Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Wetland Loss and Disturbance Monitoring Report

TEMP-2017-03

KEEYASK

Manitoba Sustainable Development Client File 5550.00
Manitoba Environment Act Licence No. 3107

2016 - 2017

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2017-03

WETLAND LOSS AND DISTURBANCE

MONITORING REPORT

Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

June 2017

This report should be cited as follows:

ECOSTEM Ltd. 2017. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2017-03: Wetland Loss and Disturbance Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2017.

SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. Before the government issued a licence to construct the Project, the Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the generating station on the terrestrial environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station are affecting the environment, and whether or not more needs to be done to reduce harmful effects.

This report describes the results of wetland loss and disturbance monitoring conducted during the third summer of Project construction. Surveys were carried out in and near wetlands that had been identified for avoidance, where possible, near the Project construction areas.

Why is the study being done?

Wetlands are land areas where the ground is usually either wet or under shallow water. Wetlands are important for the ecosystem and people for many reasons, such as protecting shorelines, adding to the variety of habitat types and providing good areas to find wildlife. Several medicinal and country food plant species used by Members of the partner First Nations (e.g., sweet flag [*wekes*, *wekas* or *wihkis* in Cree], tamarack) are either only or most often found in wetlands. In the Keeyask region, marsh off the Nelson River is a very important wetland type mostly because it is rare and it provides the only very good habitat for some kinds of plants and animals. Off-system marshes (i.e., those not along the Nelson River) are usually good areas to hunt moose and waterfowl.

Several different kinds of wetlands at Wetland 40

What was done?

The existing environment section of the EIS has mapped and characterized the various wetlands in the Project footprint area. Since it is impossible to avoid all of the wetlands given the size of the Project footprint, mitigation is provided. As construction proceeds, this monitoring program documents impacts on, and mitigation related to, the very important wetland types to make sure the predictions are accurate and that no additional unanticipated impacts are occurring.

Off-system marsh habitat (which includes existing marshes) were the very important wetlands monitored in 2015 and 2016. Each monitored wetland included the entire waterbody containing marsh habitat, plus a 100 m buffer of the waterbody. In total, 42 wetlands are being monitored under this study.

Thirty-nine of the 42 wetlands were surveyed from a helicopter on August 20, 2016 because they were within 1 km of existing Project construction activities. Eleven of these 39 wetlands were also surveyed on foot between August 21-23, 2016 because they were within 100 m of Project construction activities.

What was found?

Twelve wetlands were within 100 m of existing Project clearing or disturbance at the time of the 2016 surveys. Portions of seven of these 12 wetlands overlapped areas burned in the 2013 wildfire. The 2013 wildfire was unrelated to the Project.

A total of 1.11 ha of Project clearing or disturbance was found at four of the 42 wetlands being monitored. This was not unexpected since a portion of these wetlands overlapped either a dyke, road or reservoir clearing. For three of these four locations, the Project impacts were only within the buffer zone (and not in the marsh habitat), and only on one side of the wetland. At the fourth marsh, a band of trees at one end of the marsh was cleared for the future reservoir.

The remaining eight of the 12 wetlands located within 100 m of actual Project clearing or disturbance had not been impacted by these activities. All of these wetlands had potential future impacts that merited either a mitigation recommendation or a particular focus during ongoing monitoring. At four of the eight wetlands, mineral slopes between a Project feature (e.g., dyke, excavated material placement area) and the wetland's buffer zone had been exposed by Project clearing or by being burned in the 2013 wildfire. These exposed slopes pose a risk in that heavy rains may carry sediment or other materials into the marsh habitat. At the remaining four wetlands, runoff from an access road or from nearby clearing unrelated to the Project had the potential to have future effects on the marsh habitat.

What does it mean?

To date, there have been no unanticipated impacts on the wetlands being monitored by this study. While some Project clearing or disturbance occurred in a portion of four wetlands, it was expected that there would be some impacts at wetlands close to active construction areas.

Erosion control or other mitigation measures have been recommended where there are potential future risks to the off-system marsh or its habitat.

What will be done next?

More off-system marsh wetland monitoring will be done in 2017 (Year 4 of construction) at wetlands that may be affected by construction activities to date. Where needed, additional mitigation measures will be recommended after the 2017 surveys.

ACKNOWLEDGEMENTS

ECOSTEM Ltd. would like to thank Rachel Boone, Sherrie Mason and the on-site Manitoba Hydro staff, including Caroline Walmsley, Megan Anger, Brian Fournier and Linda Campbell for their support and assistance in planning field activities and access to the sites. Rachel Boone is also gratefully acknowledged for coordinating the terrestrial monitoring studies.

Chiefs and Councils of Tataskweyak Cree Nation (TCN), War Lake First Nation (WLCN), York Factory First Nation (YFFN) and Fox Lake Cree Nation (FLCN) are gratefully acknowledged for their support of this program. We would also like to thank Clayton Flett and Douglas Kitchekeesik of TCN for arranging logistic support and providing field staff for studies. Peter Massan (TCN) and Peter Beardy (TCN) are gratefully acknowledged for their guidance and work in the field.

We would also like to thank North/South Consultants Inc., in particular Ron Bretecher, Shari Fournier and Mary Lang, for their guidance, logistical support and other resources that made these studies possible.

Custom Helicopters is gratefully acknowledged for providing transportation during fieldwork and Ben Hofer for coordinating the logistics.

STUDY TEAM

Dr. James Ehnes was the project manager and study designer.

Fieldwork in 2016 was conducted by Alex Snitowski and Ryan Sheffield.

Data analysis and report writing in 2016 were completed by Alex Snitowski and James Ehnes. GIS analysis and cartography was completed by Alex Snitowski.

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1.0 INTRODUCTION

Construction of the Keeyask Generation Project (the Project), a 695 megawatt hydroelectric generating station (GS) and associated facilities, began in July 2014. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle GS.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project (KHLP 2012a). Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TE SV; KHLP 2012b). The *Terrestrial Effects Monitoring Plan* (TEMP) was developed as part of the licensing process for the Project (KHLP 2015). Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, wetland monitoring, during the construction and operation phases.

A wetland is a land ecosystem where periodic or prolonged water saturation at or near the soil surface is the dominant factor shaping soil attributes and vegetation distribution and composition. Wetland functions are the natural properties or processes that are associated with wetlands, stated in ways that describe what they do for the ecosystem.

As described in the Project's TEMP, two studies are monitoring Project effects on wetland function. During construction, the Wetland Loss and Disturbance study is monitoring direct Project effects on wetlands due to terrestrial habitat loss and disturbance (see KHLP 2015, Section 2.5.2). During operation, the Long-Term Effects on Wetlands study will monitor long-term direct and indirect Project effects on wetland function (see KHLP 2015, Section 2.5.3). The Created Wetlands study will monitor the efficacy of mitigation measures implemented to create 12 ha of off-system marsh (see KHLP 2015, Section 8.1).

This report presents results for the Wetland Loss and Disturbance study.

