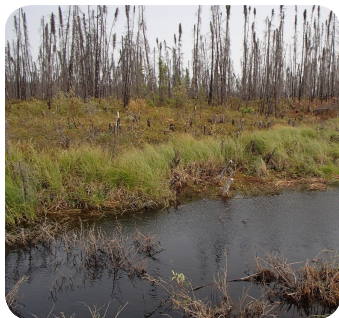




Keeyask Generation Project  
Terrestrial Effects Monitoring Plan

Wetland Loss and Disturbance Monitoring Report  
TEMP-2021-03



# **KEEYASK GENERATION PROJECT**

## **TERRESTRIAL EFFECTS MONITORING PLAN**

REPORT #TEMP-2021-03

## **WETLAND LOSS AND DISTURBANCE MONITORING**

Prepared for  
Manitoba Hydro

By  
ECOSTEM Ltd.

June 2021

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# SUMMARY

## Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. 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.

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 or country food plants used by Members of the partner First Nations (e.g., sweet flag [*wekes*, *wekas* or *wihkis* in Cree], and tamarack) are either only or mostly found in wetlands. In the Keeyask region, marsh in areas off the Nelson River (i.e., off-system marsh) 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 are usually good areas to hunt moose and waterfowl.

This report describes the results of wetland loss and disturbance monitoring conducted during the seventh summer of Project construction.



**Off-system marsh wetland in the Keeyask region in 2020**

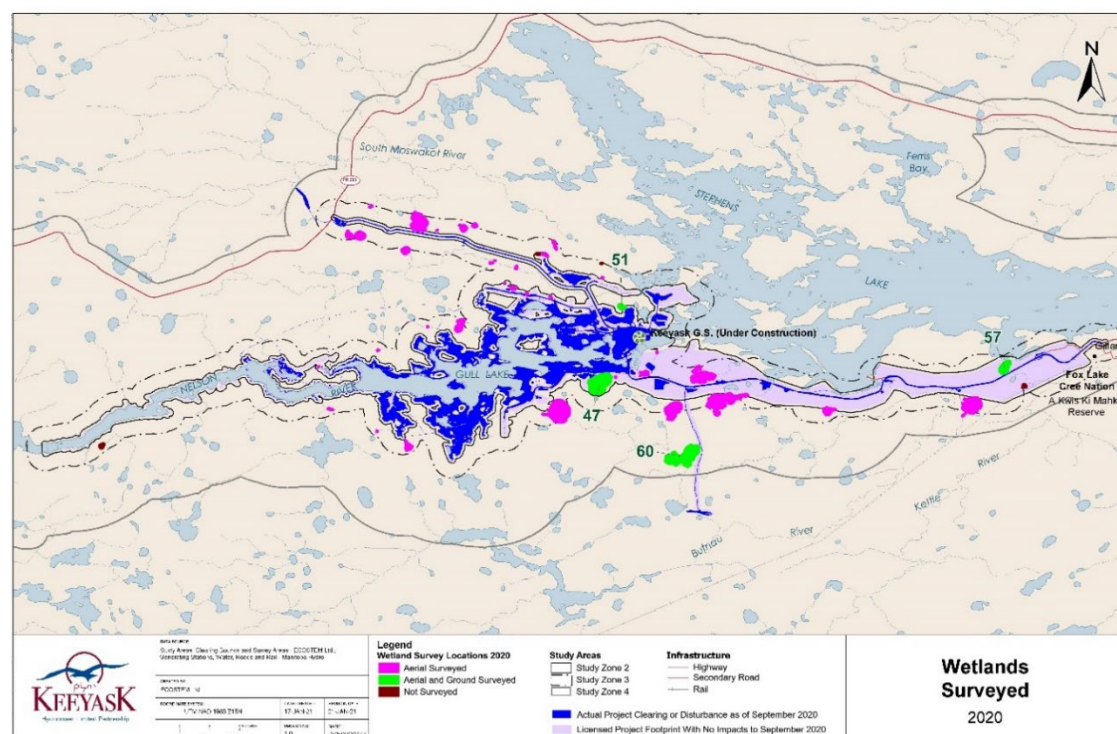


Wetland mapping for the environmental assessment showed that the Project would affect some wetland areas. Since it is impossible to avoid all wetlands in the area given the size of the Project footprint and the widespread nature of wetland habitat (i.e., peatlands are common throughout the Keeyask region), mitigation (replacement of 12 ha of off-system marsh wetland) is planned to help reduce Project effects.

