Six Mile Slough
Wetland Restoration Project

White Sturgeon

Waterfowl taking flight

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November 23, 2017

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Introduction

The Six Mile Slough Wetland Restoration Project would restore over 1,260-hectares of wetlands for fish and wildlife on the Creston Valley Wildlife Management Area. This landscape-scale ecosystem restoration project would increase habitat for tens of thousands of migrating waterfowl, and provide critical habitat for the rare white sturgeon, burbot, northern leopard frog, Forster's tern, and American bittern.

The Creston Valley Wildlife Management Area was designated by the Ramsar Convention as a wetland of International importance. Totaling 69 square kilometers of Crown Land, the Creston Valley Wildlife Management Area is a globally significant bird area.

Location of Six Mile Slough within the Creston Valley Wildlife Management Area.

This report contains an initial assessment as well as a conceptual design and cost estimates for a proposed restoration of Six Mile Slough.

Drainage History

It is difficult to believe that humans could modify a wetland as large as Six Mile Slough. However, this unique habitat has been significantly changed since the late 1880's, originally for agricultural and then wildlife management purposes. The construction of flood control dikes, dams, installation of water control structures, and channeling of streams have greatly reduced its value to waterfowl, and other wildlife and fish species. The Creston Valley used to be called the *Valley of the Swans*, where thousands could be seen at one time during spring migration.[1] Now, numbers have declined and one would be lucky to see more than 500 at one time. The following is a brief summary of how Six Mile Slough has been modified.

Enlarging the outflow of Kootenay Lake:

A shallow, narrow reach of the Kootenay River called the Grohman Narrows constricts the outflow of Kootenay Lake year-round. In his efforts to drain the Creston Flats for agricultural land, William Adolph Baillie-Grohman initiated efforts to enlarge the outflow of Kootenay Lake, using explosives to blast rock at Grohman narrows in 1884 and 1889[2]. BC Hydro estimates 18,000 cubic yards of blasted rock, boulder and gravel were removed from the river bed at Grohman Narrows in the 1890s[3]. Additional work to increase the flow through Grohman Narrows was carried out by the West Kootenay Power and Light Company in 1931 and 1939[2], including blasting and dredging to remove a total additional estimated 820,000 cubic metres of rock, boulders and gravel from the Narrows[3].

BC Hydro is currently studying the possibility of further deepening the channel of the Kootenay River at Grohman Narrows by dredging it[3]. They will decide in early 2016 whether to proceed with the project, and at what level. They are considering both a "low excavation scenario" ($21M) and a "middle excavation scenario" ($68M). BC Hydro states that the work will affect the level of Kootenay Lake only at high water, from April to July[4].

The purpose of the modifications to the outflow were to lower peak lake levels during the flood months of April through July. The largest impacts of Grohman Narrows appear to be from March to June.[5] It appears that at certain flood levels, Six Mile Slough was connected to Kootenay Lake. Beginning as early as 1889, the changes made to the outlet of Kootenay Lake likely reduced connectivity between Six Mile Slough and Kootenay Lake, as well as water depth and length of seasonal inundation in Six Mile Slough. Historic data for lake flood levels is likely available from before and after the modifications to the outflow made in the 1930s. Understanding how these modifications to the outlet changed water levels in Six Mile Slough would be helpful in determining the optimal range of water fluctuations in Six Mile Slough for restoration.

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[1] Conversation with Marc-Andre Beaucher, Creston Valley Wildlife Management Area.
[2] Creston, B.C. : History. D.M. Wilson. http://www.crowsnest-highway.ca/cgi-bin/citypage.pl?city=CRESTON, accessed November 19th, 2015.
[3] BC Hydro. Grohman Narrows Improvement Project Presentation. Sept. 12th, 2013. http://kootenaylakepartnership.com/2015/10/15/grohman-narrows-update/#more-4334. Accessed Dec 13, 2015.
[4] The Nelson Daily. Nov. 9th, 2015. http://thenelsondaily.com/news/scope-narrows-grohman-narrows-project-wake-open-house-39754#.Vm5WVr_qrCs. Accessed Dec.13th, 2015.
[5] Email from Marc-Andre Beaucher.

Crowsnest Railroad**:** The Crowsnest Railway crosses the northern end of Six Mile Slough to reach its terminus at Kootenay Landing. Diane Wilson describes the completion of this portion of the railway by the Canadian Pacific Railway on October 5th, 1898 in her book, Triumph and Tragedy in the Crowsnest Pass[6]: *With the end in sight, track-laying pushed ahead with amazing speed and was completed to Kootenay Landing at the south end of Kootenay Lake that same day. Here, 4 1/4 miles of trestles, as well as a steel bridge, were required to cross the broad, marshy delta of the Kootenay River where it merges with the lake.*[7]

The "broad, marshy delta of the Kootenay River where it merges with the lake" is Six Mile Slough. The soil and rock fill used to build the railway across the marsh separated Six Mile Slough from Kootenay Lake. No culverts are visible in the soil and rock fill used to support the railroad across Six Mile Slough. Historically, Six Mile Slough would have served as a massive rearing area for fish such as the white sturgeon. Fish can no longer pass between Six Mile Slough and Kootenay Lake because of lowered lake levels, and the embankment of the Crowsnest Railroad.

[6] Triumph and Tragedy in the Crowsnest Pass, Second Edition. 2010. Wilson, Diana., Heritage House Publishing. Victoria, BC. https://www.google.com/search?tbm=bks&q=Triumph+and+Tragedy+on+the+Crowsnest+Pass. Accessed Dec 6th, 2015.

[7]Triumph and Tragedy in the Crowsnest Pass, Second Edition. 2010. Wilson, Diana., Heritage House Publishing. Victoria, BC. https://www.google.com/search?tbm=bks&q=Triumph+and+Tragedy+on+the+Crowsnest+Pass. Accessed Dec 6th, 2015.

Location of the Crowsnest Railroad and the West Duck Lake Flood Control Dike.

Six Mile Lake

Six Mile Slough was once named Six Mile Lake. Historic hydrometric data station 08NH060 named "Kootenay River at Six Mile Lake" was located at 49°15'10" N, 116°40'41" W[8].

The area known as Six Mile Slough is named Six Mile Lake on a 1942 map showing existing and proposed reclamation areas[9].

[8] https://wateroffice.ec.gc.ca/search/searchResult_e.html. Accessed Dec 6rh, 2015.

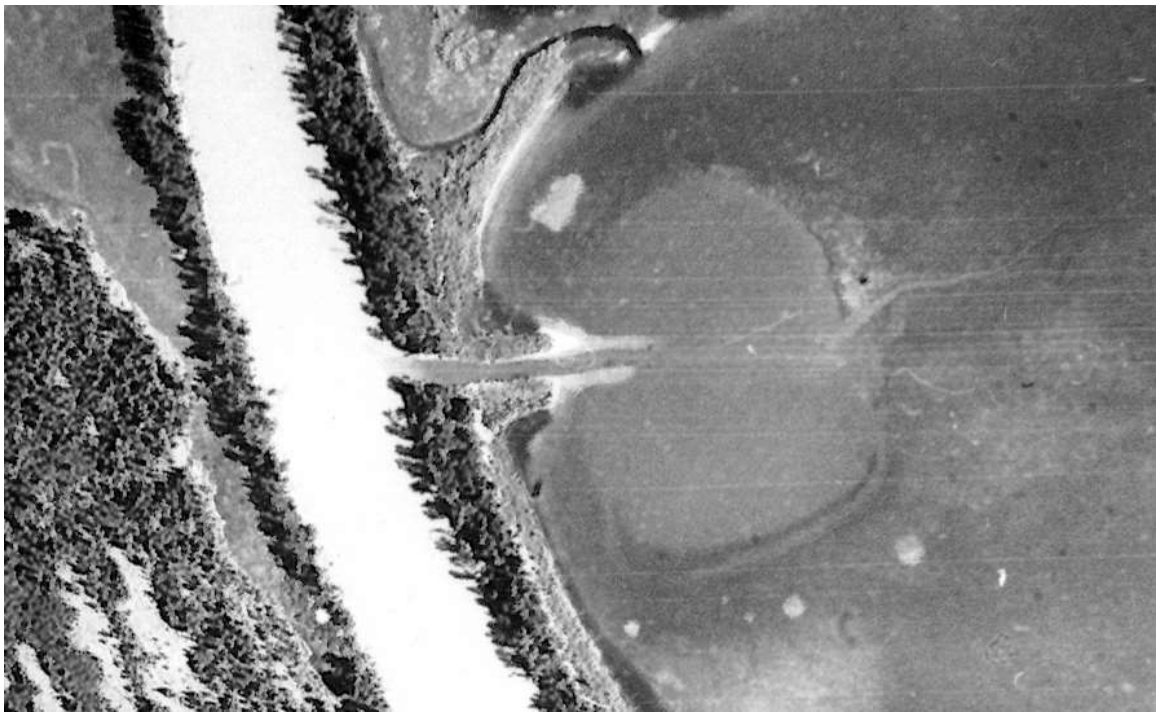
[9] Dance, Anne. 2015. Dykes, Ducks and Dams: Environmental Change and the Politics of Reclamation at Creson Flats, 1884-2014. BC Studies no184. Winter 2014-15. Pages 11-44.

This map from 1942 labels Six Mile Slough as "Six Mile L."

Ranch Operations**:** Prior to the creation of the Creston Valley Wildlife Management Area, Six Mile Slough was used to raise cattle[10]. This photograph from the Creston Archives shows the Creston Valley in 1929, looking south from the south end of Kootenay Lake.

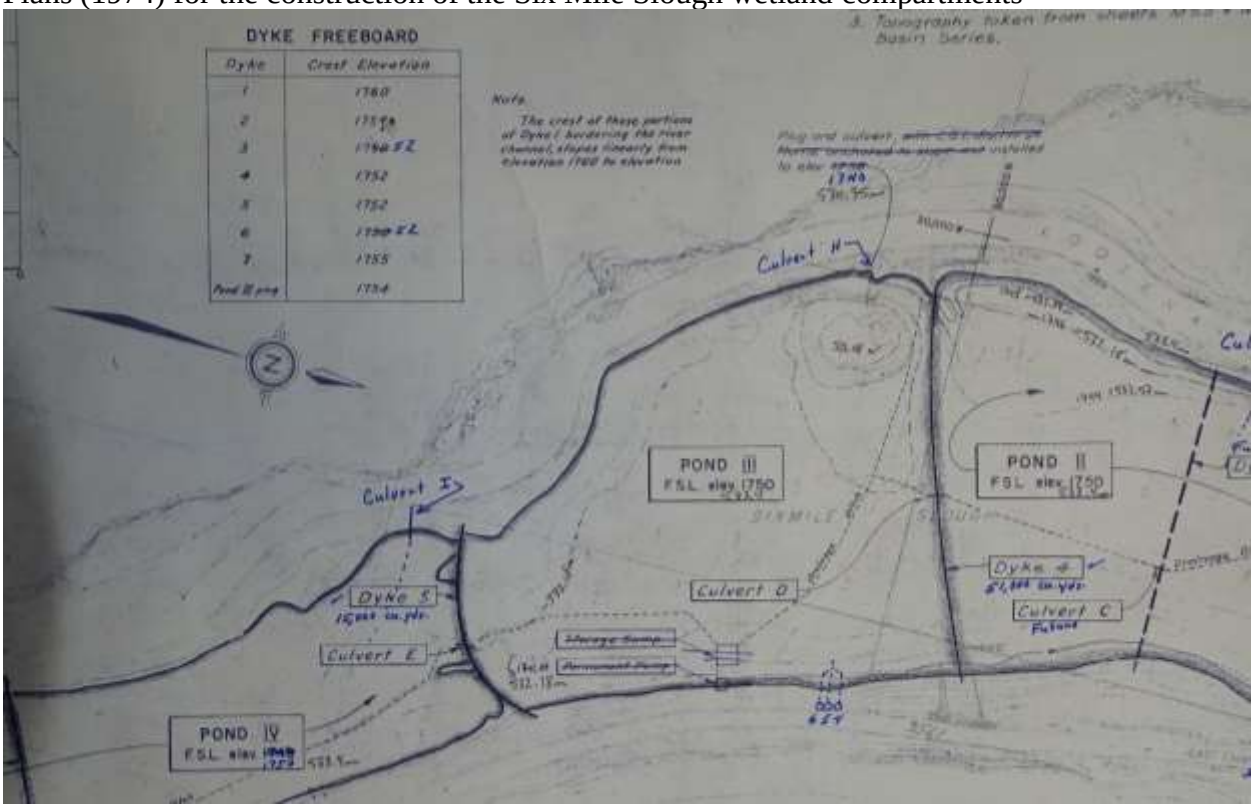
[10] Creston and District Historical and Museum Society, *Taming the Kootenay* (Creston, BC: Virtual Museum of Canada, 2004), http://www.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127379&sy=&st=six+mile+slough&ci= Accessed Dec. 6th, 2015.

Cyril Colonel, of Creston, BC, describes the photograph in a text attachment to the photograph: “There's the west channel of the Kootenay River on the right, at the base of the mountains, and the east channel of the Kootenay near the centre. In between is Six Mile Slough, or Lewis Island. That was part of a lease for farmers, until it was put into the Wildlife Area. At one time, there were as many of 250 cows and calves grazing there, and a house and slaughterhouse owned by Ike Lewis. It was torn down and burned when it became part of the Wildlife Area.”[9].



This 1958 aerial photograph shows a deep pool in what is now the northwest corner of wetland compartment #3. This deep pool predates construction of the wetland compartments, and may have been dug by the cattle farmer to provide a year-round water source for cattle and slaughterhouse operations. The channel appears to have been dug to allow water to flow into the deep pool from the Kootenay River.