The goal of the Wetland Loss and Disturbance study is to determine direct Project effects on wetland function during construction. Based on this goal, the objectives of this study are to:

- Verify the implementation and effectiveness of off-system marsh protection measures; and,
- Quantify and situate direct Project effects on wetland function during construction based on wetland quality scores.

This report addressed the first of these objectives based on monitoring conducted in 2015 and 2016. A report following the end of construction will provide a detailed evaluation of effects on off-system marshes as well as addressing the second study objective. ECOSTEM (2016) provides results for the wetland loss and disturbance monitoring conducted in 2015.

2.0 METHODS

Section 2.5.2 of the TEMP details the methods for the Wetland Loss and Disturbance study, which began in 2015. The following summarizes the activities conducted in 2016. The methods were the same as in 2015.

Prior to describing the activities, some terminology is defined to assist the reader. In the terrestrial habitat, ecosystems and plant studies, clearing refers to complete vegetation removal in a patch that was at least 400 m^2 in size. Disturbance refers to either physical disturbance in intact vegetation (e.g., machinery trail, test pits), use of a pre-existing trail or a clearing smaller than 400 m^2. Also, "impacts" refer to what the Project does in terms of the question of interest (*e.g.*, vegetation clearing), while "effects" refer to the consequences relative to the question of interest (*e.g.*, marsh habitat loss, reduced wetland function).

Environmental impact statement (EIS) studies had mapped the locations of the off-system marshes situated in Study Zone 4 as of 2012. The overall amounts and locations of off-system marsh can change from year to year in response to water level variations and other factors. Additionally, the waterbodies containing mapped off-system marsh were generally shallower than 2 m. On this basis, the entire waterbody containing a mapped marsh, and its shore zone, was considered to be off-system marsh habitat.

Marsh habitat is sensitive to human impacts such as physical disturbance or hydrological alterations. On this basis, the Wetland Loss and Disturbance study also monitors effects on a 100 m buffer zone of each of the selected marsh habitats in addition to effects on the marsh habitat (*i.e.*, the waterbody and its shore zone. These buffers coincide with those included in the Project's Environmental Protection Plans (EnvPPs) with the exception that the EnvPPs do not include buffer areas that overlap the permanent Project infrastructure.

Hereafter, references to a monitored wetland include the marsh habitat (*i.e.*, a waterbody containing off-system marsh, and its shore zone) and its 100 m buffer zone. In addition to being an EnvPP sensitive area, the buffer zone around most of the selected marsh habitats was partially or entirely comprised of a mixture of peatlands and other wetlands. Each of the monitored wetlands was assigned a unique identifier for the monitoring (*e.g.*, Wetland 21).

To meet the first study objective (Section 1.0), the Wetland Loss and Disturbance study includes annual surveys during construction. Mapping and analysis for the second objective is completed after construction completion.

The wetlands selected for monitoring related to the first objective of the Wetland Loss and Disturbance study (Section 1.0) were those situated in Study Zone 3. Wetlands outside of Study Zone 2 (*i.e.*, the areas of direct and indirect terrestrial habitat effects) were included because it was possible for some hydrological effects to extend for a considerable distance beyond the Project footprint. Map 2-1 shows the 42 wetlands being monitored for this study objective.

In each construction year, surveys are conducted at all of the monitored wetlands that are within approximately 1 km of the Project clearing or disturbance existing at the time of the surveys[1]. A large buffer was used for the selection for two reasons: physical disturbance may not be visible in the digital orthorectified images (DOIs) used to select the wetlands (see below); and additional area may have been cleared between the time the DOIs were acquired and when the fieldwork would be conducted.

For the 2016 monitoring, the selection of wetlands for inclusion in the field surveys was completed in two stages. In the first stage, the DOI created from Worldview 2 imagery acquired on June 22, 2016 was used to determine the extent of Project clearing to date. All of the wetlands within approximately 1 km of this clearing were selected for aerial survey.

During the second stage of site selection, an aerial survey determined which of the monitored wetlands were within 100 m of Project clearing or disturbance at the time of the surveys. Wetlands within 100 m of existing clearing or disturbance were ground surveyed unless there were safety-related access restrictions due to construction activities.

The desktop selection in the first stage identified 39 wetlands for inclusion in the 2016 aerial survey. These were the monitored wetlands that had the potential to have been affected by construction activities to date based on their location. Aerial surveys conducted on August 20, 2016 indicated that Wetlands 3, 17, 37, 40, 42, 45, 47, 51, 52, 53, 54 and 57 were within 100 m of Project clearing or disturbance at the time of this survey.

Ground surveys on August 21 to 23, 2016 documented mitigation measures and possible Project effects at 11 wetlands (Map 2-1). The twelfth wetland (Wetland 42) within 100 m of existing clearing or disturbance could not be ground surveyed due active construction between the road and the wetland.

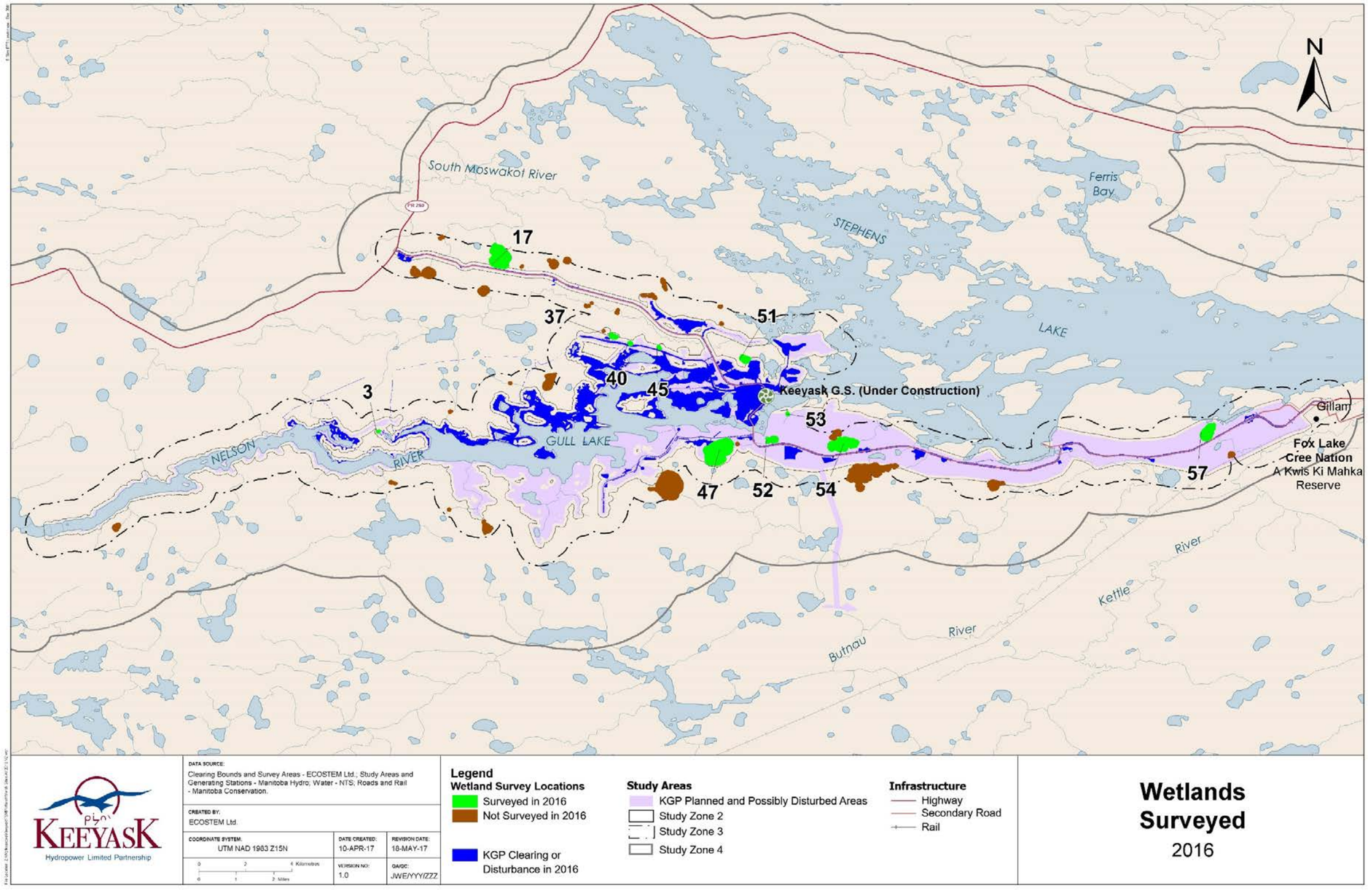
Conditions in the relevant wetlands were recorded with geo-referenced photographs, marked-up maps and/or notes. The nature of works to control Project-related erosion, siltation, and surface hydrological alteration were recorded, as well as any erosion, siltation, or surface hydrological alteration.