As construction proceeds, this monitoring study documents Project impacts on, and mitigation related to, the very important marsh wetland type. This is to make sure the Project effects predictions are accurate and that no additional unexpected impacts are occurring. Following the end of construction, Project effects on all wetland types will be evaluated.

Off-system marsh was the only very important wetland type identified by the environmental assessment. Off-system marsh and its habitat occur within a waterbody. The area surrounding these waterbodies is important for the off-system marsh and its habitat because these areas affect each other, and in most cases the surrounding area is peatland, another type of wetland common in the Keeyask region. For these reasons, each monitored wetland includes the entire waterbody, plus a 100 m buffer of the waterbody.

A total of 44 off-system marsh wetlands are being monitored by this study. In each year of construction, aerial and ground surveys are done at wetlands that are close to the Project construction areas. In September 2020, 41 wetlands were surveyed from a helicopter (see map below), and four of these wetlands were also surveyed on the ground.



**What was found?**

As of 2020, Project clearing or disturbance in the monitored marsh wetlands (including their buffers) totalled 4.2 ha, within seven of the 44 wetlands. Clearing accounted for the vast majority (99.5%) of this total area. New clearing has not been recorded in these areas since the 2016 surveys.

The vast majority (3.9 ha; 93%) of the clearing or disturbance was within the planned Project footprint. As outlined in the environmental assessment, this was expected since a portion of these wetlands overlapped a permanent Project feature such as a dyke, a road or the future reservoir area.

In six of the seven impacted wetlands, Project clearing only occurred in the marsh habitat buffer. In the seventh wetland, clearing extended into a very small amount (0.11 ha) of marsh habitat where taller vegetation had been cleared for the future reservoir area.

A very small area (<0.1 ha) in one marsh wetland had been disturbed by sediment deposition from a nearby construction area. All of this sediment deposition was in the marsh habitat buffer.

Potential future Project impacts were noted for four of the off-system marsh wetlands located within 100 m of actual Project clearing or disturbance. For two of these four wetlands, altered water flows outside of the wetland buffer could potentially affect the amounts of marsh and its habitat. At another wetland, impacts from adjacent ATV usage had potential to disturb wetland habitat. At the remaining wetland, water drainage from the Main Camp had potential to disturb wetland habitat.

**What does it mean?**

To date, there have been no unexpected Project impacts on the off-system marsh wetlands being monitored by this study. While some Project clearing or disturbance occurred in a small portion of seven wetland areas, it was expected that there would be some impacts at wetlands overlapping the planned Project footprint or to those close to active construction areas. Mitigation measures (e.g., erosion barriers) have been recommended where there are potential future risks to an off-system marsh or its surrounding habitat.

**What will be done next?**

Off-system marsh wetland monitoring, including the effectiveness of mitigation measures, will continue in 2021. Where needed, additional mitigation measures will be recommended after the 2021 surveys.

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# STUDY TEAM

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# GLOSSARY

Term	Definition
approved Project footprint areas	All areas that were either initially licenced or subsequently approved for use by the Government of Manitoba.
buffer zone	A 100 metre buffer of marsh habitat.
DOI	A spatial dataset produced from satellite images or digital stereo photos that have been stitched together and processed so that all pixels are positioned in an accurate ground position. Such processing is necessary because the earth's surface is round and has topography.
Habitat	The place where a plant or animal lives.
habitat disturbance	Physical disturbance in an area of intact vegetation or use of pre-existing trails or borrow areas.
habitat loss	Permanent physical removal or alteration of previously undisturbed habitat.
licensed Project footprint	Footprint licensed for Project use under the Project's <i>Environment Act</i> Licence.
Marsh	A class in the Canadian Wetland Classification System which includes non-peat wetlands having at least 25% emergent vegetation cover in the water fluctuation zone.
planned Project footprint	A subdivision of the licensed Project footprint where clearing or disturbance was expected and is largely comprised of permanent Project features.
possibly disturbed Project footprint	A subdivision of the licensed Project footprint where clearing or disturbance could potentially occur.
off-system	Water body or waterway outside of the Nelson River hydraulic zone of influence.