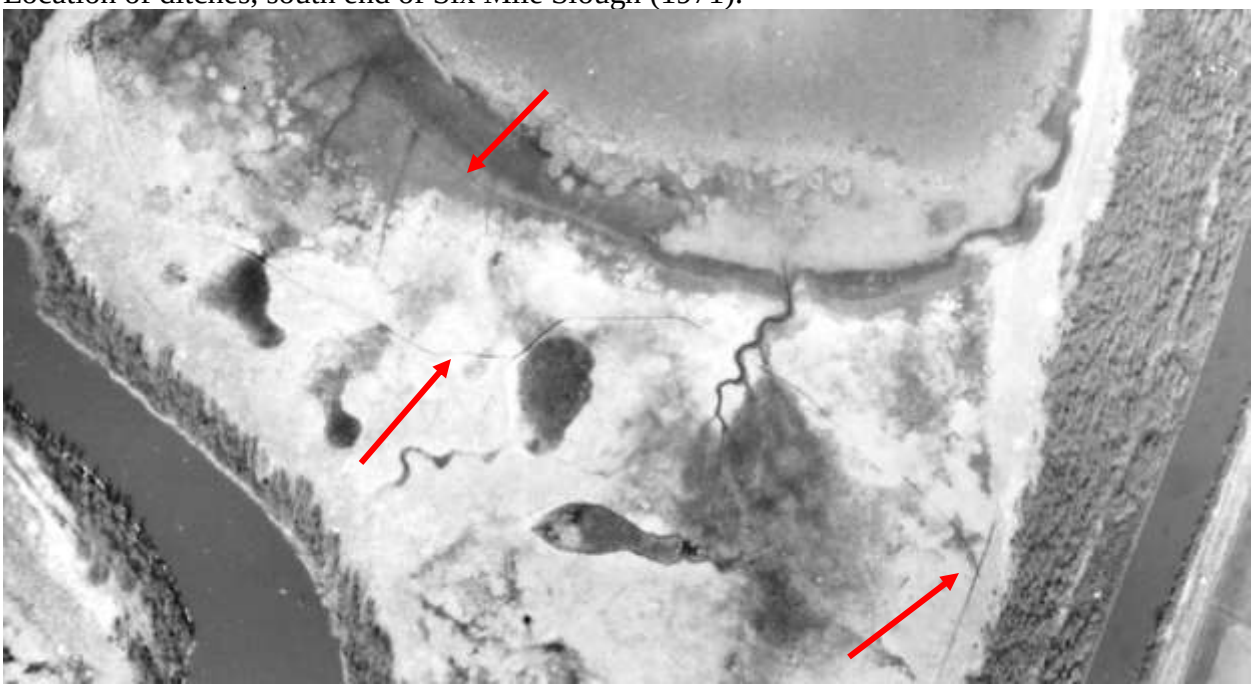
Plans (1974) for the construction of the Six Mile Slough wetland compartments



The above section from the 1974 plans for the construction of the Six Mile Slough wetland compartments shows the deep pool is at least 5m deep. It also shows a number of drainage ditches which may have been dug to accelerate drying of the pastures after the spring flooding. The channel leading from the deep pool to the Kootenay River may have provided an outlet for drainage ditches, as spring flood-waters receded. The plan shows where additional ditches were planned to direct water towards the water control structures that were installed in the dams.

The location of other ditches are visible on this 1971 aerial photograph showing the south end of Six Mile Slough. The examination of Lidar Images and a ground survey would be necessary to confirm that these lines are all ditches. Cattle trails can be also be seen.

Location of ditches, south end of Six Mile Slough (1971).



West Duck Lake Dike**:** This long and high dike borders the east edge of Six Mile Slough. Large amounts of soil were removed from the East Channel of the Kootenay River to form the dike. The dike was built to drain the Duck Lake Dyking District for farming. Prior to construction of the dike, the area flooded annually.

This photograph from the Creston and District Historical Museum Society shows a duck-hunting lodge built prior to 1944 by an American duck hunting club[11]. The lodge is west of Duck Lake, above the East Channel of the Kootenay River. The floor of the building sits 6 feet above the ground, to keep the building above the annual flood waters[10].

The East Channel of the Kootenay River was most likely straightened and deepened when the dike was built, in 1950. These photographs from the Creston and District Historical Museum Society show a dragline, dozer and scraper being used to build the Duck Lake dike in 1950[12].

[11] Creston and District Historical and Museum Society, *Taming the Kootenay* (Creston, BC: Virtual Museum of Canada, 2004). http://www.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127417&sy=&st=hunting&ci=. Accessed Dec. 6th, 2015.

[12] Creston and District Historical Museum Society, *Taming the Kootenay* (Creston, BC: Virtual Museum of Canada, 2004). http://www.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127460&sy=&st=dragline&ci=. And http://www.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127458&sy=&st=scraper&ci=
Accessed Dec. 6th, 2015.

Duck Lake, Six Mile Slough, and the East and main channels of the Kootenay River could be connected during spring floods before the West Duck Lake Dike was built, as shown on the image below (right)[13]. The image on the lower left shows the flood-waters of 1915[14]. The clipping on the right is from the Vancouver Sun in June 1948, showing the Creston Flats under flood waters.


River Keeps Shape but Not Its Course at Creston

Libby Dam**:** The Libby dam was built across the Kootenai River in the U.S. state of Montana. The dam was dedicated in 1975. The Libby dam allowed the flow to the Kootenay River to be controlled, and ended annual flooding of the Creston Flats. Since the completion of the Libby Dam, flood waters from the Kootenay River enter Six Mile Slough less frequently.

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[13]Creston and District Historical Museum Society, *Taming the Kootenay* (Creston, BC: Virtual Museum of Canada, 2004). http://www.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127403&sy=&st=1948&ci=. Accessed Dec. 6th, 2015.

[14] Creston and District Historical Museum Society, *Taming the Kootenay* (Creston, BC: Virtual Museum of Canada, 2004).ww.virtualmuseum.ca/sgc-cms/histoires_de_chez_nous-community_memories/pm_v2.php?id=search_record_detail&fl=0&lg=English&ex=00000322&rd=127274&sy=&st=1915&ci=. Accessed Dec. 6th, 2015.

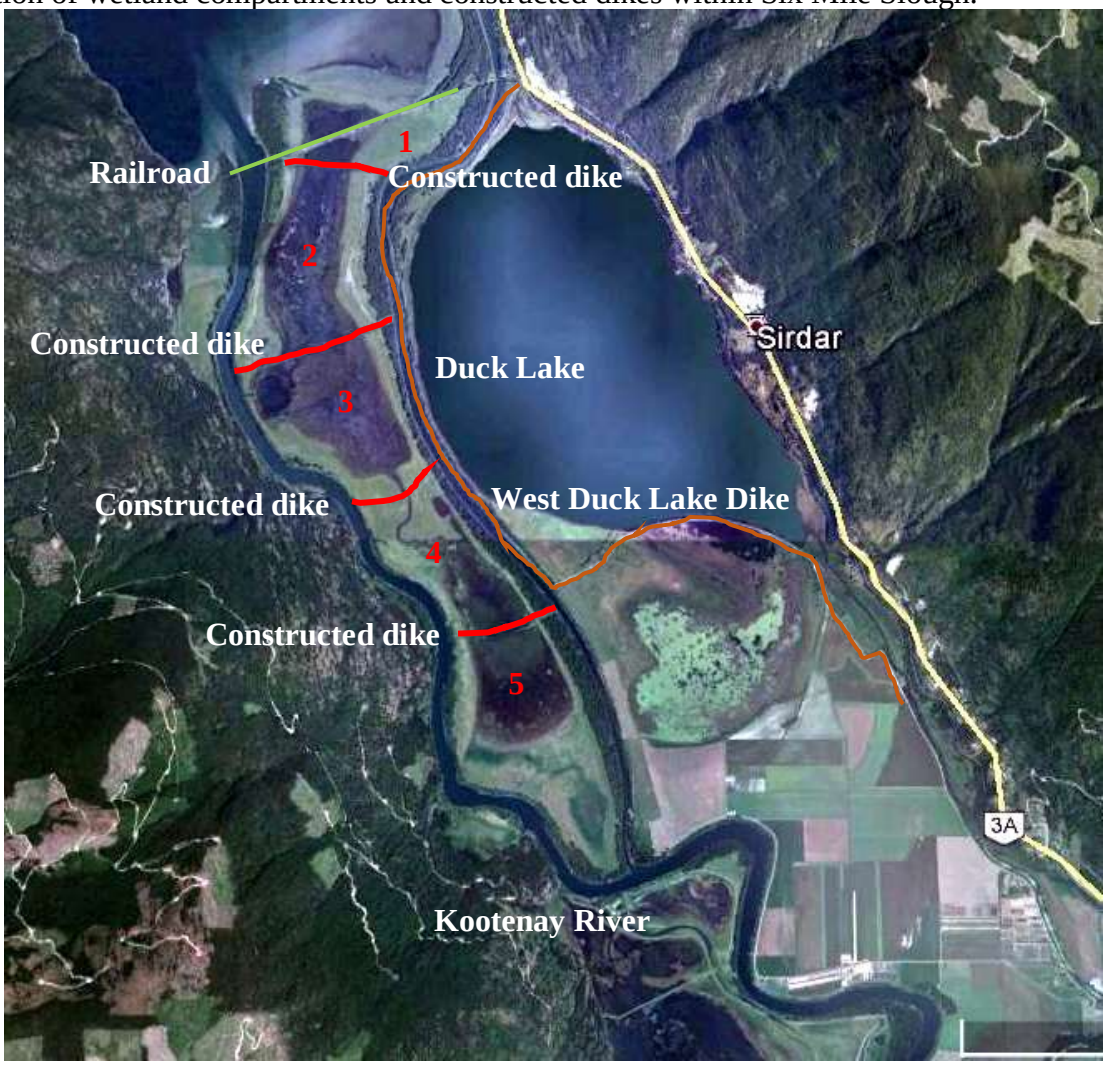
Wetland Compartments**:** Four dikes totaling 5,591 meters (3.47 miles) were built across Six Mile Slough in 1974 and 1975 to separate Six Mile Slough into 5- wetland compartments. These dikes may have been initiated by people who wanted to farm Six Mile Slough. The construction of the dikes was completed at great expense for waterfowl management. Water control structures were installed so that water levels could be managed independently in each wetland compartment. An electric line and large pumping station were built for adding and removing water from Six Mile Slough.

In her article "Dykes, Ducks and Dams: Environmental Change and the Politics of Reclamation in the Creston Flats, 1882-2014"[8], Anne Dance quotes Yorke Edwards, author of Wildness on Creston Flats: "Each unit may be flooded or drained at will. The more the units, the better the control."

The history page of the Creston Valley Wildlife Management Area[14] describes why the wetland compartments were built: "Now that the area was protected, efforts focused on turning the flood plain into productive wildlife and waterfowl habitat. With the support of Ducks Unlimited, BC Hydro, local and regional wildlife groups and federal and provincial government grants, the dikes that were intended to drain the marshes were expanded and modified to control the wide seasonal variation in water levels and create much needed waterfowl nesting and rearing habitat."[15].

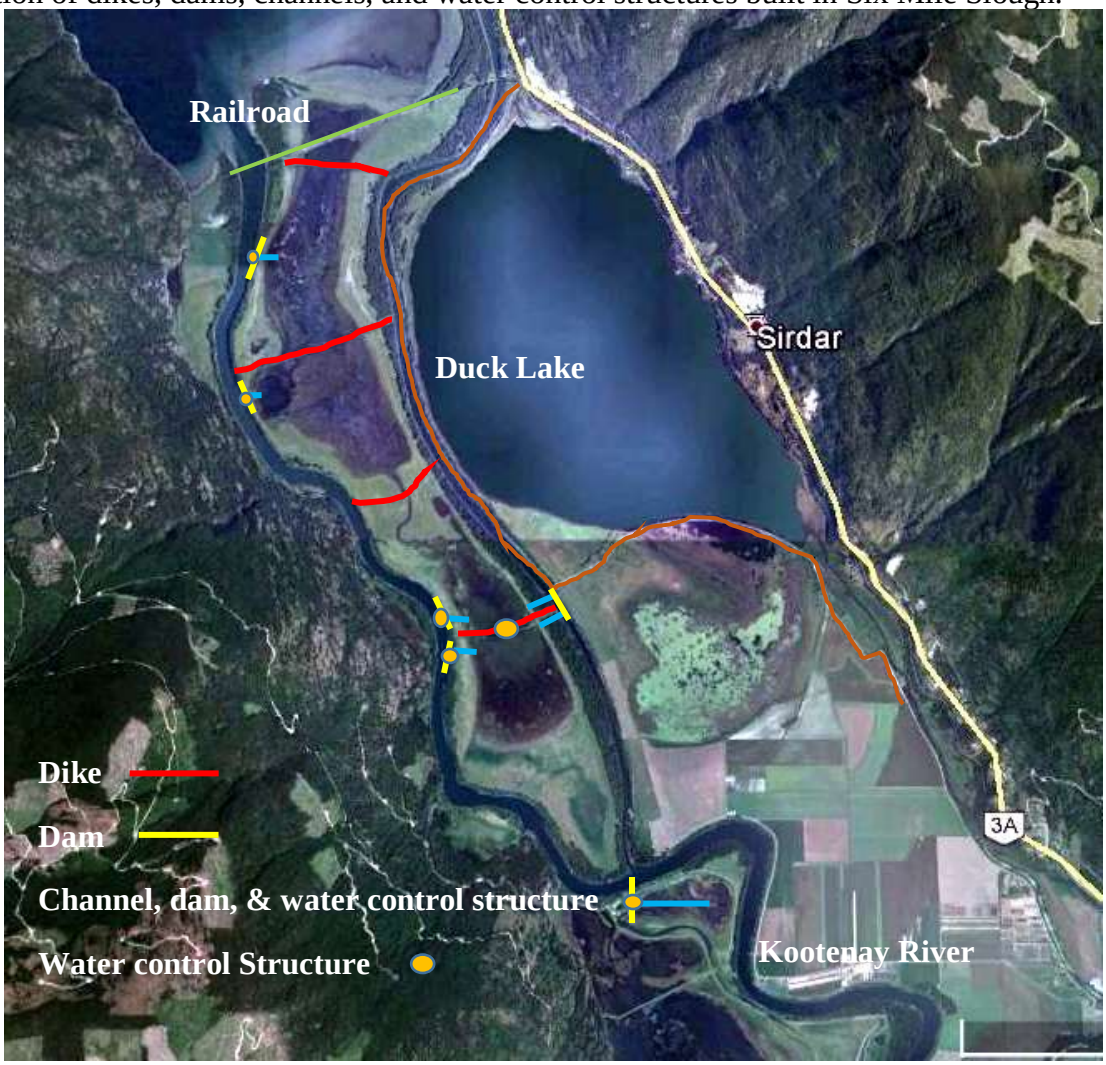
[15] https://www.crestonwildlife.ca/about/history

Location of wetland compartments and constructed dikes within Six Mile Slough.



The low places where water once naturally flowed from the Kootenay River, the East Channel of the Kootenay River, and Six Mile Slough were blocked by dams when the five wetland compartments were built. Deep and long channels were dug to connect four of the wetland compartments with the Kootenay and East Channel of the Kootenay River. Water control structures were placed at the end of these channels, where dams had been built along the rivers. When closed, the water control structures prevented the flow of water between Six Mile Slough and the Kootenay River. When open, water drained from Six Mile Slough into the channels, and then to the rivers.

Location of dikes, dams, channels, and water control structures built in Six Mile Slough.



Four dikes totaling 5,591 meters (3.47 miles) were built across Six Mile Slough to separate the waters into 5-wetland compartments.