The spatial extent of impacts on the surveyed wetlands were mapped in a GIS. The base map for most of the wetlands was a DOI created from Worldview 2 imagery acquired on September 21, 2016. The June 2016 DOI was used for wetlands outside of the September DOI spatial extents.

Some of the reported results distinguish between impacts in the three zones identified in the Project's EnvPPs, which are the red, green and yellow zones. The red zones are environmentally sensitive terrestrial sites within the possibly disturbed areas of the licensed Project Footprint, which are to be avoided to the extent practicable. The yellow zones are the remaining areas within the possibly disturbed areas of the licensed Project Footprint. The green

[1] In the terrestrial habitat, ecosystems and plant studies, clearing refers to complete vegetation removal in a patch that was at least 400 m^2 in size. Disturbance refers to either physical disturbance in intact vegetation (e.g., machinery trail, test pits), use of a pre-existing trail or a clearing smaller than 400 m^2.

zones are all of the planned Project footprint. Since the planned footprint is largely comprised of permanent features, there is limited flexibility to reduce or relocate Project impacts in these areas. As such, there are no requirements for the contractor to avoid any areas within the EnvPP green zones.



Map 2 1: Wetlands ground-surveyed in 2016

3.0 RESULTS

Aerial surveys conducted on August 20, 2016 found that 12 of the 42 wetlands being monitored during construction were within 100 m of Project clearing or disturbance at the time of the surveys (Map 2-1). Portions of seven of the 12 wetlands had been burned in the 2013 wildfire (which was unrelated to the Project), with the percentage of buffer area burned ranging from 5% to 90%.

At the time of the 2016 monitoring surveys, six of the 12 wetlands within 100 m of Project clearing or disturbance had Project clearing in a portion of its buffer zone; and one of these six wetlands (Wetland 3) also had clearing in a portion of the marsh habitat (Table 3-1). At four of the six wetlands, all of the Project impacts occurred after the 2015 surveys. Figure 3-1 to Figure 3-6 provide aerial views of the 12 wetlands.

The remainder of this section describes what was found at each of the 12 wetlands situated within 100 m of Project impacts and, where relevant, suggests possible additional mitigation or protection measures. Table 3-1 summarizes the primary noteworthy findings.

Cover Class	Percent Cover Range
Very sparse	>0 - 3%
Sparse	3 - 10%
Low	11 - 25%
Moderate	26 - 50%
High	51 - 75%
Very high	76 - 100%

Table 3-1: Impacts and potential future effects in the wetlands within 100 m of the September, 2016 Project footprint

Wet-land ID[1]	Wetland Area			Project Impacts2 in EnvPP Yellow and Red Zones			Other Project Impacts in 2016	2013 Burn in Buffer[3]	Noteworthy Potential Future Effects
	Total	Marsh Habitat	Buffer Zone	Total	Marsh Habitat	Buffer Zone			
3	5.0	1.1	3.9	0.25	0.01	0.24	None	90	None
17	135.1	97.5	37.6	-	-	-	None	85	Additional water flow from a road culvert
37	17.0	4.1	12.9	0.01	-	0.01	None	5	None
40	7.9	1.2	6.7	-	-	-	None	10	Runoff from dyke clearing through vegetated area
42	15.5	2.9	12.6	-	-	-	None	50	Runoff from borrow area clearing through vegetated area
45	7.3	0.8	6.5	-	-	-	None	50	Runoff from dyke clearing through burned area
47	189.1	140.7	48.4	0.05	-	0.05	None	0	None
51	25.7	10.5	15.2	-	-	-	Sediment deposition from an EMPA into the buffer zone	20	Sediment and deposition of other materials into the marsh habitat or Stephens Lake
52	28.4	9.1	19.3	-	-	-	None	0	Hydrological effects from a road culvert
53	5.5	0.3	5.2	-	-	-	None	0	None
54	113.1	70.1	43.0	-	-	-	None	0	Runoff from KTP ROW clearing through vegetated area
57	64.6	37.6	27.0	0.81	-	0.81	None	0	Low water levels in marsh habitat. Causes to be investigated.
All	614.2	375.8	124.4	1.11	0.18	0.93			

Notes: [1] All wetlands except Wetland 42 were ground sampled in 2016. Bold font identifies wetlands that were also ground sampled in 2015.

[2] Mapped Project clearing or physical disturbance. See ECOSTEM (2017) for the mapping.

[3] Percentage of total buffer area that burned in the 2013 wildfire (which was unrelated to the Project).

