of increasing waterfowl is not currently being met.

Then, top priorities for restoration were discussed along with any concerns and questions about the plan and area.

Tom explained how the dikes are providing no benefits to the wetlands, and Rachel, among others, argues that they provide enormous areas of habitat for other birds, such as songbirds, or perches for raptors. As well, the dikes provide recreational opportunities (although, not accessible by the public). BC Parks has stated that they have no plan for public access to the area.

The concerns brought up included:

- Incorporating all players wants/needs into this plan
- How we can reconnect the area with the river without inundating the whole area or creating erosion along the breeches that will destroy the wetland over time
- Zero maintenance
- Keeping islands or areas of refuge habitat that will still act as nesting areas for the songbirds that now inhabit the area
- Bryan Kelly-McArthur is worried about the rare plant species in the Braul compartment as these are species that are not found anywhere else in the Columbia Wetlands System
- Rachel Darvill is concerned with losing habitat for songbirds, woodpeckers, and other predators that use the dams as habitat as we created these habitats (DU did) and now these birds that do not exist anywhere else in the Columbia Wetlands System reside in this marsh.
- Mark Thomas points out the First Nations always wants to restore areas to their natural state, but this needs to be done on a case by case basis. They want no risk of further damage to the area due to removals and he suggests a partial removal of the dams.
- Chad and the Golden Rod and Gun Club believe that we have the same original goals as DUC to restore this area, but we are trying to now do it “the proper way”. He is in favour of getting machines into the area for restoration if necessary.
- Constant monitoring is needed for plant and animal response in the area as restoration is phased into the area to learn from the work being done and see how it can be changed or improved as it continues on.

In the end, the consensus for the main goals in the Moberly Marsh area are:

- Maintaining dike systems for species habitat
    - Including watching the species at risk and enhancing their habitat
    - We saw Western Toads in ephemeral ponds (that are currently dry) in the West Braul container as well as many potential nesting sites for Night Hawk.
- No maintenance needed on the enhanced wetland
- Reconnecting to the Columbia River
    - The previous two are connected and can be done together.
- Potential desire to create public access to the area by dikes.

To achieve these goals, we need to consider what kind of habitat we are trying to create in the area (i.e. For what species because they will all have different needs), as well as whether we want natural ecological restoration or to create/keep recreational opportunities, as these are very different things.