<b>Term</b>	<b>Definition</b>
Project clearing	Project areas with complete removal of trees and tall shrubs. Includes terrestrial areas that were flooded, or formerly aquatic areas that were dewatered.
Project footprint	Boundary of all areas affected by Project activities.
Wetland	A land ecosystem where periodic or prolonged water saturation at or near the soil surface is the dominant driving factor shaping soil attributes and vegetation composition and distribution.
wetland function	Natural properties or processes that are associated with wetlands, stated in ways that describe what they do for the ecosystem.

# ACRONYMS

Acronym	Name
DOI	Digital orthorectified imagery
EIS	Environmental Impact Statement
EMPA	Excavated material placement area
EnvPP	Environmental Protection Plan
GIS	Geographic Information System
GS	Generating Station
KHLP	Keeyask Hydropower Limited Partnership
KIP	Keeyask Infrastructure Project
KM	Kilometre
KTP	Keeyask Transmission Project
NAR	North Access Road
RoW	Right-of-Way
SAR	South Access Road
TEMP	Terrestrial Effects Monitoring Plan

# 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 *Keeyask Generation Project 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, which is wetland monitoring.

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.

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

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 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 monitoring conducted in 2020.

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,
- Locate and quantify direct Project effects on wetland function during construction based on wetland quality scores.

To verify the implementation and effectiveness of off-system marsh protection measures (i.e., the first study objective), the Wetland Loss and Disturbance study includes annual surveys during Project construction. Mapping and analysis to locate and quantify direct Project effects on wetland

function during construction (i.e., the second study objective) will be completed after construction completion.

This report addresses the first of these objectives based on monitoring conducted from 2015 to 2020. A synthesis report completed 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, 2017, 2018, 2019 and 2020) provides results for the wetland loss and disturbance monitoring conducted from 2015 to 2019.

The wetland function monitoring uses the same five nested study zones as were used for the environmental assessment (Map 1-1).