Wetland 3

Wetland 17

Figure 3-1: Aerial views of Wetland 3 and 17 on August 20, 2016

Wetland 37

Wetland 40

Figure 3-2: Aerial views of Wetland 37 and 40 on August 20, 2016

Wetland 42

Wetland 45

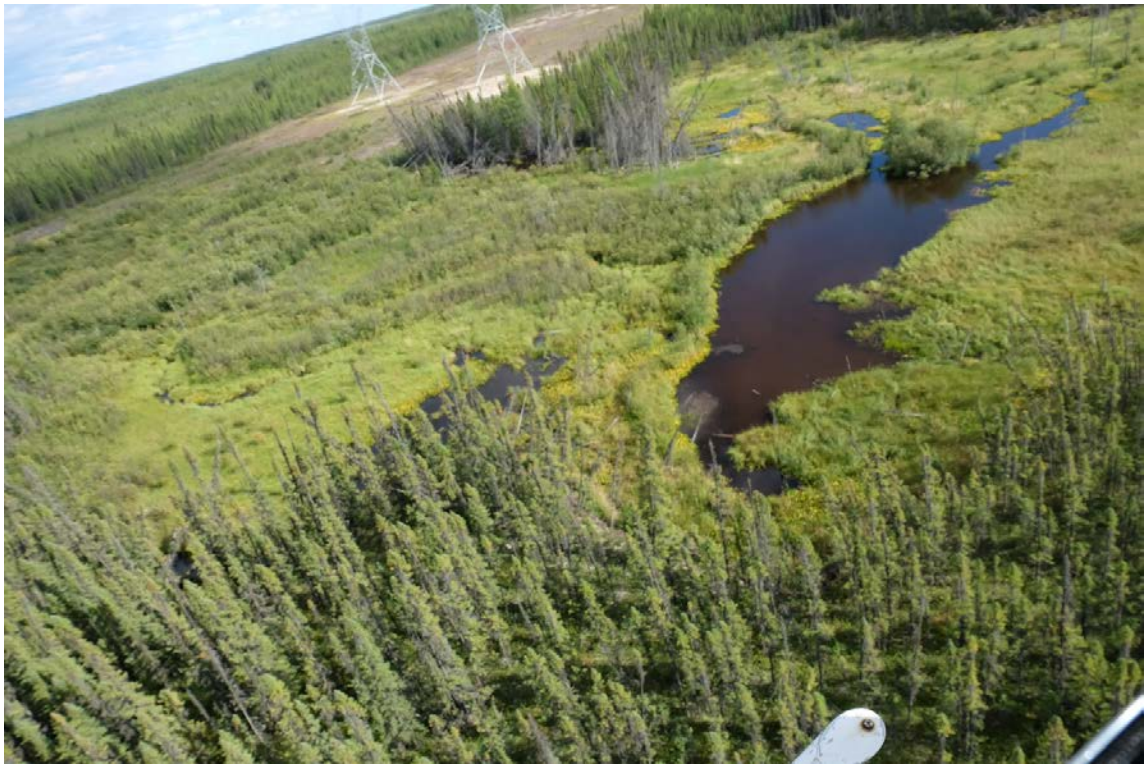
Figure 3-3: Aerial views of Wetland 42 and 45 on August 20, 2016

Wetland 47

Wetland 51

Figure 3-4: Aerial views of Wetland 47 and 51 on August 20, 2016

Wetland 52



Wetland 53

Figure 3-5: Aerial views of Wetland 52 and 53 on August 20, 2016

Wetland 54

Wetland 57

Figure 3-6: Aerial views of Wetland 54 and 57 on August 20, 2016

3.1 WETLAND 3

Wetland 3 (Figure 3-1) is 5.0 ha in size (Table 3-1), and located about 1 km from the Nelson River, approximately 21 km west of the generating station site (Map 2-1). Marsh habitat comprises 1.1 ha of the wetland's total area. Approximately 90% of the buffer zone (*i.e.*, a 100 m buffer of the marsh habitat; see Section 2.0 burned in a 2013 wildfire that was unrelated to the Project.

No Project clearing or disturbance was observed in Wetland 3 during the 2015 survey.

At the time of ground surveys in August 2016, a band of trees ranging from approximately 1 to 10 m wide in the marsh habitat (Figure 3-7, Figure 3-8), as well as within the buffer zone, had been removed by reservoir clearing. This clearing, which was situated along the shoreline, impacted 0.25 ha of the total 5.0 ha marsh area, including 0.01 ha of marsh habitat (Table 3-1). All of this clearing was within an EnvPP red zone. No other Project impacts (*e.g.*, sedimentation, hydrological alterations) were noted at Wetland 3 in 2016.

Figure 3-7: Cleared trees along the Nelson River shoreline in the marsh habitat of Wetland 3 in August, 2016

Figure 3-8: Aerial view of cleared trees in the marsh habitat of Wetland 3 in August, 2016

3.2 WETLAND 17

Wetland 17 (Figure 3-1) is 135.1 ha in size, and located on the southwest shore of a small lake situated at approximately kilometre 6 along the north access road (NAR; Map 2-1). Marsh habitat comprises 97.5 ha of the wetland's total area. Approximately 85% of the buffer zone burned in the 2013 wildfire.

To date, Project disturbance or clearing has not been observed within Wetland 17. A small natural depression between the NAR and the lake near the south end of the marsh has the potential to carry runoff water towards the marsh. There were no obvious signs of median water level changes in 2015 or in 2016.

Some shrub and white birch mortality were observed in 2015 along the south side of this marsh at the shoreline (Figure 3-9), with some of the dead stems emerging from the water. The cause of this vegetation mortality was unclear. Some possibilities include the 2013 wildfire, depth to groundwater changes after the wildfire, ground slumping after massive ground ice below the peat had melted (see next paragraph), or indirect hydrological effects of nearby construction. No incremental changes were observed in these locations in 2016.

Shoreline slumping was observed around the southwestern edge of the marsh (Figure 3-9) was observed in 2015. Given its distance from the NAR, this slumping was likely caused by melting massive ground ice in peat (which the EIS showed was naturally occurring in the region).

Ground ice melting was likely accelerated in locations burned during the 2013 wildfire. No incremental changes were observed in these locations in 2016.

Future surveys will continue to monitor these locations.

View along the shore of Wetland 17

Ground slump along the southwestern edge of Wetland 17 (likely due to melting ground ice in peat plateau bog)

Figure 3-9: Ground photos of Wetland 17 in August, 2016

Shrub mortality at Wetland 17

Figure 3-9: Continued...

3.3 WETLAND 37

Wetland 37 (Figure 3-2) is 17.0 ha in size, and situated near the north dyke, adjacent to EMPA D3-E (Map 2-1). Marsh habitat comprises X ha of the wetland's total area. Approximately 5% of the buffer zone burned in the 2013 wildfire.

Project clearing or disturbance was not observed in Wetland 37 in 2015.

The 2016 ground survey found that a very small amount of EMPA clearing (< 0.01 ha; Table 3-1) extended into the buffer zone (Figure 3-10). All of this clearing was within the Project's possibly disturbed area. No other Project impacts were noted at Wetland 3 in 2016. Mitigation measures were not observed in this area in 2016.

It is recommended that further clearing of the northeastern edge of this EMPA be limited to minimize the potential impacts on the marsh habitat in Wetland 37. These should be monitored for any potential effects from runoff as they are downslope of the cleared area.