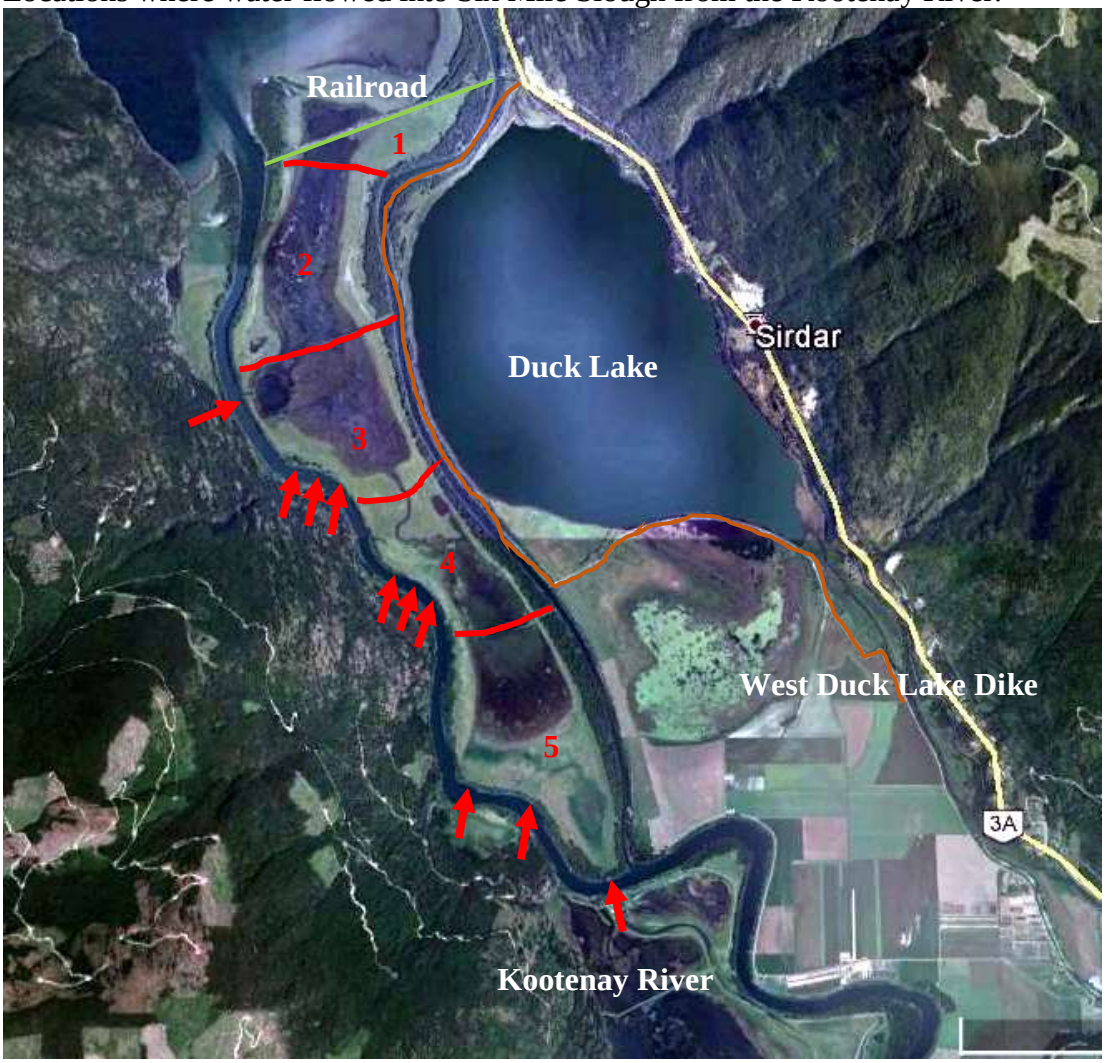
Water control structures were installed in the dikes and dams, dividing Six Mile Slough into five wetland compartments. This water control structure was damaged by ice.

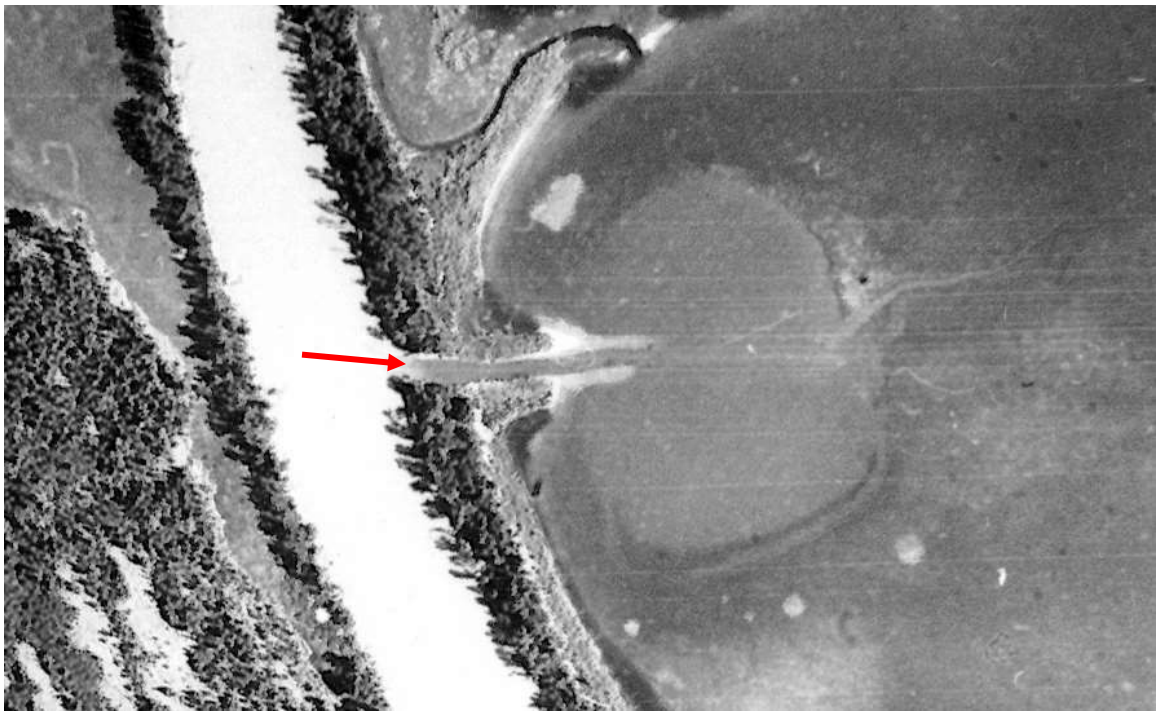
River Bank Low Places**:** A review of historic aerial photographs shows that the Kootenay River once flowed into Six Mile Slough in a number of locations. Aerial photographs taken before the mid 1970's show water from the Kootenay River flowing into Six Mile Slough on a regular basis. The Kootenay River now only rarely flows into Six Mile Slough.

The completion of the Libby Dam and the construction of the wetland compartments occurred roughly at the same time. Therefore, it is not known which action had the greatest effect on water

levels in Six Mile Slough. The historic elevation of the river banks where water once flowed into Six Mile Slough, before the wetland compartment dams were built, is not known.

Locations where water flowed into Six Mile Slough from the Kootenay River.

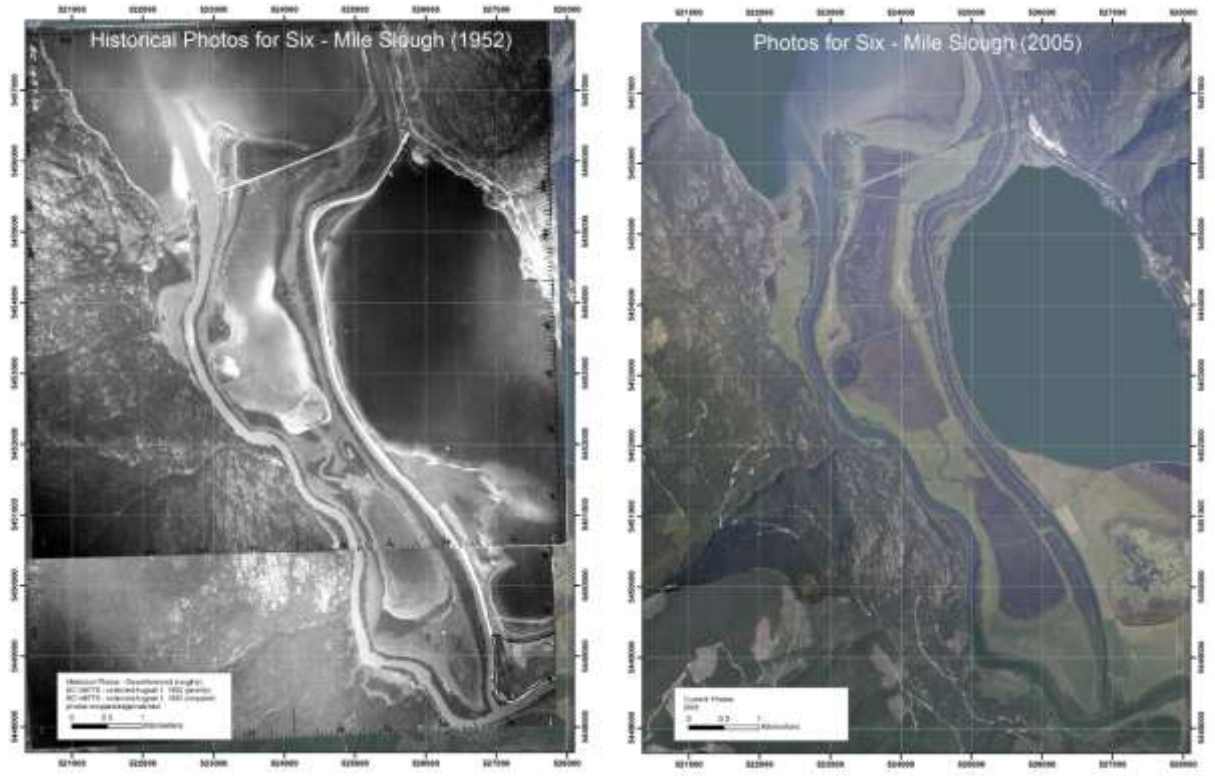




This 1958 aerial photograph clearly shows water flowing into Six Mile Slough from the Kootenay River. A channel had been dug between the deep-water pond, now in wetland compartment 3, and the Kootenay River. The deep pond may have been dug to provide water for livestock, and to act as a sump for draining Six Mile Slough.

This 2015 aerial photograph shows a dam built in the 1970's, across the channel connecting wetland compartment 3 with the Kootenay River.

Aerial photographs showing Six Mile Slough in 1952, and in 2005.



The above aerial photographs show Six Mile Slough before and after the wetland compartments were built. The photographs show that the surface area of water in Six Mile Slough was greater before the wetland compartments were built.

Summary of Impacts to Six Mile Slough

These conclusions can now be made concerning the 5-wetland compartments built in Six Mile Slough:

1. It became very difficult to optimize water levels for wildlife use without functioning water control structures, dikes, and dams. Water levels became too deep for proving nesting and staging habitat for waterfowl. Dense cattail and reed canary grass growth became a problem because water could not be added in time of drought. The even bottoms and compacted soils where shallow water occurred favored cattail and reed canary grass growth. The operation and maintenance of Six Mile Slough became expensive and unpractical due to its remoteness and absence of land access.
2. Habitat for nesting and migratory waterfowl was not improved. Deep water in the wetland compartments failed to support the diversity of aquatic plants and invertebrate's waterfowl require for food, protection, and nesting habitat. Pumping water was problematic due to the lack of road access, and it was not possible to drain the wetland compartments by using the water control structures alone.
3. It became very difficult to independently control water levels in each compartment by using pumps.
4. The dikes built across Six Mile Slough did not increase the size of the wetland. The dikes actually reduced wetland area by filling in over 6.7-hectares (12m average width of dam x 5,591m of dam constructed) of Six Mile Slough.
5. The construction of dams along the rivers contributed to the loss of shallow, open water and plant diversity in Six Mile Slough because they blocked the flow of spring flood-waters, preventing the regular scouring of vegetation.
6. The water in Six Mile Slough is now deeper for much longer time periods because the water control structures along the river have failed in the closed position.
7. The dams significantly reduced the flow of water from the Kootenay River into Six Mile Slough, reducing seasonal water fluctuations that were critical to migratory waterfowl.
8. The dams prevented large woody debris from entering Six Mile Slough, greatly reducing habitat for waterfowl, fish, and turtles.
9. The dams, dikes, and water control structures became barriers to fish and aquatic organism movement.
10. The dams, dikes, and water control structures prevented the white sturgeon and burbot from accessing over 1,260 hectares of wetland habitat.
11. It became too expensive and difficult to maintain the wetland compartments, especially since the area does not have road access, and one must use a boat to reach the site. The dikes and dams have not been maintained for over 15-years. Muskrats and beaver have tunneled into the dams and dikes. Maintenance of the water control structures ended before 2005. The water control structures are no longer functional due to rust and ice damage. The cost of replacing a single water control structure is estimated to be $200,000. The electric line for the pumping station was removed in 2015.

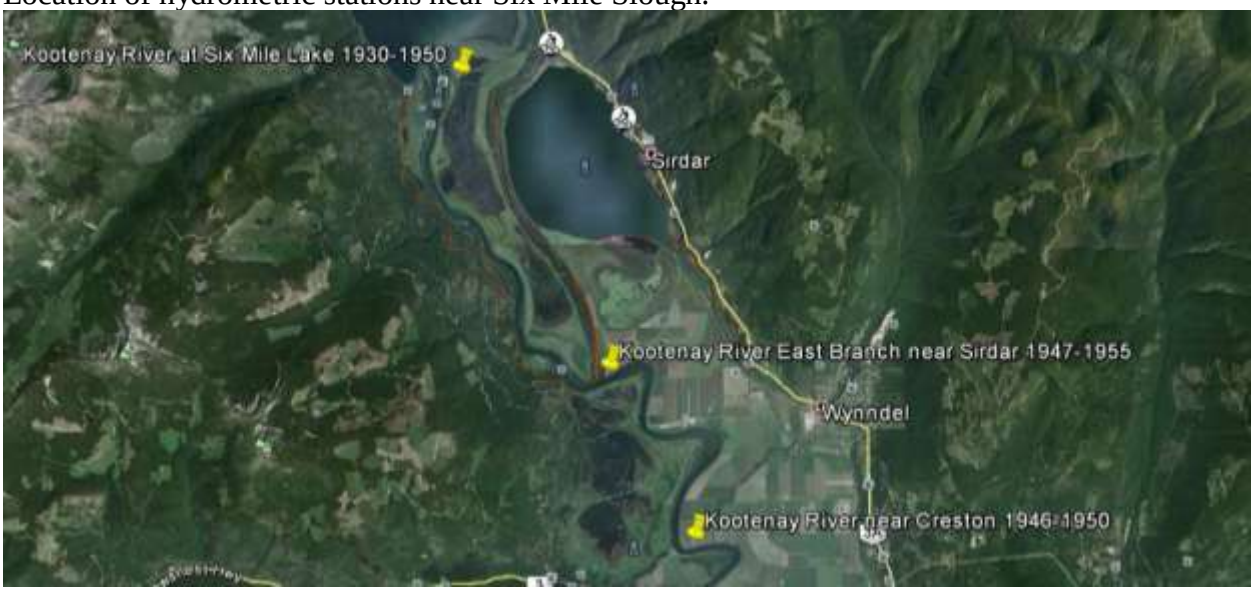
Hydrometric Data

A considerable amount of hydrometric data is available for water elevations in the Six Mile Slough area. Historic data is available from 29 hydrometric stations in the Creston Valley and adjoining creeks extending from the south end of Kootenay Lake to the US border[16]. The earliest data is from 1921.[15]

Close-up of hydro-metric station near Six Mile Slough.