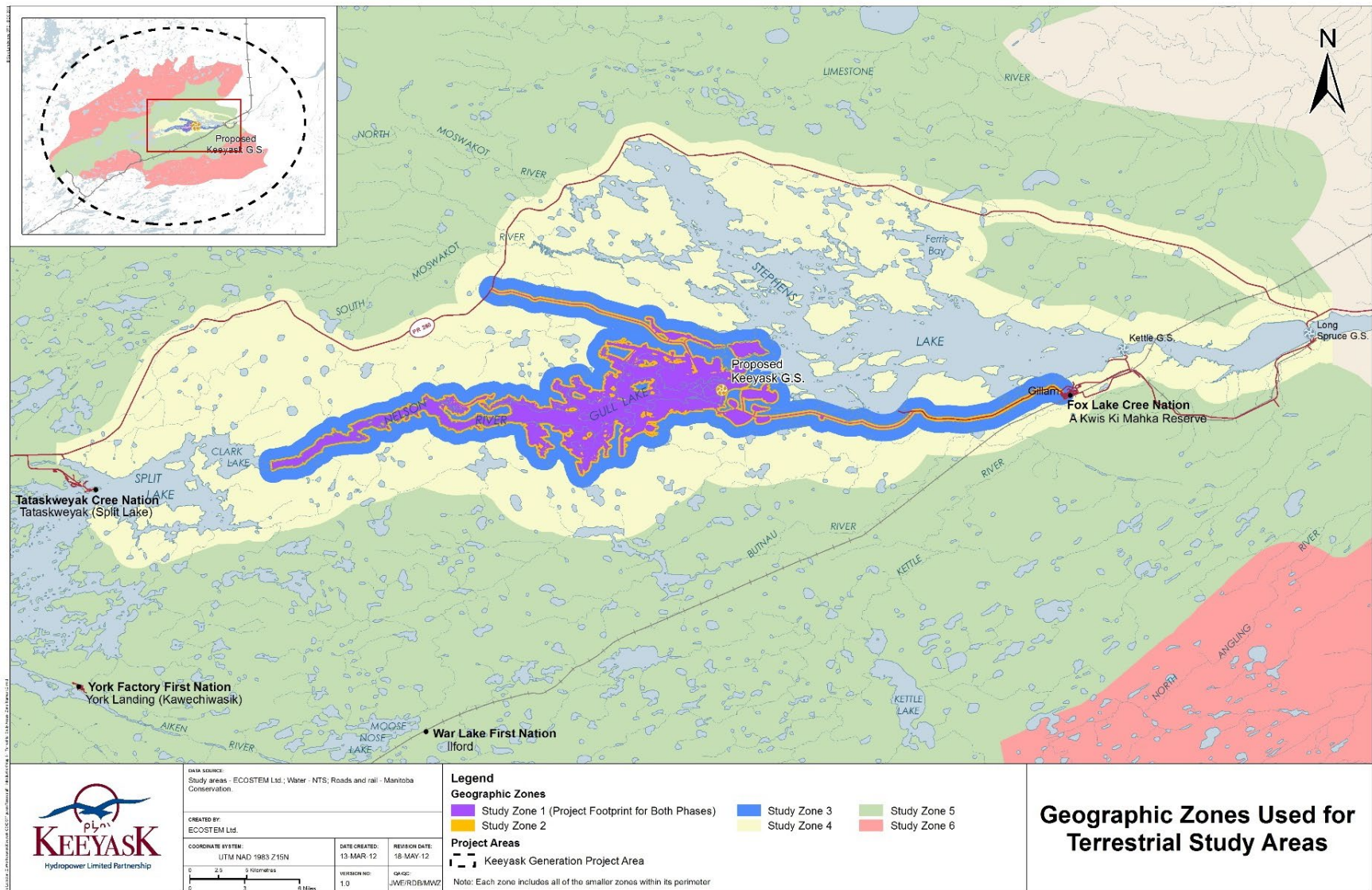
Prior to describing the monitoring activities, some terminology is introduced to assist the reader. The following definitions are used in all of the terrestrial habitat, ecosystems and plant monitoring studies.

“Impact” refers to what the Project does in terms of the question of interest (e.g., lowering water levels in a lake, vegetation clearing), while “effect” refers to the consequence relative to the question of interest (e.g., marsh habitat loss, reduced wetland function).

Clearing refers to complete vegetation removal of trees and tall shrubs (e.g., the herbaceous and moss cover can be intact) in an area that is at least 400 m<sup>2</sup> in size. In the results, “clearing” also includes areas where excavated material was piled on uncleared vegetation since the vegetation was no longer visible. Many of the cleared areas also included excavation of topsoil and overburden (e.g., in a borrow area).

Disturbance refers to either physical disturbance in an area of intact vegetation (e.g., machinery trail, test pits), use of a pre-existing trail or an area of clearing smaller than 400 m<sup>2</sup>.

It is noted that, while the definition of clearing means that every cleared patch being referred to in this report is at least 400 m<sup>2</sup>, the portion of a clearing that overlaps a wetland or its buffer can be much smaller than 400 m<sup>2</sup>. In other words, all uses of “clearing” in this report are referring to the entire area cleared (including areas outside the wetland and its buffer).



**Map 1-1: Study zones used for the environmental assessment and monitoring**



## 2.0 METHODS

### 2.1 INTRODUCTION

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 2020. The same monitoring methods were used from 2015 to 2020.

As noted above, this monitoring is focusing on how the Project is affecting off-system marsh wetlands. ECOSTEM (2013) describes the pathways of potential Project effects on off-system marsh.

Even under natural conditions, the amounts and locations of off-system marsh change from year to year in response to a number of factors. Such changes are possible because only a portion of the area that is able to support marsh (i.e., marsh habitat) actually has vegetation in it at a given time. For this reason, the off-system marsh monitoring extends beyond the patches of off-system marsh that were mapped for the EIS studies to include all marsh habitat. This approach is analogous to monitoring both the number of beavers and the amount of beaver habitat to understand Project effects on beaver.