View along the shores of Wetland 37

Clearing into the Wetland 37 buffer

Figure 3-10: Ground photos of Wetland 37 in August 2016

3.4 WETLAND 40

Wetland 40 (Figure 3-2) is 7.9 ha in size, and located along the north dyke, approximately 750 m east of Wetland 37 (Map 2-1). Marsh habitat comprises 1.2 ha of the wetland's total area. Approximately 10% of the buffer zone burned in the 2013 wildfire.

The 2013 wildfire burned areas south and east of this wetland.

There was no Project clearing or disturbance observed within Wetland 40 during the 2015 ground survey.

By the time of the 2016 survey, planned dyke clearing had impacted the southern portion of Wetland 40 (Figure 3-11), extending to approximately 3 m away from the of the marsh habitat (Figure 3-12). Some of the marsh habitat within the planned clearing (or EnvPP green zone) had been avoided. No other Project impacts were noted at this wetland in 2016.

A situation that could create future Project effects on this wetland consisted of a very shallow slope which extended through the Project clearing area to the edge of the open water (Figure 3-12). The exposed mineral slope created the potential for runoff from the dyke to transport material into the marsh, either on the surface or by eventually moving through the peat. These areas will be monitored for any future effects from runoff.

It is recommended that site staff evaluate and implement sediment control measures where needed to prevent sediment and other runoff from entering the marsh site (*e.g.*, a silt fence be erected at the base of the slope). It is also recommended that a northward extension of the existing dyke clearing be avoided, if possible, to limit additional impacts on Wetland 40.

View along the shores of Wetland 40

Clearing and burned area close to Wetland 40

Figure 3-11: Ground photos of Wetland 40 in August 2016

Figure 3-12: Aerial view of dyke clearing (all within an EnvPP green zone) at Wetland 40 in September 2016

3.5 WETLAND 42

Wetland 42 (Figure 3-3) is 15.5 ha in size, and located approximately 750 m north of the NAR at kilometre 14, at the northwestern end of Borrow Area KM15 (Map 2-1). Marsh habitat comprises 2.9 ha of the wetland's total area. Approximately 50% of the buffer zone burned in the 2013 wildfire.

There was no Project clearing or disturbance observed near Wetland 42 during the 2015 aerial survey.

Ground surveys were not conducted at Wetland 42 in 2016 due to safety-related access restrictions. Aerial surveys in 2016 found that clearing for Borrow Area KM15 had expanded northwest towards Wetland 42 since 2015. At the time of the 2016 surveys, clearing was still approximately 90 m away from the wetland boundary. Project disturbance within the wetland was not visible in the DOIs or aerial photos.

During the 2016 aerial survey, it was noted that there was a significant slope downwards from Borrow Area KM15 clearing to the southern edge of the wetland (Figure 3-13). A sediment control recommendation was not made given the amount of undisturbed vegetation between the exposed mineral area and the marsh habitat. This area will continue to be monitored in order to determine if there is any erosion or surface runoff from the slope into the marsh.

Figure 3-13: Aerial view of Wetland 42 from the northeast and Borrow Area KM15 clearing to the south in August 2016

3.6 WETLAND 45

Wetland 45 (Figure 3-3) is 7.3 ha in size, and located along the north dyke, approximately 1.5 km east of Wetland 40 (Map 2-1). Marsh habitat comprises 0.8 ha of the wetland's total area. Approximately 50% of the buffer zone burned in the 2013 wildfire. Some of the burned area was between the planned north dyke and the marsh habitat, and some sites within this area had either a thin layer of organic matter or exposed mineral substrate.

At the time of the 2015 ground survey, north dyke clearing extended approximately 3 m into the buffer zone on the south side Wetland 45 for about 60 m. All of this clearing was within an EnvPP green zone. No other Project clearing or disturbance observed in this wetland in 2015.

By the time of the 2016 ground survey, north dyke clearing had been extended to approximately 25 m into the wetland buffer zone (Figure 3-14 and Figure 3-15). All of this clearing was within an EnvPP green zone. No other Project impacts were noted at this wetland in 2016. All of the dyke clearing within Wetland 45 was also within the above noted burned area.

A 15% slope through the dyke clearing to the marsh habitat created the potential for future surface runoff to carry material into the marsh habitat. In addition to the slope containing exposed mineral material in the cleared area (Figure 3-15), the entire slope had been burned with some sites having virtually all vegetation removed. These areas will be monitored for any potential effects from runoff.

It is recommended that site staff evaluate and implement sediment control measures where needed to prevent sediment and other runoff from entering the marsh site (*e.g.*, a silt fence be erected at the base of the slope). It is also recommended that a northward extension of the existing clearing be avoided to minimize additional impacts on Wetland 45.

Figure 3-14: North dyke clearing (all within an EnvPP green zone) at Wetland 45 in September 2016

View along the shore of Wetland 45

Exposed mineral on slope in burned forest between north dyke and Wetland 45

Figure 3-15: Ground and aerial photos of Wetland 45 in August 2016

Aerial view showing the proximity of north dyke clearing to Wetland 45

Figure 3-15: Continued...

3.7 WETLAND 47

Wetland 47 (Figure 3-4; Figure 3-16) is 189.1 ha in size, and located approximately 100 m southeast of EMPA D27(4)-E (Map 2-1). Marsh habitat comprises 140.1 ha of the wetland's total area. None of the buffer zone burned in the 2013 wildfire.

Project clearing or disturbance in this wetland was not observed during the 2015 aerial survey.

The 2016 ground surveys found that a very small amount of EMPA clearing (approximately 0.02 ha) extended into the Wetland 47 buffer along the northwestern edge (Figure 3-17). All of this clearing was within an EnvPP red zone. A small amount of clearing from a cutline (approximately 0.03 ha) extended into the buffer zone on the northeastern edge of the wetland, all of which was in an EnvPP green zone. No other Project impacts were noted at this wetland in 2016.

It is recommended that a southeastern extension of the existing clearing be avoided to minimize additional impacts on Wetland 47.

Figure 3-16: View along the Wetland 47 shore

Aerial view showing the proximity of north dyke clearing to Wetland 47

Clearing into the Wetland 47 buffer

Figure 3-17: Clearing into the Wetland 47 buffer in August 2016

3.8 WETLAND 51

Wetland 51 is 25.7 ha in size, and located immediately northwest of EMPA D16 (Map 2-1). Marsh habitat comprises 10.5 ha of the wetland's total area. Approximately 20% of the buffer zone burned in the 2013 wildfire.

Ground surveys in August 2015 identified Project EMPA clearing within 25 m of the boundaries for Wetland 51. Project disturbances noted in 2015 included heavy machinery rutting around the western edge of the EMPA. Other Project impacts included erosion and sedimentation at the base of the EMPA slope on the northern and northwestern edges. Mitigation measures in place at the time of the survey included a soil berm and a silt fence to prevent runoff into the adjacent marsh habitat. Portions of the silt fence, which was installed along the western edge of the EMPA, had fallen over. Erosion and sedimentation into a creek flowing into Wetland 51 was observed.