The image below shows the location of 3-hydrometric data stations where water levels in the Kootenay River were collected over a period of years:

Location of hydrometric stations near Six Mile Slough.



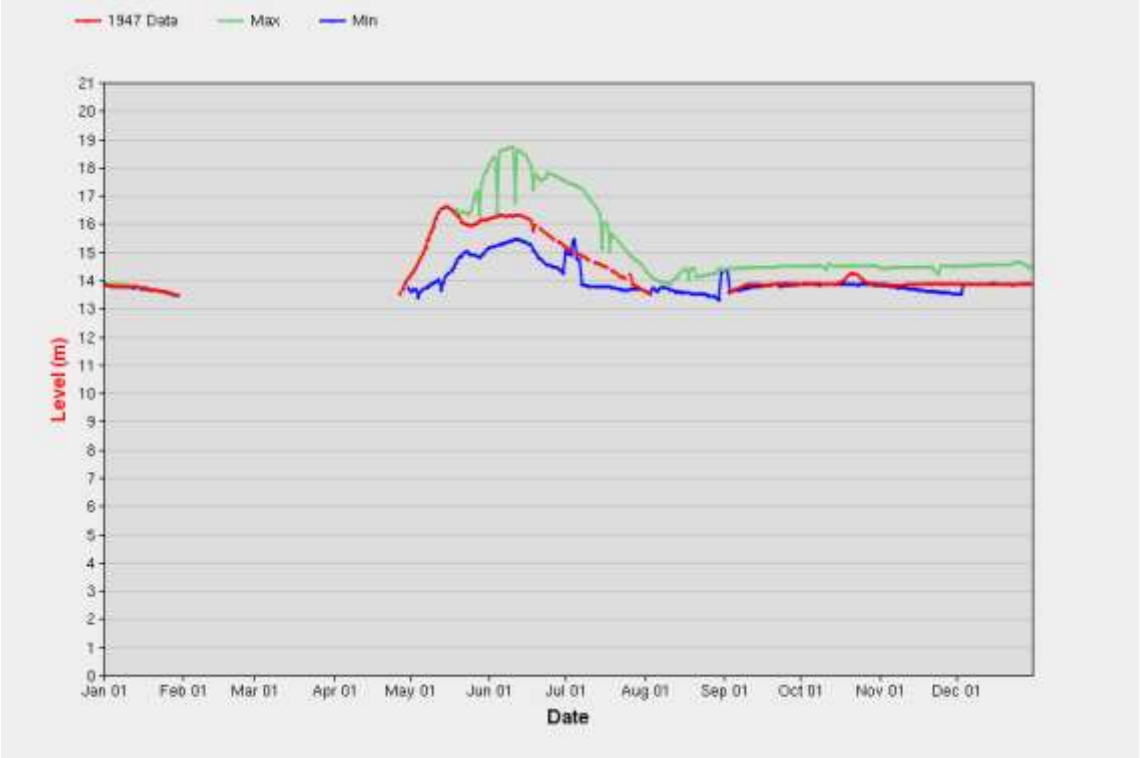
[16] https://wateroffice.ec.gc.ca/search/search_e.html?sType=h2oArc. Accessed Dec. 6th, 2015.

The image above shows the location of hydrometric data station #08NH060 called “Six Mile Lake.” The station was used to monitor water levels in Six Mile Slough. Water levels in “Six Mile Lake” were collected for the years 1930, 1931, and 1947 through 1950. Water levels were recorded daily in June, July and August in 1930 and 1931, and daily from May to December from 1947 through 1950.

The years 1947, 1948 and 1950 are years for which data was collected at all three stations. The water levels in these years follow similar curves and reach similar levels at all three stations, suggesting Six Mile Lake was connected to the river and flooded annually until at least 1950.

1947 Daily Water Level: KOOTENAY RIVER (EAST BRANCH) NEAR SIRDAR (08NH098)

1947 Daily Water Level Graph for KOOTENAY RIVER AT SIX MILE LAKE (08NH060)



1947 Daily Water Level: KOOTENAY RIVER NEAR CRESTON (WELL NO. 436) (08NH094)

A more detailed study of this water level data could provide useful information in determining the desired inlet and outlet elevations for restoring in Six Mile Slough.

Conceptual Design

Tom Biebighauser, Robin Annschild, Marc-Andre Beaucher, and Barb Houston examined portions of Six Mile Slough on October 6, 2015. The purpose of the visit was to assess the site for possible restoration approaches that would meet management objectives for Six Mile Slough The group used a laser level to sample elevations of the wetland compartment dams, water control structures, water levels in wetland compartments, and the Kootenay River. A soil auger and tile probe were used to measure groundwater elevations and soil texture.

Research was done to identify historic modifications to Six Mile Slough, and what can be done to restore the area. Primary management objectives were identified by the group for the restoration of Six Mile Slough. This report describes actions that can be taken to meet these objectives.

Here are the primary management objectives for restoring Six Mile Slough:

1. Improve habitat for staging and nesting waterfowl
2. Increase habitat for juvenile white sturgeon and burbot.
3. Increase habitat for the northern leopard frog
4. Improve nesting habitat for the Forster's Tern and the American bittern
5. Improve habitat for the western painted turtle
6. Eliminate maintenance needs and expenses

Four main actions are proposed to restore Six Mile Slough:

1. Decommissioning of 5,591 meters of constructed dikes and their 2-water control structures. This would open up access to 1,260-hectares of wetland habitat for the white sturgeon. The dams would be changed into naturally appearing peninsulas, and nesting islands for the Forster's tern, basking sites for the western painted turtle, and shallow water areas for waterfowl and the American bittern.
2. Removal of 5-constructed dams and 4-water control structures along the Kootenay River, and the East Channel of the Kootenay River, to provide sturgeon and other aquatic organisms with access to over 1,269-hectares of wetland habitat on the floodplain of the Kootenay River within Six Mile Slough.
3. Reducing the depth of water in Six Mile Slough to improve habitat for waterfowl and the American bittern.
4. Building naturally appearing and functioning ephemeral wetlands within dry portions of Six Mile Slough for northern leopard frog breeding.

Proposed Actions

This section describes in detail main actions that could be taken to restore Six Mile Slough:

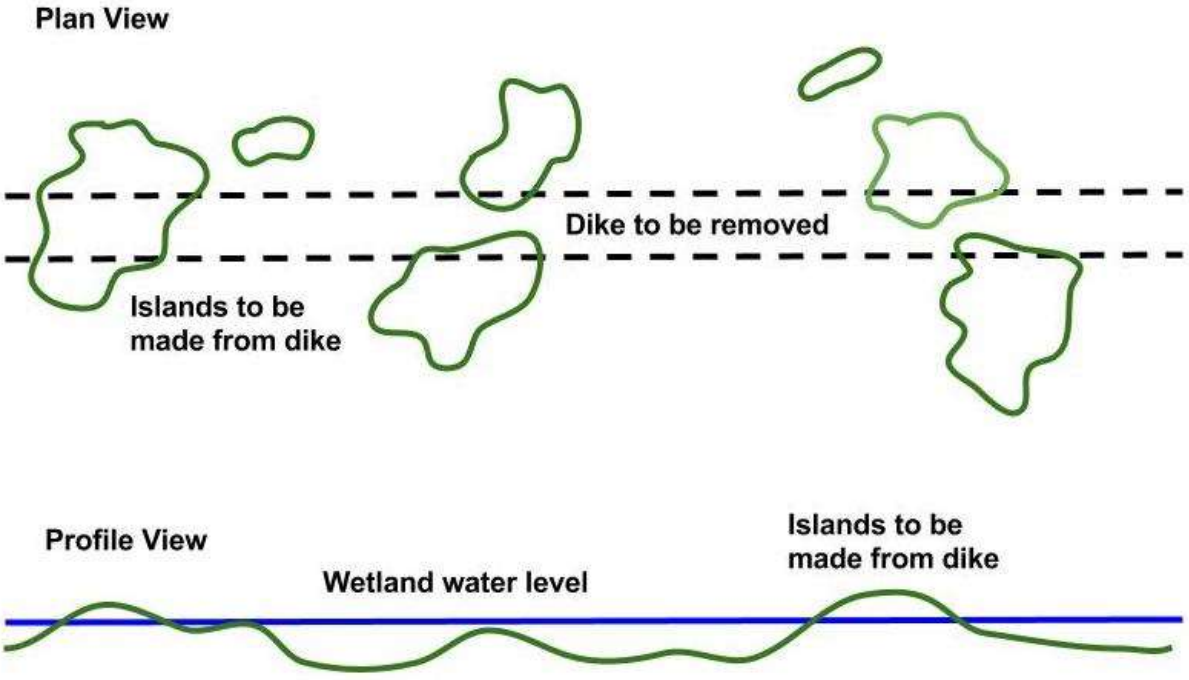
1) Wetland Compartment Dike Removal

The four dikes totaling 5,591 meters long that were built across Six Mile Slough to form 5-compartments would be removed, along with their water control structures. Sections of the dikes

would be completely removed in many locations to provide fish with access to the wetland compartments. The soil in the dikes would be changed into areas of shallow water, and naturally appearing islands and ridges. Natural ridges and peninsulas that were modified when the dikes were built would be restored. Logs and root masses would be returned to Six Mile Slough at the same time. Nesting beaches would be built for turtles where sand is found.

Removing the dikes that were built across Six Mile Slough would not change the size or depth of Six Mile Slough. This is because the elevation of the water is the same between wetland compartments.

Habitat would be improved for migrating and nesting waterfowl with the creation of numerous islands and areas of shallow water. Habitat for the Forster's tern would be improved with the creation of numerous nesting islands. The action would greatly increase the number of loafing sites for waterfowl, and basking sites for turtles.



Typical plan and profile view of how soil removed from decommissioning the dikes would be used to form islands of various shapes, sizes, and elevations

Techniques to be used

1. The wetland compartment dikes would be removed at a time of year when the Kootenay River is not likely to flood.
2. Excavator(s) with operators would be used to remove the dikes, and form naturally appearing islands and peninsulas. The soil would not be moved by truck.
3. Islands and peninsulas would be made to vary in size, shape, and elevation.
4. The slopes on the islands and peninsulas would be shaped to appear natural.

5. The soil in the islands and peninsulas would not be compacted.
6. The dikes would be removed completely in a number of places, down to the original elevation of the bottom of the wetland, to provide fish with access.
7. Water control structures and pipes would be removed and buried on site.
8. Logs and root masses would be placed in the restored wetlands. These would be partially buried so they do not float away. These would be obtained on site.
9. Peninsulas and ridges modified for dike construction would be restored.
10. Exposed soil would be seeded to wheat, and sedges and rush seeds collected on site for erosion control, and to reduce colonization by nonnative plants.

Estimated costs

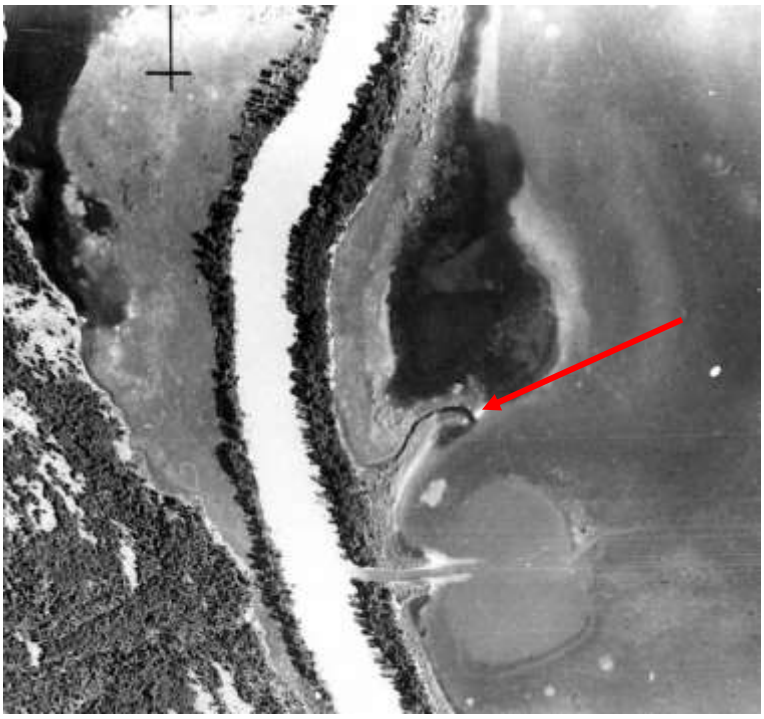
These cost estimates are based on the conceptual design prepared for the Six Mile Slough Wetland Restoration Project. The prices are not based on a detailed design, nor on bids received from contractors. The prices do not include costs for preparing designs, obtaining approvals, and administering the project. A detailed design would be required to prepare an accurate budget for implementing the actions described in this report.

1. Excavator (CAT 320E or equivalent): (5,591meters of dike) ÷ (8-meters dike decommissioned/hour) = (699-hours) x ($220/hour) = $153,780
2. Wheat: (5,591 meters of dike) (1-50lb bag/100 meters dike) = (56 bags wheat) x ($30/bag) = $1,680.
3. Log and root mass acquisition on site: (1 unit of wood/30-meters of dam) ÷ (5,591meters of dam) = (186 units of wood) x (1-hour Excavator time/unit wood) x ($220.00/hour for Excavator) = $40,920
4. Barge transportation: $3,000.00/day x 5-days = $15,000.
5. Project Design and Supervision (includes salary and all expenses): 45-days @ $1,200.00/day = $54,000.
   Total = $265,380

The deep water and even terrain in the bottom of the wetland compartments provides poor habitat for nesting and migratory waterfowl.

The dikes would be changed into a series of naturally appearing islands, similar to these in Six Mile Slough.