The locations of marsh habitat are predominantly determined by water depths and water level variations (TE SV; KHLP 2012b). In Study Zone 4 (Map 1-1), which is where detailed marsh mapping was completed, off-system marsh was not found in water known or thought to be deeper than 2 m (ECOSTEM 2012; unpublished raw data). Bathymetry was not available to identify which portions of waterbodies were shallower than 2 m, to identify marsh habitat. However, the available information indicated that the waterbodies that could potentially be affected by the Project were either predominantly or entirely shallower than 2 m. To err on the side of caution, the entire waterbody was included as off-system marsh habitat.

Marsh and its habitat can be strongly influenced and altered by human impacts such as physical disturbance or hydrological alterations, both within its habitat and in surrounding areas. For this reason, in addition to monitoring selected waterbodies (i.e., the marshes and their habitat), this study also monitors changes within a 100 m buffer of the waterbody. For this same reason, the Project's environmental protection plans (EnvPPs) had already designated the portions of the marsh habitat buffers outside of the planned Project footprint as environmentally sensitive sites, which are to be avoided whenever possible.

In this report, a waterbody and its buffer are referred to as a monitored wetland. In other words, references to a specific wetland in the Wetland Loss and Disturbance study include a waterbody and its 100 m buffer zone.

## 2.2 PROJECT AREAS

In this study, four distinct Project areas are used when reporting on where Project clearing or disturbance occurred. This is being done to facilitate future comparisons with EIS predictions.

The first two areas are a subdivision of the footprint licensed for Project use under the Project's *Environment Act* Licence (i.e., licensed Project footprint): the planned Project footprint and the possibly disturbed Project footprint (Map 2-1). The planned Project footprint is largely comprised of permanent Project features. There is little to no opportunity to reduce Project impacts in these areas.

The possibly disturbed Project footprint provided for some of the unknown components of the Project design at the time the Project was being licensed (e.g., the actual volume of suitable material available in each borrow area, or the actual area needed for each of the Excavated Material Placement Areas (EMPAs)). There is some flexibility in locating clearing, disturbance or material placement within the possibly disturbed Project footprint. Project EnvPPs include provisions to minimize clearing or disturbance within the possibly disturbed Project footprint, and the avoidance of environmentally sensitive sites to the extent feasible within this area.

After the Project was licensed, several additional areas (called “subsequently approved Project areas” in this report) were approved for Project use by the Government of Manitoba (initially Conservation and Water Stewardship, then Sustainable Development, now Conservation and Climate). This is the third type of Project area. These subsequently approved areas primarily included the former KIP start-up camp (which was originally planned as only a temporary camp for the KIP) and trails that were used to access reservoir clearing areas.

The subsequently approved areas were evaluated for potential effects by terrestrial specialists prior to their submission to the Government of Manitoba, and their locations were modified to alleviate any ecological concerns that were identified at that time. Given the modifications recommended by terrestrial specialists, the subsequently approved areas were not a concern from the terrestrial ecosystem health perspective.

An important consideration for the evaluation of areas that were subsequently submitted for approval was how these potential additions would alter predicted cumulative effects. This evaluation primarily focused on the characteristics of the potentially affected areas and the amount of the licensed Project footprint that was expected to remain undisturbed at the end of construction. For the latter factor, it was expected that a large proportion of the licensed Project footprint would remain undisturbed because the EIS intentionally erred on the side of overestimating the amount of habitat loss and disturbance. As of September 2020, the majority (55%) of the originally licensed Project footprint had not been impacted by the Project (ECOSTEM 2021).

This report refers to the licensed Project footprint and the subsequently approved areas as the “approved Project footprint”.

The fourth, and final, type of Project area used in this report includes any areas cleared or disturbed outside the approved Project footprint. This includes all areas that are not part of the approved Project footprint.

It was expected that portions of a particular wetland (Section 2.1) that overlapped the planned Project footprint would be lost or disturbed. Project impacts on the off-system marshes and/or their buffers were assessed during the EIS and were expected to be minimal outside of the planned Project footprint. This study monitors the area actually impacted by the Project in comparison to the amount assessed for the Project in the EIS. The operations Long-Term Effects on Wetlands study will monitor long-term direct and indirect Project effects on wetland function.