Some dead and dying vegetation was observed adjacent to the creek near the base of the EMPA slope during the 2015 survey. It was unclear if construction activity or sedimentation had caused this. Mineral soil had begun to cover the creek bed in areas where marsh plants were growing (this was outside of Wetland 51 boundaries).

By the time of the 2016 ground survey, some EMPA banks had been graded (Figure 3-18), creating gentler slopes on the northwestern edges. This grading extended the toe of the EMPA banks to approximately 2 m away from the Wetland 51 boundaries (Figure 3-19). Also, the heavy machinery rutting, soil berm, fallen silt fence locations, dying vegetation and erosion and sedimentation into waterways connected to Wetland 51 that had been observed in 2015 were no longer present (Figure 3-19). No Project clearing, disturbance or other impacts were observed within Wetland 51 in 2016.

While erosion and sedimentation at the base of the EMPA slopes on the northern and northeastern edges were observed in 2016 (Figure 3-19), there were no signs that this sediment had yet entered the channel between the Nelson River and Stephens Lake or the waterway running from the marsh habitat into this channel. Investigations in the area found that the undisturbed peat appeared to be capturing surface movement of materials. To date, there has been no evidence of sediment being transported through the peat, however, heavy rainfalls could produce substantial erosion and sedimentation. Additionally, EMPA banks are within 100 m of the channel between the Nelson River and Stephens Lake as well as a waterway running from the marsh habitat into this channel (Figure 3-18).

It is recommended that sediment control measures be placed at strategic locations along the northwestern, northern and eastern EMPA banks to prevent further spread towards the northwest. The strategic locations are as follows: where the undisturbed area adjacent to the EMPA has moderate to steep slopes; where there is open water near the base of the slope; or, where the undisturbed peat appears to be floating. Both of the latter two conditions may facilitate sediment transport into the marsh habitat or into the waterway leading from the marsh into the channel between the Nelson River and Stephens Lake. It is also recommended that, if

this EMPA receives further excavated material, then it should be placed to the southwest of the existing material or on existing areas well back from the top of the bank.

Figure 3-18: Aerial imagery of Wetland 51 in September 2016

View along the east shore of Wetland 51

Graded slope between EMPA and Wetland 51, where disturbances and other impacts were noted in 2015

Figure 3-19: Aerial and ground photos of Wetland 51 in August 2016

EMPA approaches Wetland 51 boundary

Erosion and sedimentation at base of slope on northern EMPA banks

Figure 3-18: Continued...

3.9 WETLAND 52

Wetland 52 (Figure 3-5) is 28.4 ha in size, and located south of Gull Rapids (Map 2-1). Marsh habitat comprises 9.1 ha of the wetland's total area. None of the buffer zone burned in the 2013 wildfire.

There was no observed clearing or disturbance in or near the wetland boundary at the time of the 2015 aerial survey. The south access road (SAR) right-of-way (ROW) had been cleared, but road construction had not reached the area.

Project clearing or disturbance was not observed within Wetland 52 during the 2016 surveys.

For other potential Project impacts, one instance of a potential hydrological effect was found in 2016. A culvert on the north side of the SAR was draining water into a woodland south of the marsh, creating pooling water at and into the woodland edge (Figure 3-20). Closer to the marsh, the water table was at or above ground level in a natural depression between the SAR and Wetland 52. It was unknown at the time of the survey whether runoff from the SAR was contributing to an elevated water table in this area. However, it appeared that a high peat plateau bog (which contains ground ice) between the actual marsh area and the natural depression (Figure 3-20) was likely raising the water table by impeding drainage. In any event, if there had been additional flow into the marsh habitat from the SAR, it appeared that the drainage outlet for this wetland was passing such flows downstream into a bay on the Nelson River. Future monitoring of water levels and the condition of the marsh outlet will help determine if runoff from the SAR is affecting this wetland.

Aerial view of south shore with surrounding peat plateau bog between the SAR and Wetland 52

Pooling water at tree line edge on the north side of the SAR

Figure 3-20: Aerial and ground photos of Wetland 52 in August 2016

3.10 WETLAND 53

Wetland 53 (Figure 3-5) is 5.5 ha in size, and located on the south side of the Nelson River, just downstream of the future GS site (Map 2-1). Marsh habitat comprises 0.3 ha of the wetland's total area. None of the buffer zone burned in the 2013 wildfire.

The clearing in the marsh buffer that was visible in the 2015 imagery and DOIs (*e.g.*, cut trees, an access trail though the east side of the marsh buffer) was associated with the Keeyask Transmission Project ROW. These were the only impacts found in the marsh buffer during the 2015 ground survey (Figure 3-21). Some flooded vegetation at the cleared transition zone between the creek/marsh and the degrading peat plateau bog, just outside of the marsh buffer, was also found in 2015.

Ground surveys in 2016 found no expansion of the impacts recorded in 2015. No new clearing, disturbance or other impacts were observed in 2016.

View along the Wetland 53 shore

Figure 3-21: Ground photos of Wetland 53 in August 2016

Access trail through east side of Wetland 53 buffer

Cut trees in the Wetland 53 buffer

Figure 3-21: Continued...

3.11 WETLAND 54

Wetland 54 (Figure 3-6) is 113.1 ha in size, and located along the SAR, north of Borrow Area S-2b (Map 2-1). Marsh habitat comprises 70.1 ha of the wetland's total area. None of the buffer zone burned in the 2013 wildfire.

The clearing visible in the 2015 DOIs and aerial survey photos was associated with the Keeyask Transmission Project RoW. This clearing, which only impacted the buffer zone, had come as close as 20 m to the marsh habitat in some locations (Figure 3-22). No evidence of erosion or sedimentation into the marsh habitat was observed during the 2015 ground survey.

Ground surveys in 2016 found no expansion of the impacts recorded in 2015. New impacts were limited to clearing and disturbance for two Keeyask Transmission Project towers south of the marsh, which came right up to the marsh buffer boundary (Figure 3-23).

The relatively dense existing low vegetation in the cleared areas within 100 m of the marsh should be adequate to stabilize soils and facilitate revegetation.