Naturally appearing peninsulas would be restored from the dikes, like this one in Six Mile Slough. The peninsulas would generally be located where the dikes were connected to the river banks.



Natural features, like the peninsula shown by the red arrow (1958 aerial photograph), would be reshaped where dikes are removed. This peninsula may have been maintaining open water in Six Mile Slough.

One can see where the natural peninsula was reshaped into the dike for wetland compartment 2 on this 2015 aerial photograph

2) Kootenay River Dam & Water Control Structure Removal

An efficient way of restoring flooding and fish access to Six Mile Slough is to remove the dams and water control structures that were built for the wetland compartments along the Kootenay River and the East Channel of the Kootenay River. A reasonable amount of soil would need be removed to connect both rivers with Six Mile Slough via the dug channels. Five water control structures and the dams built on either side of them would be removed to create streams from the channels. The dams and water control structures were built in the 1970's to control water flowing in and out of Six Mile Slough from the Kootenay and the East Channel of the Kootenay River.

Inspection shows that erosion along the channels is limited to around the dams and water control structures. This erosion could be controlled by removing the dams and sloping the channels where the water control structures are located.

Here a tremendous amount of erosion is occurring along the banks of the Kootenay River, opposite Six Mile Slough. The banks are steep at this location, with high shear stress. This demonstrates what might happen if careful planning and construction oversight are not used in connecting the Kootenay River with Six Mile Slough.

White sturgeon would gain access to over 1,260-hectares of wetland habitat in Six Mile Slough if the dams and water control structures were removed. This is because the channels are at a much lower elevation than the historic elevation of the river banks. Connecting the rivers with Six Mile Slough via the channels would compensate for the reduction in the frequency of flooding that historically occurred over the river banks into Six Mile Slough when the Libby Dam was built.

The dug channels appear to be physically suitable for providing stream access between the Kootenay River, East Channel of the Kootenay River, and Six Mile Slough. The channels were dug wide with gradual slopes. The channels show little signs of erosion, and the erosion that is present can be controlled. The channels do not appear to be collecting sediment, and should remain open for fish passage.

Techniques to be used:

1. The project would be completed when the Kootenay River is not at flood stage.
2. An excavator would be used to remove water control structures and drain pipes.
3. The dams would be removed to open up stream channels between Six Mile Slough and the rivers.
4. Gradual slopes and bays would be shaped along the channels to reduce shear stresses, and to help make the channels appear like streams.
5. The elevation of riffle crest (spillways) between Six Mile Slough and the Kootenay River would be made so that water depth in Six Mile Slough is reduced, but the wetland is not drained.
6. Vertical grade control structures made of rock would be buried across the floodplain of the channels near the river to prevent head-cuts from forming that could drain Six Mile Slough. The head-cuts would most likely begin at the Kootenay River, which is generally lower elevation than the Kootenay River.

Estimated cost:

These cost estimates are based on a conceptual design prepared for the Six Mile Slough Wetland Restoration Project. The prices are not based on a detailed design, nor on bids received from contractors. These prices do not include costs for preparing designs, obtaining approvals, and administering the project. A detailed design would be required to prepare an accurate budget for implementing the actions described in this report.

1. Excavator (CAT 320E or equivalent): (70-hours/structure & dam removal) x (5-structures & dams to be removed) = (350-hours) x ($210.00/hour) = $73,500.
2. Rock: (6-tandem size dump truck loads channel liner rock for each buried vertical grade control structure) x (5 buried vertical grade control structures to be installed) = (30 tandem loads of rock) x ($1,000.00/load[17]) = $30,000.00
   The dump trucks would travel by barge to Six Mile Slough, and then drive the dikes to deliver the rock.
3. Wheat: (5-50lb bags/structure & dam removed) x (5-structures & dams to be removed) = (25 bags wheat) x ($30/bag) = $750.00.
4. Barge transportation: $3,000.00/day x 12-days = $36,000.00
5. Project Design and Supervision (includes salary and all travel costs): 20-days @ $1,200.00/day = $24,000.
   Total = $164,250

[17] This price is double what is normally paid for rock and its delivery due to the remote location.

This is one of the channels dug to connect Six Mile Slough with the Kootenay River. Note the metal wheel on the water control structure, and an erosional head-cut shown by the red arrow.

This photo shows the same constructed channel, only facing the Kootenay River. The people are standing on the dam built across the channel, and the drain pipe from the water control structure. The dam, water control structure, and pipe would be removed to connect Six Mile Slough with the Kootenay River.

The elevation of water in the Kootenay River was compared to the elevation of water in Six Mile Slough. The river was from 1.04 to 1.16 meters lower than the wetland when readings were taken on October 6, 2015, at the end of a severe drought, and during the driest time of year.

This photo shows one of the dams built along the Kootenay River to prevent water from flowing out from Six Mile Slough, unless the water control structure was opened.

This photo shows one of the long channels that was built to connect the East Channel of the Kootenay River with Wetland Compartments 4 & 5. One dam would be removed at this location to create fish passage. Another restoration approach involves filling these channels to restore the natural elevation of river banks surrounding Six Mile Slough.

3) Restoring natural river banks and the connection with Kootenay Lake:

The natural river banks surrounding Six Mile Slough would be restored by filling and contouring the deep and long channels dug between Six Mile Slough and the Kootenay River, and the East Channel of the Kootenay River when the wetland compartments were built. The water control structures in these channels would be removed when the channels are filled.

Providing permission could be obtained, large diameter culverts would be installed in the rock and soil fill beneath the Crowsnest Railroad to reconnect Six Mile Slough with Kootenay Lake. Low places along the Kootenay River would be also be restored by removing dams to allow flood waters to enter Six Mile Slough.

Techniques to be used:

1) The soil removed to dig the channels between Six Mile Slough and the Kootenay and East Channel of the Kootenay Rivers would be placed back in the channels. Groundwater dams would be used to prevent water from leaving Six Mile Slough by following the soil placed in the channels. The 4-water control structures installed in the channels would be removed.
2) Large diameter culverts would be installed in the rock and soil fill used to make the Crowsnest Railroad to reconnect Kootenay Lake with Six Mile Slough. Naturally appearing stream channels would be built between Kootenay Lake and Six Mile Slough to direct water through the culverts.
3) Low places would be restored along the banks of the Kootenay River, and the East Fork of the Kootenay River, to allow flood waters to enter Six Mile Slough.

Estimated budget:

Costs would be determined following the completion of a detailed design for implementing these actions. The cost estimate would include the costs for preparing designs, obtaining approvals, and administering the project.

4) Restoration of ephemeral wetlands

From 10 to 30 large ephemeral wetlands may be restored from drier areas within Six Mile Slough. These wetlands would be built on areas dominated by reed canary grass. Building the wetlands would help meet these objectives:

1. Increase breeding and migratory habitat for waterfowl
2. Provide critical habitat for Federal Species at Risk
3. Increase habitat for a diversity of animals and plants.
4. Restore wetlands from dry lands affected by ditches and dikes
5. Increase opportunities for viewing and hunting wildlife
6. Clean runoff
7. Adding wetlands that do not become dominated by cattails, reed canary grass, or watershield
8. Establish naturally appearing and functioning wetlands that would require little, if any maintenance

This photo shows one of nine large wetlands restored near the Old Goat Channel on the Creston Valley Wildlife Management Area in 2016. The wetland is 9-months old in this photo.

The wetlands would be designed to provide breeding habitat for the northern leopard frog, and for waterfowl. They would dry in the fall season, or possibly freeze to the bottom in winter, and

not provide habitat for fish or the American bullfrog, which conflict with management of the northern leopard frog.

Large dry areas such as this one within Six Mile Slough, would be transformed into naturally appearing and functioning ephemeral wetlands to benefit the northern leopard frog, western toad, and waterfowl.

The following construction steps and specifications are suggested for building the ephemeral wetlands:

1. A small diameter test hole, at least 140cm deep, would be dug in the center of each planned Ephemeral Wetland-Long Hydro-Period site. The holes would be dug in August. One should wait to see if water enters each hole that is dug. If water enters the hole, one should record the elevation of water below the surface of the ground. This information would guide how deep to dig the planned wetland.
2. Any needed permits would be obtained prior to construction.
3. Funding would be obtained for building the wetlands.
4. Service Agreements would be issued for the heavy equipment and operators needed to build the wetlands.
5. Tom Biebighauser and/or Robin Annschild would be onsite supervising heavy equipment and personnel in the construction of the wetlands. Their participation would help insure success, saving time and money.
6. The location of any buried utilities would be marked in advance of construction.
7. If possible, the water in adjacent managed wetlands would be removed or lowered in advance of construction.
8. The area within the marked perimeter would be mowed within 30-days of construction to facilitate the removal of reed canary grass by heavy equipment.
9. Logs would be used to prevent the excavators from sinking in saturated soils when digging the Ephemeral Wetlands-Long Hydro-Periods when the soils are wet. The logs should be at least 20-inches in diameter, and 20-feet long. The logs should be cut from live trees. Logs that are too long are difficult to move and get in the way of piling soil.

Logs that are too short may tip, allowing the excavator to slide off and become stuck. Logs too small in diameter may break. Tree species that work well for logs include fir and larch. Cedar, cottonwood, and hemlock are too soft and are likely to break. A chainsaw and safety items should be onsite to cut the logs if needed. The logs should be delivered in advance of wetland construction. Some of the logs used would be left behind and placed in and around the wetlands to provide hiding cover for frogs, perches and loafing sites for birds, and basking sites for turtles.

10. Supplies such as native plants, wheat seed, and straw would be purchased in advance.
11. The following heavy equipment with operators would be used to build the wetlands:

Ephemeral-Wetlands with Long Hydro-Periods (Work may be done when the soils are dry or wet)

Excavator #1
100 or 200 Series
John Deere 200C LC or equivalent
Minimum 60-inch wide bucket or larger
141HP Net or greater
46,130lbs or greater
Ground pressure no greater than 4.9 PSI (This is critical to staying afloat, and minimizing the use of logs)
Working thumb attachment
10-years old or less preferred

Excavator #2
100 or 200 Series
Caterpillar 314CLR or equivalent
Minimum 52-inch wide bucket or larger
94HP Net or greater
32,590lbs or greater
Ground pressure no greater than 4.9 PSI (This is critical to staying afloat, and minimizing the use of logs)
Working thumb attachment
10-years old or less preferred

Dozer
CAT D6T LGP or equivalent
228HP
48,024lbs
Ground pressure 5.2 PSI or less (This is critical to staying afloat)
10-years old or less preferred

Ephemeral-Wetlands with Short Hydro-Periods (Work would be done when the soils are dry)

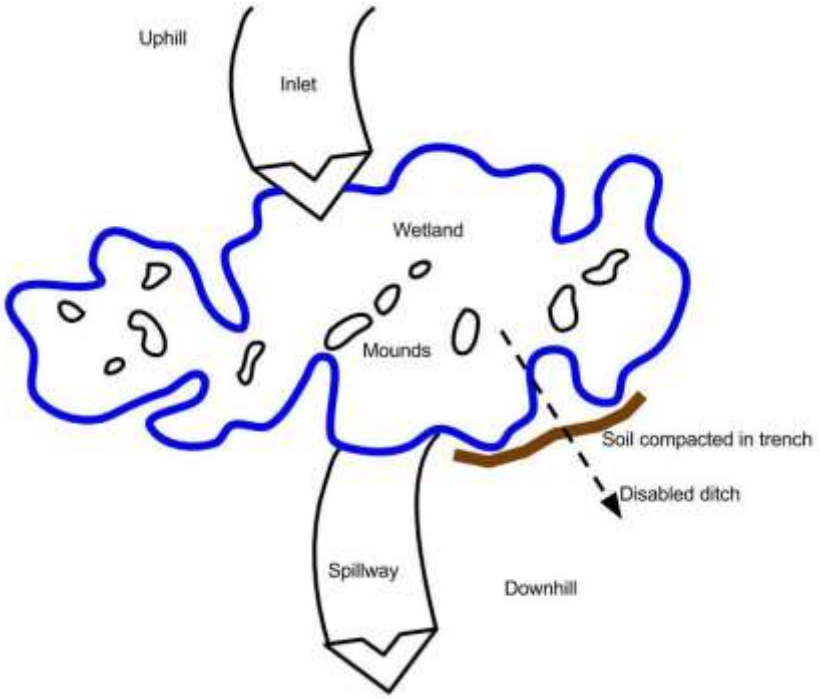
Dozer #1
CAT D6D or larger
139HP or greater
20,359lbs or greater
10-years old or less preferred

Dozer #2
CAT D6T LGP or equivalent
228HP
48,024lbs
Ground pressure 5.2 PSI or less (This is critical to staying afloat)
10-years old or less preferred

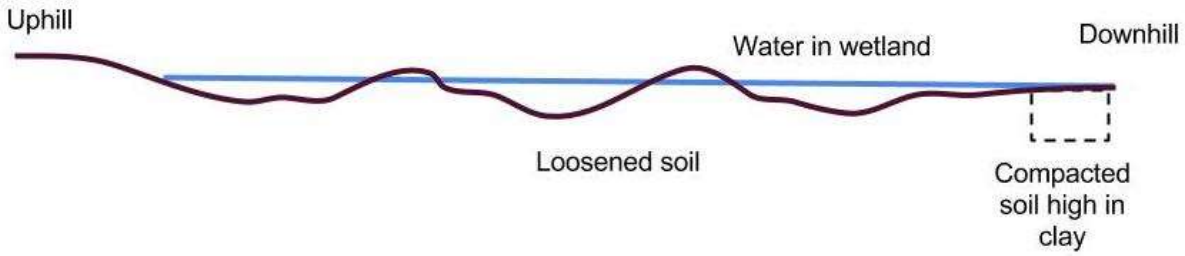
12. Heavy equipment would be cleaned prior to construction to avoid introducing non-native plants.
13. The perimeter of each planned wetland would be remarked in advance of construction.
14. Elevation readings would be taken over each planned wetland to identify the low edge of the marked perimeter, and the desired depth prior to construction. A laser level, tripod, and survey rod would be used for this purpose.
15. Native plants of value such as sedges and rushes would be removed by the excavator and saved for planting in the finished wetland.
16. Heavy equipment would be used to remove nonnative plants and associated topsoil from within the marked perimeter. This material would be covered with soil removed from building the wetland. This action has been found to be an effective way of controlling nonnative plants.
17. Topsoil not containing nonnative plants would be saved for spreading in and around the finished wetland.
18. A shallow basin would be dug for each wetland. The basin would be dug deepest in the center, in relation to the low edge of the marked perimeter. The basin would be dug less than 20cm deep for Ephemeral Wetlands with a short hydro-period, and up to 180cm deep for Ephemeral Wetlands with a long hydro-period.
19. The wetlands designed to be Ephemeral Wetland-Long Hydro-Period would be shaped so there is an area of deeper water in the center approximately 42-meters in diameter. The area outside of this deep-water zone would be made an average of 30cm deep. The area of water 30cm deep is designed for Northern leopard frog egg laying.
20. The soil in the wetland basin would not be compacted. Compacted areas in the basin would be loosened by using the excavator. The water in the wetland is expected to soak into the ground as Summer progresses, with a small pool remaining in the center that drains by the end of August, providing time for Northern leopard frog larvae to develop.
21. Shallow water areas from 10 to 20cm deep would be created around the perimeter of the wetland with gradual slopes for use by Northern leopard frog and Western toad larvae, and by waterfowl and shorebirds.