**Map 2-1: Project areas as of September 2020**

## 2.3 WETLANDS TO MONITOR

For the first study objective (Section 1.0), the wetlands selected for monitoring were all off-system marsh wetlands located in Study Zone 3 and not entirely within the planned Project Footprint (Map 2-2). Wetlands entirely in the planned Project Footprint were excluded because we expected they would be lost to Project construction, and this is reflected in the Project's Environmental Protection Plans (EnvPPs). Wetlands in Study Zone 2 were included as this zone captures the areas that could potentially experience direct and indirect Project effects on terrestrial habitat, which includes off-system marsh wetlands. Wetlands in Study Zone 3 were also included because, while unlikely, it is possible for some hydrological effects to extend for a considerable distance beyond the licensed Project footprint. Although not a focus for the first objective of this study (Section 1.0), it is important to document when potential hydrological effects occur as they will be evaluated when addressing the second objective.

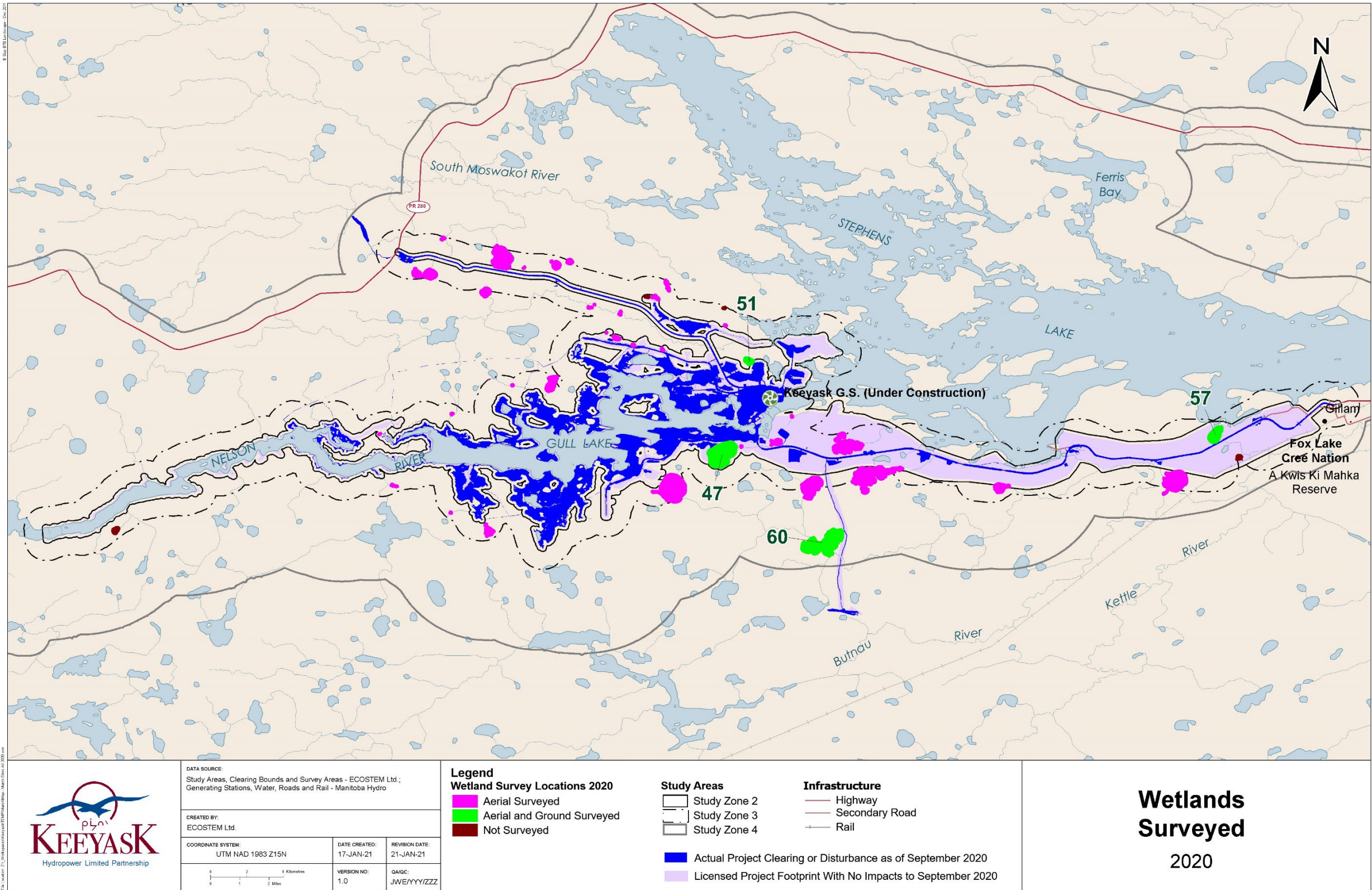
Studies completed for the environmental impact statement (EIS) had mapped the off-system marshes that were present in Study Zone 4 (Map 2-2) in 2012. This mapping was used to select the waterbodies (Section 2.1) in Study Zone 3 to be included in this monitoring.