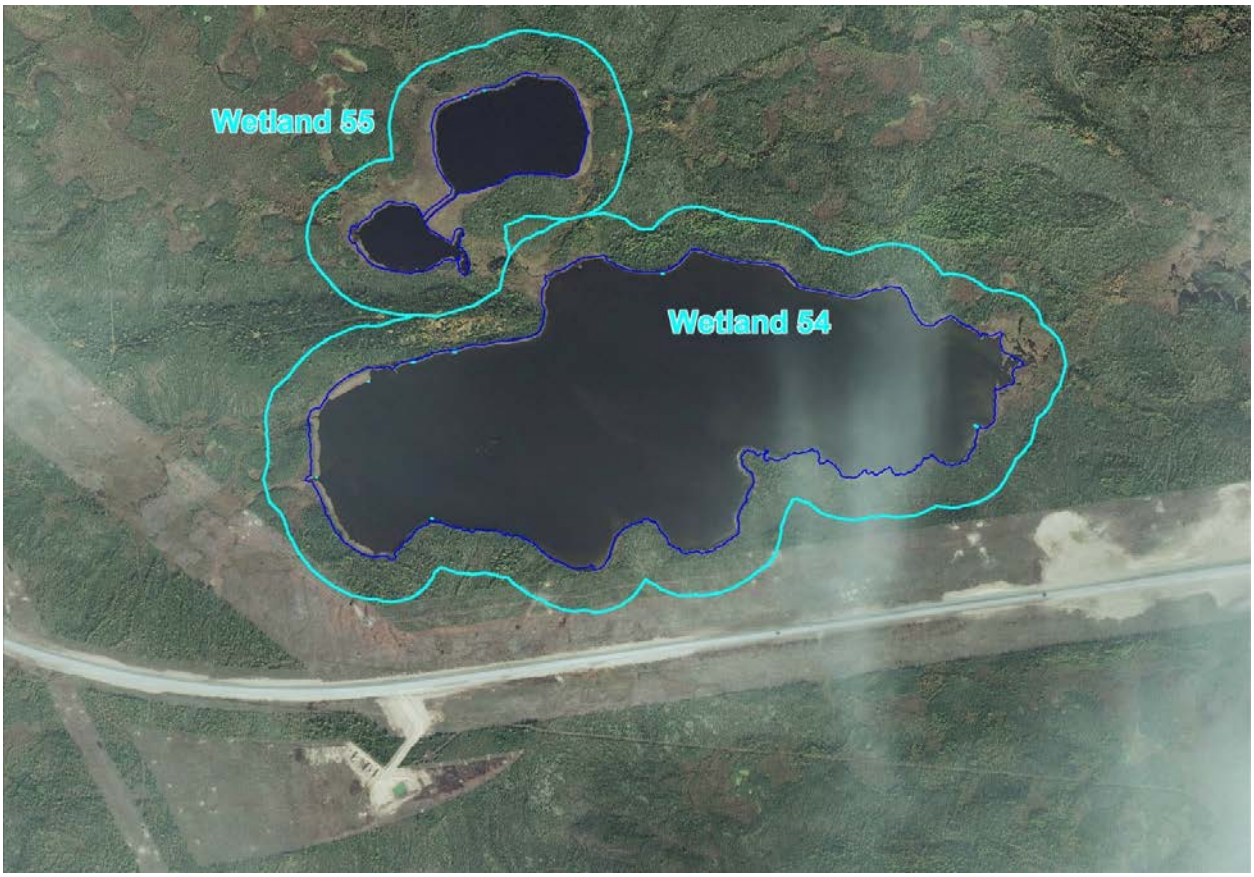


Figure 3-22: Aerial view of Wetland 54 in September, 2016

View along the Wetland 54 shore

Transmission towers adjacent to Wetland 54 buffer

Figure 3-23: Aerial and ground photos of Wetland 54 in August 2016

Ground view of transmission tower clearing and disturbance adjacent to Wetland 54 buffer

Figure 3-22: Continued...

3.12 WETLAND 57

Wetland 57 is 64.6 ha in size, and nestled between Butnau Road and Stephens Lake, with its buffer overlapping the road to the south and a dyke to the north (Map 2-1). Marsh habitat comprises 37.6 ha of the wetland's total area. None of the buffer zone burned in the 2013 wildfire.

Ground surveys in 2015 found that the Project cleared 0.21 ha of the marsh buffer for the SAR. All of this area was within an EnvPP green zone. No clearing or disturbance was found in the marsh habitat.

Ground surveys in 2016 found that the SAR clearing at the southern edge of the buffer zone had increased to 0.89 ha, which was 0.68 ha higher than in 2015 (Figure 3-24). All of the clearing was still within EnvPP green zone. No clearing or disturbance was found in the marsh habitat in 2016.

In terms of other potential Project impacts, a ditch from the SAR drains into the marsh habitat. The observed water levels in the marsh in 2016 were very low compared to those observed in 2015. Some of the possible causes were lower water levels on Stephens Lake (marsh habitat is

within 75 m of Stephens Lake) or altered hydrology due to road construction. These and other possible causes for low water levels will be investigated during the 2017 surveys.

View along the Wetland 57 shore

Water levels were lower than those in 2015

Figure 3-24: Ground photos of Wetland 57 in August 2016

3.13 REMAINING WETLANDS

As described above, 12 of the 42 wetlands being monitored were closely surveyed in 2016 because they were within 100 m of existing Project clearing or disturbance. Figure 3-25 shows the state of some of the remaining 30 wetlands during the aerial surveys. Monitoring in 2017 will determine if any of these or other wetlands have been impacted by the Project since the 2016 surveys.

Wetland 7

Wetland 36

Figure 3-25: Aerial photos of some remaining wetlands in August 2016

Wetland 49

Wetland 55

Figure 3-24: Continued...

4.0 SUMMARY AND CONCLUSIONS

Wetlands typically make relatively high contributions to ecosystem function. EIS studies found that off-system marsh is a particularly important wetland type in the Keeyask region based on its contributions to the range of wetland functions.

The Wetland Loss and Disturbance study is monitoring Project effects on wetland function. Until the end of construction, this study is focusing on off-system marsh and its habitat. A previous monitoring study and report (ECOSTEM 2015) assessed effects on wetland function from the Keeyask Infrastructure Project (KIP), which ended in June 2014.

EIS studies identified the waterbodies in Study Zone 3 that contain off-system marsh. All of these waterbodies are included in the construction monitoring for the Wetland Loss and Disturbance study. At each waterbody, the marsh habitat includes the waterbody and its shore zone. Since marsh habitat can be affected by Project impacts in the surrounding area, and because most of the marsh habitat buffers are red zones in the Project's EnvPPs, each monitored wetland includes the marsh habitat and a 100 m buffer around it.

In total, 42 individual wetlands are being monitored by this study for potential Project effects. During the construction phase, the monitoring focuses on impacts, and primarily clearing, disturbance or hydrological alterations. In the terrestrial habitat, ecosystems and plant studies, clearing refers to complete vegetation removal in a patch that was at least 400 m^2 in size. Disturbance refers to either physical disturbance in intact vegetation (e.g., machinery trail, test pits), use of a pre-existing trail or a clearing smaller than 400 m^2.

Of the 42 wetlands being monitored during construction, 39 were surveyed from a helicopter on August 20, 2016 because they were within 1 km of Project clearing or disturbance. Twelve of these 39 wetlands were within 100 m of the existing clearing or disturbance observed during the aerial survey. Ground surveys were conducted at 11 of these 12 wetlands (Wetland 42 could not be accessed due to construction activity). The buffer zones of seven of these twelve wetlands overlapped areas burned in the 2013 wildfire (which was unrelated to the Project).