22. The excavator would dig a trench along the lower edge of the constructed basin, and across any ditches draining the area. The trench would be dug across and on either side of ditches, and be deep enough to interrupt topsoil, organic material, and roots. Soil would be placed in the trench and compacted using the excavator. Enough soil would be placed in the trench until the top elevation of the compacted soil equaled the elevation of original ground. The location, depth, and width of the trench would vary from site to site. This action would prevent water from leaving the wetland by flowing in soil and organic materials that have collected in the ditches over the years. The same practice would be used to block any buried drainage structures that are found.
23. Zones where the water from springs enters the restored wetlands would be modified to serve as hibernacula for the Western painted turtle. This would be done by loosening compacted soils where water emerges, and then inundating this zone.
24. The soil removed from digging the wetland basin would generally be pushed on higher ground using the dozer. The soil would be spread using the dozer and blended into the surroundings, and shaped so it would not erode.
25. Where feasible, the soil spread on level ground would be shaped to form large and shallow depressions that would pool water after heavy rains, and from snowmelt. These large depressions would form wetlands with short hydro-periods, and would be used by shorebirds and waterfowl.
26. Areas of sand and gravel unearthed while building the wetland would be placed on high ground in full sunlight to be used as warming sites for the Northern leopard frog, and for nesting sites for the Western painted turtle. These areas would not be seeded, planted, or mulched.
27. No dams would be built.
28. No pipes, pumps, or water control structures would be used.
29. The wetland basins would be shaped to appear natural, with no straight lines or steep slopes.
30. Any topsoil that was saved would be spread loosely in and around each completed wetland. Wet and dry meadows surrounding the wetland would not be grazed by livestock, and would be available for waterfowl nesting.
31. Mounds, ridges, tufts, and peninsulas of various sizes and elevations would be shaped within and around each wetland. Some of the mounds would be shaped like muskrat houses, and others like beaver lodges. The soil in these features would not be compacted.
32. The existing low edge of each wetland basin would be used as a spillway. A wide spillway for overflow would be created over gradual slopes to prevent erosion, and to establish wet-meadow wetlands. Water would flow over the spillway in a sheet-like pattern and not cause erosion.
33. Logs, root masses, woody debris, boulders, and rocks, would be placed in and around the wetlands to provide hiding cover for the Northern leopard frog and Western toad, loafing sites for waterfowl, and basking sites for the Western painted turtle.
34. Compacted soils surrounding the wetlands would be prepared for seeding and planting using the rough and loosen technique. Heavy equipment tracks within and surrounding the wetland would be removed using the rough and loosen technique.
35. Exposed soils on higher ground, along with the spillways, would be seeded to native species and mulched using straw to control erosion.

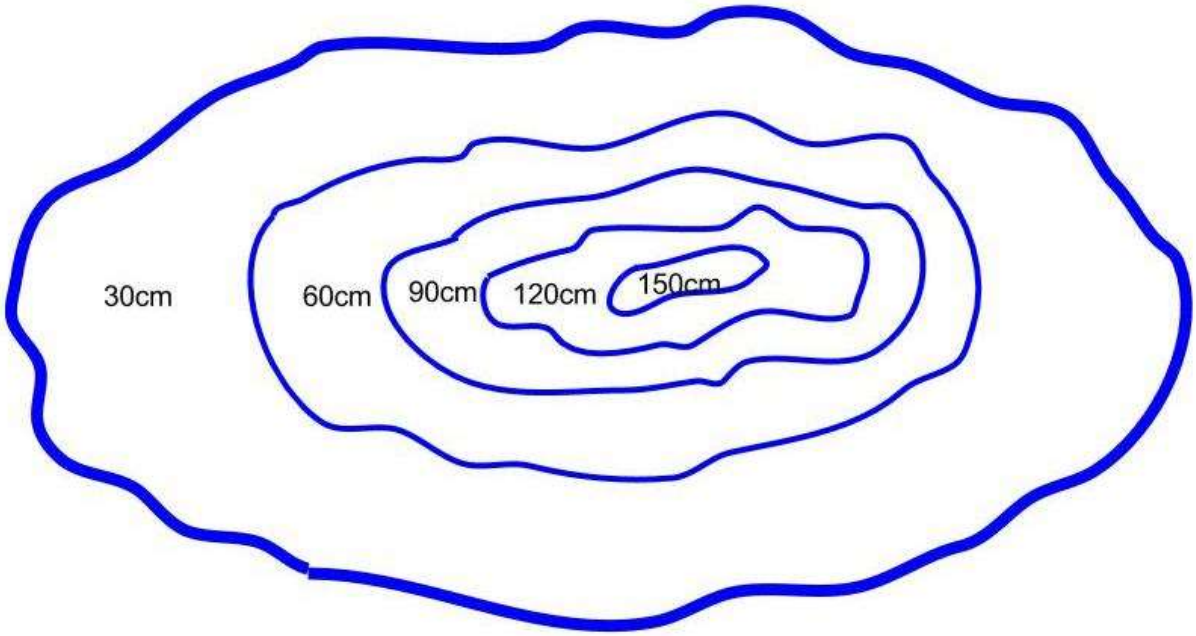
36. A diversity of native plants including sedges, rushes, and wildflowers may be established in and around the wetlands.



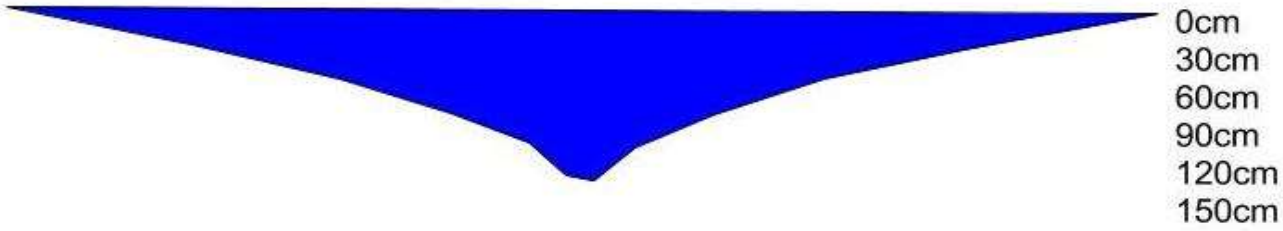
Typical Plan View of Ephemeral Wetland (without large woody debris and boulders)



Typical Profile View of Ephemeral Wetland (without large woody debris and boulders)



Typical Plan View of Ephemeral Wetland-Long Hydro-Period showing contours



Typical Profile View of Ephemeral Wetland-Long Hydro-Period showing water depths

This photo shows one of nine large wetlands restored near the Old Goat Channel on the Creston Valley Wildlife Management Area in 2016. The wetland is 9-months old in this photo.

Estimated budget

These cost estimates are based on a conceptual design prepared for the Six Mile Slough Wetland Restoration Project. The prices are not based on a detailed design, nor on bids received from contractors. A detailed design would allow for the preparation of a more accurate budget for implementing the actions described in this report.

Estimated budget for building Ephemeral Wetlands with a Longer Hydroperiod

Wetland Number	Total Wetland Area (m^2)	Area to Excavate (m^2)	Production rate/ machine/hour	Total Heavy Equipment Hours Needed	Excavator #1 Hours	Excavator #1 Cost	Excavator #2 Hours	Excavator #2 Cost	Dozer Hours	Dozer Cost	Logs Needed (40-foot)	Log Cost (40-foot)	Wheat bags	Wheat cost	Native Plant Seed Cost	Heavy Equipment Supervision Hours	Heavy Equipment Supervision Cost	Total Cost	Total working days to build	Cost/m^2
SMS1	6000	4000	81	49	16.5	$ 4,115	16.5	$3,786	16.5	$5,926	4	$320	9	$435	$600	16	$1,975	$17,157	2.1	
SMS2	6000	4000	81	49	16.5	$ 4,115	16.5	$3,786	16.5	$5,926	4	$320	9	$435	$600	16	$1,975	$17,157	2.1	
SMS3	7500	5000	81	62	20.6	$ 5,144	20.6	$4,733	20.6	$7,407	5	$400	11	$543	$750	21	$2,469	$21,447	2.6	
SMS4	7500	5000	81	62	20.6	$ 5,144	20.6	$4,733	20.6	$7,407	5	$400	11	$543	$750	21	$2,469	$21,447	2.6	
SMS5	9000	6000	81	74	24.7	$ 6,173	24.7	$5,679	24.7	$8,889	6	$480	13	$652	$900	25	$2,963	$25,736	3.1	
SMS6	9000	6000	81	74	24.7	$ 6,173	24.7	$6,173	24.7	$8,889	6	$480	13	$652	$900	25	$2,963	$26,230	3.1	
Barge Transportation																		$6,000		
	45000	30000		370	123	$ 30,864	123	$28,889	123	$44,444	30	$2,400	65	$3,261	$4,500	123	$14,815	$135,173	15.4	$3.00

Six Mile Slough Ephemeral Wetland Projects

Ephemeral Wetlands with Longer Hydro-Periods for the Northern Leopard Frog, and for Waterfowl

The wetland areas and prices listed are estimates, and may vary with actual contract and supply costs

Total Wetland Area = (Area of Ephemeral Wetland-longer hydroperiod being excavated) + (Area of Ephemeral Wetland-shorter hydroperiod being built from 1/2 of the soil being spread)

Area to excavate = Area of Ephemeral Wetland-longer hydroperiod being built

The Production Rate per machine applies to the area excavated to build each wetland. This is based on similar wetland projects that have been completed.

Total Heavy Equipment Hours Needed = Area to be excavated/production rate per machine

Estimated Excavator #1 Cost (200-Series Excavator) = (Total Heavy Equipment Hours/3) x ($235.00 per hour) + ($15.00/hour for mobilization and demobilization) = $250.00/hour

Estimated Excavator #2 Cost (100-Series Excavator) = (Total Heavy Equipment Hours/3) x ($215.00 per hour) + ($15.00/hour for mobilization and demobilization) = $230.00/hour

Estimated Dozer cost (CAT D-6 LGP) = (Total # Heavy Equipment Hours/3) x ($345.00 per hour) + ($15.00/hour for mobilization and demobilization) = $360.00/hour

Estimate that (1)-40-foot long log or (2)-20-foot long logs will be placed for wildlife for every 1,000m^2 of Area Excavated. A minimum of (20)-20-foot logs are needed (10/excavator) for floatation to build each wetland

Estimated cost of $80.00 for each 40-foot long log ,or $40.00 for each 20-foot long log. The logs should be from live cut trees, 20-inches in diameter, and 20-feet long

(Area to Excavate) ÷ (460m^2), (Wheat is packaged in 50lb bags, 1-50lb bag/460m^2 wetland built (for seeding areas where soil is spread, generally equal to the area excavated)

Wheat cost = $50.00/50lb bag

Native seed cost = Total Wetland Area m^2/10,000m^2 x $1,000.00

Heavy Equipment Contract Supervision Hours by Tom Biebighauser or Robin Annschild = # Dozer hours

Heavy Equipment Supervision Cost = (# Heavy Equipment Supervison Hours) x ($120.00/hour), includes all costs, i.e. consulting fee, airfare, lodging, car rental, meals

Barge Transportation = $3,000.00/day x 2-days = $6,000.00

Wetland Restoration Specifications Summary

The wetlands may be built when the ground is wet, and during the winter season

Two excavators and one dozer would be building the wetlands at the same time

The wetlands would be built to maximize the area of water 30cm deep in late Spring, to provide breeding habitat for the Northern leopard frog

The wetlands would be built to have various depths and hydro-periods

The wetlands would contain naturally appearing ridges, mounds, islands, and shallow depressions

The wetlands would be built to have an area of deeper water in the center, averaging 40m in diameter, so they would contain water until early Fall season

Shallow depressions would be shaped from the soil removed to restore additional wetlands with short hydroperiods

The wetlands would be built to require no maintenance with no water control structures, pumps, wells, dams, dikes, or diversions being used

This photo shows a wetland restored near Salmo by the authors. The wetland is only 4-months old in this photo.

Estimated budget for building Ephemeral Wetlands with a Shorter Hydroperiod.

Wetland Number	Size (m²)	Production Rate/ Machine/Hour	Total Heavy Equipment Hours Needed	Dozer #1 Hours	Dozer #1 Cost	Dozer #2 Hours	Dozer #2 Cost	Wheat bags	Wheat cost	Heavy Equipment Supervision Hours	Heavy Equipment Supervision Cost	Native Wetland Seed	Total Cost	Total Working Days to Build	Cost/m²
SMS7	5000	210	24	12	$3,750	12	$4,286	11	$543	12	$1,429	$250	$10,258	1.5	
SMS8	6000	210	29	14	$4,500	14	$5,143	13	$652	14	$1,714	$300	$12,309	1.8	
SMS9	7000	210	33	17	$5,250	17	$6,000	15	$761	17	$2,000	$350	$14,361	2.1	
SMS10	8000	210	38	19	$6,000	19	$6,857	17	$870	19	$2,286	$400	$16,412	2.4	
Barge Transportation													$6,000		
Total	26000		124	62	$19,500	62	$22,286	57	$2,826	62	$7,429	$1,300	$59,340	7.7	$2.28

Six Mile Slough Ephemeral Wetland Projects

Ephemeral Wetlands with Shorter Hydro-Periods for Waterfowl and Shorebirds

The wetland areas and prices listed are estimates, and may vary with actual contract and supply costs

Dozer #1 hours (CAT D6D) = (Wetland size in m²/210m² progress rate/hour) ÷ (2-dozers)

Dozer #1 cost = (Dozer hours) x ($300.00 per hour) + ($15.00/hour for mobilization) = $315.00/hour

Dozer #2 hours (CAT D6T LGP) = (Wetland size in m²/210m² progress rate/hour) ÷ (2-dozers)

Dozer #2 cost = (Dozer hours) x ($345.00 per hour) + ($15.00/hour for mobilization) = $360.00/hour

(Size of wetland) ÷ (460m²), (Wheat is packaged in 50lb bags, 1-50lb bag/460m² wetland built (for seeding the areas where soil is spread, generally equal to the size of the wetland area)

Wheat cost = $50.00/50lb bag

Native seed cost = Wetland Size m²/10,000m² x $1,000.00

Heavy Equipment Contract Supervision Hours by Tom Biebighauser or Robin Annschild = # Dozer hours

Heavy Equipment Supervision Cost = (# Heavy Equipment Supervison Hours) x ($120.00/hour), includes all costs, i.e. consulting fee, airfare, lodging, car rental, meals

Barge Transportation = $3,000.00/day x 2-days = $6,000.00

Wetland Restoration Specifications Summary

The wetlands would be built when the ground is dry so wide tracks would not be needed on the dozers

Two dozers with operators would be building the wetlands at the same time

The wetlands would be built shallow with gradual slopes to provide habitat for waterfowl and shorebirds

The wetlands would be built to require no maintenance

No dams, water control structures, pipes, or pumps would be used

The wetlands would be built to have various depths and hydro-periods

The wetlands would contain naturally appearing ridges, mounds, islands, and shallow depressions

Ephemeral wetlands would be built in dry areas dominated by reed canary grass, such as this area within Six Mile Slough.