The ground-surveyed wetlands included one along the NAR, one north of Work Area A, three along the north dyke, three along the SAR, one south of the future tailrace area, one along the south dyke and one overlapping the reservoir clearing area. The buffer zone of seven of these 12 wetlands overlapped areas burned in the 2013 wildfire.

Project clearing or disturbance was not observed within eight of the 12 wetlands that were within 100 m of actual Project clearing or disturbance at the time of the 2016 surveys. The observed clearing or disturbance in four of the 12 wetlands extended into marsh habitat in only one wetland, and this was for the future reservoir area. In the three other wetlands, there was only 0.86 ha of Project clearing or disturbance, all of which was in the buffer zone, and all but 0.02 ha was in an EnvPP green zone.

The following paragraphs summarize observed Project impacts on wetlands, and potential future impacts that merit mitigation or a particular focus during ongoing monitoring. Mitigation recommendations are summarized in Table 4-1.

Wetlands 3, 37, 47 and 57 had Project clearing or disturbance in a portion of their area at the time of the 2016 surveys.

Wetland 3 was the only location where clearing or disturbance extended into the marsh habitat. Here, a band of trees was removed along the shoreline during clearing for the future reservoir. The clearing impacted 0.25 ha of Wetland 3 area, including 0.01 ha of marsh habitat. In this case, the clearing only affected vegetation taller than 1 m, and not the ground surface as it was done in the winter.

Project clearing or physical disturbance only extended into the buffer zone at Wetlands 37, 47 and 57.

At Wetlands 37 and 47, a very small amount of clearing from the adjacent EMPA extended into the buffer zone. The total clearing was less than 0.01 ha for Wetland 37 and approximately 0.02 ha for Wetland 47. It is recommended that an extension of the existing clearing be avoided, to the extent possible, to minimize additional impacts on these wetlands.

At Wetland 57, a small amount of SAR clearing extended into the marsh buffer zone but not into the marsh habitat. In terms of other potential Project impacts, a ditch from the SAR drains into the marsh habitat. The observed water levels in the marsh were very low in comparison with 2015. Some of the possible causes were lower water levels on Stephens Lake (wetland is within 75 m of Stephens Lake) or altered hydrology due to road construction. These and other possible causes for low water levels will be investigated during the 2017 surveys.

Project disturbance or clearing was not observed at the remaining eight wetlands within 100 m of actual Project clearing or disturbance at the time of the 2016 surveys. However, all of these wetlands had potential future impacts that merited either a mitigation recommendation or a particular focus during ongoing monitoring.

At Wetland 17, the marsh habitat is downslope and within 100 m of the NAR, so there is potential for road-related surface runoff or hydrological alterations. It was thought that a small amount of vegetation mortality observed along the south shore was likely due to the ground collapsing due to natural permafrost melting. Monitoring in 2017 will revisit these sites to determine whether mitigation is recommended.

While no clearing or disturbance was observed in Wetlands 40, 42 and 45, these wetlands were near Project clearing on mineral slopes. Wetland 45 also had additional mineral material exposed by the 2013 wildfire. The exposed mineral slopes created the potential for runoff and sediment deposition from existing Project areas into the marsh habitat. Continuing care should be taken by construction crews when working in these areas. For Wetlands 40 and 45, it is recommended that a silt fence be added between the dyke clearing and these wetlands at the base of the slope. that extensions of the existing dyke clearing be avoided, if possible, to limit additional impacts on these wetlands. A sediment control recommendation was not made for

Wetland 42 given the amount of undisturbed vegetation between the exposed mineral area and the marsh habitat.

While Wetland 51 was not affected by Project clearing or disturbance, the ground survey identified sediment deposition and runoff from the northern banks of EMPA D16 into the adjacent forest. As the situation between this EMPA and the marsh area is somewhat complex, several mitigation measures are recommended for strategic locations (see Section 3.8 for details). Measures to control erosion and stabilize portions of the selected EMPA slopes should also be considered as these slopes are close to a waterway draining the wetland into Stephens Lake. It is also recommended that if this EMPA receives further excavated material, it should be placed to the southwest of the existing material or on existing areas well back from the top of the bank.

To date, Wetland 52 has not been affected by Project clearing or disturbance. Water from a south access road culvert was pooling in a natural depression between the SAR and the marsh habitat. Water input from the SAR had the potential to alter wetland hydrology. If there has been additional flow into the marsh area from the SAR, it appeared that the drainage outlet from this wetland was passing it downstream into a bay on the Nelson River. Continued monitoring of this site will be done to help determine if runoff from the SAR is affecting this wetland.

Wetlands 53 and 54 had not been affected by Project clearing or disturbance at the time of the 2016 surveys. The clearing visible in the September, 2016 satellite imagery was for the Keeyask Transmission Project ROW, which is a separately licensed project with an associated terrestrial monitoring program. The clearing, which was in the marsh buffer zone, may interact with Project effects in the future. Monitoring in 2017 will include revisiting the physical disturbance to further evaluate the potential for interactions with Project effects. For Wetland 54, the relatively dense existing low vegetation in the cleared areas within 100 m of the marsh should be adequate to stabilize soils and facilitate revegetation.

To date, there have been no unanticipated effects on the wetlands being monitored by this study. While there has been some clearing or disturbance within four locations, it was expected that it would be necessary to impact some locations during construction.

Table 4-1: Summary of Mitigation Recommendations

Wetland	Recommendation[1]
Wetland 37	2015: Evaluate and implement sediment control measures where needed to prevent sediment from entering the site along the north dyke. 2016: Limit further clearing along northeastern edge of EMPA that overlaps buffer zone. Monitor for potential effects from slope runoff.
Wetland 40	2015: Silt fence be added between the dyke clearing and marsh at the base of the slope. Evaluate and implement sediment control measures where needed. 2016: Evaluate and implement sediment control measures such as silt fence where needed. Avoid northward extension of the existing dyke clearing, if possible.
Wetland 45	2015: Silt fence be added between the dyke clearing and marsh at the base of the slope. Evaluate and implement sediment control measures where needed 2016: Evaluate and implement sediment control measures such as silt fence where needed. Avoid northward extension of the existing clearing, if possible.
Wetland 47	2016: Avoid a southeastern extension of the existing clearing, if possible.
Wetland 51	2015: Inspect and enhance sediment control measures along the northern edges of the EMPA. Erect a silt fence be built around the north and northwest side of the EMPA. 2016: Silt fence be placed between the EMPA and marsh and water channel along the northwest and north edges of the EMPA at strategic locations. Place any additional excavated materials to the southwest of the area, or well back from the top of the bank
Wetland 52	2016: Monitor water levels and condition of marsh outlet for runoff effects from SAR.
Wetland 57	2016: Investigate possible causes for low water levels during 2017 surveys.

Notes: [1] Recommendations in addition to continued monitoring. See ECOSTEM (2016) for the 2015 recommendations.

4.1 NEXT STEPS

Monitoring fieldwork for the off-system marsh wetlands will continue in 2017. No major changes to field methods are anticipated.

5.0 LITERATURE CITED

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