The water present along the base of this dam at Six Mile Slough shows that cattails and reed canary grass do not have to dominate wetlands. Cattails are not growing in the water because of the depth, lack of topsoil, and compaction of soil. Similar techniques would be used to prevent cattails and reed canary grass from dominating ephemeral wetlands that are constructed at Six Mile Slough.

Heavy Equipment & Supply Access

There are two possible ways to access Six Mile Slough for completing the restoration projects, by boat or by rail. We do not know if the railroad would be interested in working with us to transport heavy equipment and supplies to Six Mile Slough. However, it is possible to access the area by boat.

Large boats may be used to move trucks, fuel, and heavy equipment into Six Mile Slough for completing these projects. Careful planning can help manage the high costs associated with accessing Six Mile Slough by keeping the number of trips by boat to a minimum. Tom Biebighauser discussed the project with Ian Graham, owner of Graham Marine Construction (250-229-2169) (info@grahammarine.ca) on November 25, and with Cheryl Graham on November 26, 2015. They suggested using their barge, tug boat, and push boat with operators to move supplies and heavy equipment. The barge can haul up to 100,000lbs, and can float in very shallow water. The barge also has a boom for unloading logs. Logs would be placed in the water and pulled by the barge.

Ian suggested launching the boats from Kuskonook, where there is an improved boat ramp. It would take about 5-hours to transport the boats by truck to Kuskonook from his place of business. Graham Marine rents their boats and operators by the day, week, or month. They could provide an accurate estimate of costs with detailed information concerning dates and times

needed to complete the project. Their rough estimate of costs associated with renting three boats with drivers, and fuel, could be as high as $15,000 for every 5-days of work.

Tom Biebighauser discussed how to access Six Mile Slough with Clayton Jones, Kootenay Lake Barge and Pile Driving Ltd., 2409 Perrier Road, Nelson, BC, phone number 250-505-4207 on December 31, 2015. Mr. Jones also owns a barge, tug boat, and pilot boat with crew and Capitan. He was very interested in helping with the project.

Mr. Jones knows how to access Six Mile Slough using a barge and boats. He recently transported large trucks to Six Mile Slough for removing the power poles and electric transformers. He reported that the trucks were able to drive off his barge and travel the dams at Six Mile Slough. He estimated the cost for providing a barge, tug boat, and pilot boat with crew to be from $4,000.00 to $5,000.00/day for completing the Six Mile Slough Wetland Restoration Project. Don Bjarnason (Field Operations Technician, Creston Valley Wildlife Management Area) coordinated the removal of the electric line. He is also familiar with barge access to Six Mile Slough.[18]

Improvements would probably need to be made to the access road and staging area for unloading and moving heavy equipment and supplies from the barge at Six Mile Slough. The road and parking lot would probably need to be graveled, and be made large enough so that the excavators, dump trucks with rock, and possibly logs can be unloaded and moved up the river bank to the work sites. One should examine the access site used by the barge to identify what improvements may be needed. Any improvements made to the access road and staging area may be removed when the project is completed.

The lowest elevation of water in Kootenay Lake occurs by March 31 each year. Under the International Joint Commission, Kootenay Lake has to be brought down to and kept below 1739.32 feet by March 31 each year - The elevation of water in Kootenay Lake can vary as much as 14-feet. The changing water levels may affect where and how boats and heavy equipment can access Six Mile Slough.

I suggest asking Don Bjarnason to show us the site used for barge access in advance of construction. This trip would confirm the feasibility of accessing the Six Mile Slough Wetland Restoration Project. It is also important to meet with heavy equipment contractors in advance to gain their ideas how best to complete the project. They could help answer questions concerning the number of excavators with operators to use at one time, and if the rock should be hauled in as needed, or all in advance.

Estimated cost for improving the staging area & access roads:

These cost estimates are based on a conceptual design prepared for the Six Mile Slough Wetland Restoration Project. The prices are not based on a detailed design, nor on bids received from contractors. A detailed design would be required to prepare an accurate budget for implementing the actions described in this report.

[18] Don Bjarnason, discussion with Tom Biebighauser, January 24, 2016.

Excavator (CAT 320E or equivalent): (10-hours) x ($210.00/hour) = $2,100.00
Rock: (4-tandem size dump truck loads gravel) x ($1,000.00/load) = $4,000.00
Wheat: (2-50lb bags) x ($30/bag) = $60.00.
Barge transportation: $3,000.00/day x 1-day = $3,000.00
Project Design and Supervision (includes salary and all travel costs): 2-days @ $1,200.00/day = $2,400.00.
Total = $11,560.00

Islands to be built at Six Mile Slough would be used by a great diversity of animals and plants

Heavy Equipment Requirements

Heavy equipment with skilled operators should be used to complete the Six Mile Slough Wetland Restoration Project. A Service Contract is recommended for hiring heavy equipment and operators to do the work. Under a Service Contract, the machines and operators are hired by the hour to build the wetlands. 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 price. The heavy equipment should be the size and type needed for restoring the wetlands. Tom Biebighauser and Robin Annschild are available to provide project management for this project, which would include preparing a RFQ (Request for Quote) contract package.

A minimum of two excavators with operators are recommended for completing the work at Six Mile Slough. This recommendation is based on experiences restoring similar wetlands in British Columbia, and across North America. Both pieces of heavy equipment and operators should be onsite working at the same time. Each machine should be operated by an experienced individual who is interested in restoring wetlands for fish and wildlife.

Excavator Specifications:

CAT 315C minimum size acceptable
(CAT320 or equivalent preferred)
Minimum 42-inch wide bucket (1.0yd^3) or larger
115HP Gross or greater
36,160lbs minimum weight
Working thumb attachment (for handling logs, root masses, and rocks)
No more than 10-years old (to reduce the likelihood of spills and breakdowns)

Here are advantages of using the above size excavator for restoring the wetlands, instead of using a smaller machine:

1. The excavator can stay in one place and reach a large portion of each work area. This saves destroying surrounding vegetation because the machine does not have to move over the entire work area to remove soil.
2. The excavator does not have to pick up and move the soil a number of times, greatly speeding progress. A smaller excavator must pick up and move the soil a number of times across a work area.
3. The larger excavator does not have to move the wooden mats or logs to stay afloat as often.
4. The unit cost of moving soil is less for using a large excavator compared to a small excavator.

Long Reach Excavators are available for hire in some regions. These excavators are made with a very long boom, and are often used for cleaning deep ditches. The long reach excavator is not as efficient as a standard reach excavator, and takes much longer to move the same quantity of soil.

Logs for Floatation

Logs may be needed to keep the excavators afloat during construction of the ephemeral wetlands. At least 15-logs would be needed for each excavator to use at one time. The logs are easily moved by an excavator using a thumb attachment. The logs should hold together long enough to build from 3 to 4 wetlands. Logs can be placed in the wetlands as snags while the wetlands are being built. Logs also break or become lost in the mud as work continues. More logs are needed to build additional wetlands, or if they are placed in the wetlands for wildlife habitat as the job progresses.

The logs should be at least 20-inches in diameter, and 21-feet long. Logs that are too long are difficult to move and get in the way of piling soil. Logs that are too short may tip, allowing the excavator to slide off and become stuck. Logs too small in diameter may break. Tree species that work well for logs include fir and larch. Cedar and hemlock are too soft and are likely to break. The contractor should have a chainsaw on site to trim the logs if needed.

The logs should be ordered in advance and piled where the excavator can access the area. A load of logs may be purchased from a logger in the area. An average of 45-logs can be hauled on a

full-size logging truck and trailer should be able to deliver 45-logs at a time. Delivering the logs with a self-loading or “hook” truck makes it easy to unload them at the site.

Large diameter logs are used to keep the excavator from sinking on saturated soils

Logs should be used to keep the excavator from sinking when building the wetlands. The logs should be of similar diameter and length to prevent the excavator from rocking and slipping.

Here a logger uses a self-loader to unload 45-logs at a wetland restoration site.

Permit Needs

Permits may be needed to complete this project. It is recommended that one begin the application process one or more years in advance of construction. The project may need to be completed during the fish window, between June 15 and August 15. An archeological Investigation should not be required because the area was disturbed by heavy equipment when the dams were built.

Restoring Biologically Productive Water Fluctuations:

Water elevations in Six Mile Slough are believed to have fluctuated widely prior to the construction of the Libby dam, channeling of the East Channel of the Kootenay River, and construction of dikes and dams. These fluctuations in water levels created habitat conditions that were ideal for migrating waterfowl and shorebirds. The stabilizing of water levels from historic management practices created conditions for the spread of nonnative species such as narrow leaf cattail and reed canary grass that now cover mudflats and shallow waters waterfowl and shorebirds once used during migration.

Returning all of the historic fluctuations in water levels in Six Mile Slough is not possible. However, it is possible to significantly increase seasonal flooding of Six Mile Slough by implementing the actions described in this report.

It would be necessary to carefully set the elevation at which water leaves and enters Six Mile Slough when the projects are completed. The place where water leaves a wetland is known as the *spillway* for the wetland, which is similar to the *riffle crest* for a stream. The elevation may be the same, or different for the four-dug channels connecting Six Mile Slough with the Kootenay River, and the one channel connecting Six Mile Slough with the East Channel of the Kootenay River.

The hydrographic data from 1930 to 1950 shows that Six Mile Slough formerly had significant fluctuations in water level – up to 5m change over the course of the year. It appears to have flooded every spring, and water levels dropped significantly in the fall. The constructed wetland compartments greatly reduce water fluctuations, keeping water out at some flood stages, and maintaining high water levels throughout the dry season.

Determining the spillway elevation for each channel would be challenging. Here is a summary of the advantages and disadvantages of making the connections between Six Mile Slough and the rivers deeper than what they are now:

Pros:
Longer time period for fish passage between the rivers and Six Mile Slough
Shallower water depth in Six Mile Slough
Improved habitat for waterfowl and the American Bittern in Six Mile Slough

Cons:
Smaller surface area of water in Six Mile Slough
Possible increase in cattail and reed canary grass growth in Six Mile Slough

A team of experts should be consulted concerning the question of spillway elevations. Tom Biebighauser and Robin Annschild are willing to take the lead in determining the optimum elevations for inlets and outlets in Six Mile Slough. The habitat needs of waterfowl and the white sturgeon should be main considerations. Land survey data for Six Mile Slough would be examined, along with data on water elevations in the Kootenay River, and the East Channel of the Kootenay River.

We know that that water is generally too deep in Six Mile Slough to benefit waterfowl, and that deepening the channels would benefit both white sturgeon and waterfowl. The main question is what elevation is best for the channels, after the dams and water control structures are removed.

Benefits to wildlife and fish

Waterfowl

Habitat for a diversity of breeding and migratory waterfowl would be improved by completing the Six Mile Slough Wetland Restoration Project. A biologically productive pattern of fluctuations in water level would be restored to Six Mile Slough. Large areas of shallow water would allow dabblers to forage in the wetlands. Features such as tufts, mounds, islands, peninsulas, branches, and logs would be added to increase invertebrate and plant abundance. The wetlands to be added would be made ephemeral. These wetlands would lack fish and would contain an abundance of aquatic plants, seeds, and invertebrates for ducks to eat.

These and other waterfowl species would benefit from implementing the Six Mile Slough Wetland Restoration Project:

1. American Goldeneye
2. American Wigeon
3. Blue-winged Teal
4. Cinnamon Teal
5. Canada Goose
6. Greater Scaup
7. Green-Winged Teal
8. Lesser Scaup
9. Mallard
10. Northern Shoveler
11. Pintail
12. Redhead
13. Ring-necked Duck
14. Ruddy Duck
15. Wood Duck

White Sturgeon

The Sturgeon is perhaps the most endangered fish in the world, according to the IUCN Red List of Threatened Species. The White Sturgeon is on the British Columbia Ministry of Environment Red List.

The White Sturgeon *Acipenser transmontanus* is found in the Kootenay River, which is adjacent to Six Mile Slough. The White Sturgeon moves freely between Canadian and American waters, using the Kootenay River between Kootenay Lake and Kootenai Falls, Montana. Experts believe the wild adult Kootenay River sturgeon will continue to decline.

Sturgeon make use of wetland habitats for feeding. White Sturgeon fry use wetlands for rearing areas. The construction of the Crowsnest railroad and the wetland compartment dams stopped the white sturgeon from accessing over 1,260-hectares (3,113-acres) of wetland habitat in Six Mile Slough.

White sturgeon may enter Six Mile Slough under severe flood conditions, and these fish most likely remain trapped in the wetland. The Six Mile Slough Wetland Restoration Project would remove over 5,591 meters of dikes and dams, providing the white sturgeon with regular access to over 1,260-hectares of natural wetland habitats.

Discussions with experts is being undertaken to identify how the Six Mile Slough Wetland Restoration Project could be designed to benefit the white sturgeon. Monitoring would be done in association with project implementation to quantify benefits of the project to the white sturgeon.

Burbot

The burbot is a landlocked species of cod that inhabits the Kootenay River Basin. In Idaho, the burbot are native only to the Kootenai River and are genetically distinct from burbot in the Montana reach of the river. Burbot once provided a substantial fishery with tens of thousands of burbot harvested annually. Burbot now number fewer than 1000 in the Kootenai River and Kootenay Lake and may be nearing demographic extinction. Studies completed in the winter of 1997-1998 indicated that flow management at Libby Dam was probably interfering with burbot spawning migration during winter.[19]

Although common in large portions of their range, the Kootenai population has declined significantly in past years. In the 1960s, the winter fishery on the Kootenai River was thought to have exceeded thousands of pounds of fish in both the commercial and sport harvest. In 1994, Idaho Department of Fish and Game only caught 8 fish for an average of 1 fish per 111 net days (Paragamian et al. 2000).[20]

Implementing the Six Mile Slough Wetland Restoration Project could restore a significant amount of habitat for the burbot along the Kootenay River. Actions could be taken to improve habitat for burbot in Six Mile Slough as part of this restoration project.

Discussions with experts is being undertaken to identify how the Six Mile Slough Wetland Restoration Project could be designed to benefit the burbot. Monitoring would be done in association with project implementation to quantify benefits of the project to the burbot.

Forster's Tern

The Creston Valley Wildlife Management Area is the only location where the Forster's Tern is found in British Columbia. Its nesting habitat varies from an unlined scrape in mud or sand, to elaborate raft of floating vegetation, or on top of muskrat lodges. They typically place their nests in clumps of marsh vegetation close to open water.[21]

The Forster's Tern has declined in some areas with loss or degradation of marsh habitat. Recreational boating on nesting lakes may have impact as well, since wakes from speedboats often floods nests.[22]

The Six Mile Slough Wetland Restoration Project would greatly improve foraging and nesting habitat for the Forster's tern. Hundreds of islands of various shapes and sizes would be created

[19]krisweb, Kootenai River Burbot: http://www.krisweb.com/kriskootenai/krisdb/html/krisweb/burbot/burbot.htm, pulled February 2, 2016.
[20] Burbot: http://fishandgame.idaho.gov/ifwis/cwcs/pdf/Burbot.pdf, pulled February 2, 2016.
[21] The Cornell Lab of Ornithology All about Birds. https://www.allaboutbirds.org/guide/Forsters_Tern/lifehistory. Pulled November 21, 2015.
[22] Audubon Guide to North American Birds. https://www.audubon.org/field-guide/bird/forsters-tern. Pulled November 21, 2015.

that the Forster's tern would use for nesting in wetlands. Six Mile Slough is not used for recreational boating, so these nests would be protected from wave damage.

American Bittern

The nesting of the American bittern is solitary and non-colonial, and their mating strategy is suspected to be polygamous. A platform nest is constructed out of reeds, sedges, cattail, and other emergent marshland vegetation, and is lined with fine grasses. Nests are typically located on the ground, or are constructed with a dense overhead cover and made to float on the surrounding water. Eggs are laid from late April to early May. There are typically three to five eggs in a clutch, and a single brood in a year. The eggs are incubated for 24-28 days before hatching, after which the chicks will remain near the nest for two weeks and be fed fish, frogs, snakes, crayfish and mice by the female.[23]

Relatively high numbers of American Bittern calling males were recorded in one annual survey conducted in the early 2000's in Six Mile Slough. It is not known if large numbers of American Bittern actually nested that year.[24] The Six Mile Slough Wetland Restoration Project would improve habitat for the American bittern by restoring shallow water wetland areas that would support a diversity of emergent vegetation, along with fish, frogs, and snakes used for food.

Shorebirds

Shorebirds make great use of mudflats in wetlands during migration. Building a wetland that produces mudflats in the spring and fall is quite challenging. Either the wetland is too dry, and grows dense upland vegetation that shorebirds do not use, or it's too wet, and grows dense aquatic vegetation shorebirds do not use. Water elevations must be constantly changing in a wetland to produce mudflats that shorebirds use.

Six Mile Slough would provide high quality habitat for shorebirds following the completion of the Six Mile Slough Wetland Restoration Project. The shallow water would be more likely to dry in the fall season, exposing mudflats that shorebirds require. Water levels in the wetlands would fluctuate more often, following changes in the Kootenay and East Channel of the Kootenay Rivers. These changing water levels would expose a greater area of mudflats shorebirds use.

A number of the ephemeral wetlands to be restored at Six Mile Slough can be expected to be used by shorebirds. Heavy equipment would be used to create shallow water basins with gradual slopes, and mudflats. Topsoil would not be returned to these shallow depressions to reduce plant growth, helping to maintain the presence of mudflats that shorebirds would use.

[23] ECOS Species Profile for American bittern (Botaurus lentiginosus), U.S. Fish and Wildlife Service, http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=B0F3#lifeHistory, pulled November 28, 2015.

[24] Email from Marc-Andre Beaucher to Tom Biebighauser, January 11, 2016.

Peninsulas, like this one, would be shaped in wetlands to restore mudflats for shorebirds.

Northern Leopard Frog

Northern leopard frogs have been documented using wetlands immediately adjacent to Six Mile Slough for breeding. They are expected to use Six Mile Slough, but surveys have not been completed in the large wetland. The majority of water in Six Mile Slough is perennial, and have the potential of supporting populations of the American bullfrog, and fish, that prey on the northern leopard frog. Fortunately, the American bullfrog has not be recorded at the Creston Valley Wildlife Management Area.

Wetlands would be restored in dry areas of Six Mile Slough to benefit the northern leopard frog. These wetlands would be made to contain water long enough for northern leopard frog larvae to develop, but not long enough to support fish or the American bullfrog.

The following features would be added to the wetlands to improve habitat for the northern leopard frog:

1. Shallow water areas in sunlight.
2. Piles and ridges of loose soil, both dry and saturated
3. Piles of organic material
4. Logs and branches

The wetlands should be of great benefit to northern leopard frogs for breeding. They are located near where the species is found, in areas surrounded by meadows. The wetlands would be supplied with a combination of surface water and groundwater. Rainfall and runoff should help keep the temperature of water in the wetlands warm enough to promote egg and larvae development. The northern red-legged frog is most successful breeding in surface water wetlands, compared to groundwater wetlands, and the same could be true for the northern leopard frog.

One of 9-large wetlands restored by the authors on the Creston Valley Wildlife Management Area in December, 2016 to provide habitat for the Northern Leopard frog. The Northern leopard frog began using the new wetlands in 2017.

Here is an example of shallow, ephemeral wetland, surrounded by cattails. This wetland is located at Bummers Flats.

Here is an example of a shallow, ephemeral wetland, surrounded by cattails. This wetland is located at Goat River near Six Mile Slough. The flat bottom in the wetland may have been caused by livestock grazing

Western Painted Turtle

The western painted turtle is found at the Creston Valley Wildlife Management Area. The following actions would be taken to improve habitat for the species at Six Mile Slough:

1. A diversity of wetlands of various sizes, shapes, and depths would be restored.
2. Islands, tufts, ridges, and logs, and root masses would be added to wetlands for basking.
3. Areas of sandy loam texture soil would be spread in sunlit locations near the restored wetlands for turtle nesting.
4. Hibernaculum for turtles would be created during the restoration of ephemeral wetlands by creating deep, saturated soils in places where springs emerge.

Western Toad

Western toads are likely to breed in the ephemeral wetlands to be restored by this project. The water in the ephemeral wetlands should support the warm temperatures needed for egg and larvae development. The hydro-period of the wetlands should not be long enough to support fish or the American bullfrog, which conflict with western toad management.

Wildlife Habitat Features:

Large Woody Debris

Large logs, branches, and root masses would be placed in Six Mile Slough and the ephemeral wetlands to be restored to improve habitat for waterfowl, invertebrates, fish, and a diversity of plants and animals.

Logs placed in wetlands support a diversity of plants.

Small Woody Debris

Branches of various diameters and lengths would be placed in the wetlands to provide egg attachment sites for amphibians, and improved habitat for invertebrates.

Logs would be placed in the restored wetlands to provide loafing sites for waterfowl.

Planting

The restored ephemeral wetlands, islands, and peninsulas do not have to be seeded or planted to be successful. However, seeding and planting these areas to native species would reduce the possibility of nonnative plants colonizing the sites, and increases animal and plant diversity. Compacted soils would be loosened as part of wetland restoration, reducing the potential for erosion and providing ideal conditions for plant survival and growth.

The seeds from a diversity of native sedges and rushes may be collected from wet-meadows on the Creston Valley Wildlife Management Area, and sown by hand on soil exposed during restoration of the wetlands. It is recommended that the exposed soil surrounding each restored wetland be seeded to wheat for erosion control and weed suppression. Native wildflowers may also be seeded to benefit pollinators.

Root masses would be placed in the restored wetlands to provide resting sites for waterfowl, and basking sites for turtles.

Arrowhead is growing throughout the nine large wetlands restored on the Creston Valley Wildlife Management Area, near the Old Goat Channel. The wetlands were restored in December, 2016.

Mosquitoes

The wetlands can be expected to lower mosquito populations. The dragonfly larvae, damselfly larvae, water boatman, water striders, frogs, toads, and salamanders living in the new wetlands would control mosquito numbers. Swallows, bats, and adult dragonflies flying near the wetlands would consume adult mosquitos. The wetlands can be expected to become population "sinks" for mosquitoes.

Cattails & Reed Canary Grass Control

There is great concern that cattails and reed canary grass would take over wetlands to be restored at the Creston Valley Wildlife Management Area. Both species dominate the areas where wetland projects are proposed. Fortunately, techniques have been developed to prevent this from happening. These techniques have been used across British Columbia and other regions with success.

Here's a summary steps that would be taken to control cattails and reed canary grass, and to prevent any one plant from dominating the wetlands to be restored:

1. The excavator would be used to remove cattails, cattail rhizomes, and roots.
2. The excavator would be used to remove reed canary grass and its roots.
3. The excavator would be used to remove topsoil from areas marked for ephemeral wetland restoration.
4. The cattail and reed canary grass parts, along with associated topsoil, would be removed and covered with mineral soil so they do not grow
5. The bottom of each ephemeral wetland restored would be clay, silt, and sand, not topsoil.
6. The elevations in and around each wetland would be varied to include deep and shallow areas.
7. Ridges, mounds, tufts, scrapes, would be created within and surrounding each wetland basin.
8. Exposed soils would be seeded to a diversity of sedges, and wheat, the same day the wetland is completed.
9. The fluctuating water levels in restored ephemeral wetlands would discourage the growth of cattails and watershield.

The wetlands to be restored should be monitored for cattail colonization following restoration. Young cattails growing in the new wetlands should be removed for 3-years following construction. These intensive efforts can be concentrated in areas of high value to the Northern Leopard Frog to facilitate the colonization of a diversity of sedges and rushes in the wetlands.

Project Scheduling

Tom Biebighauser and/or Robin Annschild are available to assist with the implementation of the Six Mile Slough Wetland Restoration Project. Tom and Robin would work with contractors and heavy equipment operators, and help train personnel how to complete wetland restoration projects. Tom and Robin are also available to help prepare the contract for the project if needed.

Detailed Design

A detailed design for the Six Mile Slough Wetland Restoration Project may be prepared. The design may be completed by Tom Biebighauser and Robin Annschild, in partnership with the Creston Valley Wildlife Management Area, Ducks Unlimited Canada, and other agencies and organizations. The design would address the following questions concerning the management of Six Mile Slough:

1. Feasibility of installing large diameter culverts in the Crowsnest Railroad grade.
2. Determination of spillway elevations for each channel connecting Six Mile Slough with the Kootenay River and East Channel of the Kootenay River.
3. The permits needed for implementing restoration actions.
4. Whether Six Mile Slough should be accessed by boat or by rail.
5. The best location(s) used for accessing Six Mile Slough for restoration.
6. Locations and numbers of ephemeral wetlands that may be restored within Six Mile Slough.
7. Locations of trees and root masses that may be used for restoring Six Mile Slough.
8. Whether the elevation of river banks should be lowered to increase flooding of Six Mile Slough.
9. Heavy equipment contractors who are interested in the restoration project.
10. An accurate cost estimate for completing the Six Mile Slough Wetland Restoration Project.

Wetland Photos

Photographs showing wetlands and streams built on public and private lands are available for viewing at: www.wetlandrestorationandtraining.com Detailed information describing how wetlands were drained and streams were moved can found in the book *Wetland Drainage, Restoration, and Repair* by Thomas R. Biebighauser. Instructions concerning how wetlands may be restored are available in his book: *Wetland Restoration and Construction – A Technical Guide.*

Summary

The Six Mile Slough Wetland Restoration Project would restore over 1,260-hectares of emergent and ephemeral wetlands on the Creston Valley Wildlife Management Area near Kootenay Lake in British Columbia. Habitat conditions would be significantly improved for tens of thousands of migrating waterfowl and shorebirds. Special actions would be taken to increase habitat for the

white sturgeon and burbot by removing over 6,000-meters of constructed dams, and failed water control structures. Nesting habitat for the uncommon Forster's tern would be improved by constructing hundreds of naturally appearing islands when dams are removed. Features would be returned to Six Mile Slough to benefit waterfowl, the American bittern, western painted turtle, white sturgeon, and burbot. Ten or more ephemeral wetlands would be restored specifically to increase habitat for the northern leopard frog, and for waterfowl. The restored wetlands would greatly improve wildlife viewing opportunities, clean runoff, and recharge groundwater. The restored Six Mile Slough would appear natural, and require no maintenance.

Recommendations

1. Obtain permits needed to complete the Six Mile Slough Wetland Restoration Project.
2. Complete a detailed design for the Six Mile Slough Wetland Restoration Project.
3. Examine the possibility of installing culverts in the Crowsnest Railway that crosses Six Mile Slough.
4. Request funding to implement the Six Mile Slough Wetland Restoration Project.
5. Identify skilled heavy equipment operators to help complete the Six Mile Slough Wetland Restoration Project.
6. Complete the Six Mile Slough Wetland Restoration Project when the Kootenay River is not flooding.
7. Schedule Tom Biebighauser and Robin Annschild to assist with the planning and implementation of the Six Mile Slough Wetland Restoration Project.

About the designers

This report was prepared for the Creston Valley Wildlife Management Area by Tom Biebighauser and Robin Annschild:

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Tom Biebighauser is a Wildlife Biologist and Wetland Ecologist who has restored over 2,000 wetlands in 24-States, in Canada, New Zealand, Puerto Rico, and Taiwan. He retired in 2013 after working 34-years for the U.S. Forest Service as a Wildlife Biologist. Tom has designed over 400-wetlands in British Columbia. 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 college courses on the topic. He received the National Wetlands Award for Conservation and Restoration in 2015.

You are encouraged to visit http://www.wetlandrestorationandtraining.com/?page_id=427 to see photos of the wetlands he has restored. Please visit www.wetlandrestorationandtraining.com for information about training offered in wetland restoration techniques.

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Robin Annschild has worked with Tom Biebighauser to restore 219-wetlands in British Columbia, Arizona, California, and South Carolina. She works with Tom Biebighauser to provide wetland restoration project design, management and construction supervision for sites across British Columbia. Robin developed project management and program planning skills in her former role as a conservation director for the Salt Spring Island Conservancy. Under Robin's leadership, the Salt Spring Conservancy's conservation program raised $4.8 M dollars in program and acquisition funds to protect and restore habitat for over 50 species at risk on Salt Spring Island.