Map 2-2 shows the 44 wetlands in Study Zone 3 that are being monitored to verify the implementation and effectiveness of off-system marsh protection measures, and to quantify direct Project effects on wetland function. Each of the 44 monitored wetlands was assigned a unique wetland identification number for the monitoring (e.g., Wetland 17).

Once each year during construction, surveys are conducted in the monitored wetlands that are sufficiently close to actual Project impacts to be potentially affected. Potentially affected wetlands are identified in two stages. The first stage selects all of the wetlands that are within approximately 1 km of the Project clearing or disturbance as seen in the most recent digital orthorectified imagery (DOI; a DOI is a digital dataset produced from satellite images or digital stereo photos that have been stitched together and processed so that all pixels are positioned in an accurate ground position). A 1 km distance was used because it is possible for hydrological effects to extend well beyond the immediate vicinity of a Project impact in continuous peatlands (Section 2.1).

In the second stage of wetland selection, an aerial survey is conducted to identify and add any other of the monitored wetlands within 1 km of Project clearing or disturbance that occurred after the DOI was acquired.





Map 2-2: Monitored off-system marsh wetlands, and those that were surveyed in 2020

## 2.4 DATA COLLECTION

Aerial surveys are conducted for every wetland that has been selected for monitoring in that year. Ground surveys are also conducted at a subset of these wetlands that are within 100 m of the actual Project footprint if impacts have changed with the past three years. Ground surveys search for effects not visible from the air, document implemented mitigation measures, and document possible Project effects.

In 2020, the first stage of wetland selection used a DOI created from Worldview 2 imagery (30 cm resolution) acquired on October 2, 2019 because a DOI from summer 2020 was not available prior to the September 2020 aerial surveys. A total of 42 wetlands were identified for inclusion in the aerial surveys.

Aerial surveys conducted on September 13, 2020 did not identify any additional wetlands for inclusion in the 2020 monitoring. One of the 42 wetlands greater than 100 m from existing clearing or disturbance was inadvertently missed during the aerial surveys (an adjacent, connected wetland was surveyed instead).

Of the 41 wetlands surveyed in 2020, 13 were within 100 m of existing clearing or disturbance. Ground surveys were conducted at four of the 13 wetlands within 100 m of existing clearing or disturbance (Map 2-2) on September 13, 2020. The remaining 9 wetlands (wetlands 3, 17, 37, 40, 42, 45, 52, 53 and 54) were not ground-surveyed because there had been no new clearing or other impacts near them for several years, and there were no documented Project effects at these wetlands in the previously surveyed years.

Conditions in the surveyed wetlands are recorded with geo-referenced photographs, marked-up maps and/or notes. Any erosion, sedimentation, or surface hydrological alteration observed is recorded, as well as any mitigation implemented to address these issues.

## 2.5 MAPPING

The spatial extent of impacts on the surveyed wetlands are mapped in a GIS from remote sensing. Remote sensing refers to data obtained from above the ground from sources such as satellite imagery, digital stereo photos or photos taken from a helicopter). In this monitoring, remote sensing includes a combination of photos acquired from a helicopter and DOIs. The most recent growing season DOI is also generally used as the base map. Exceptions occur where the spatial extents of the most recent DOI do not overlap a wetland, in which case the next most recent DOI is used.

Areas burned in the 2013 wildfire (which was prior to and unrelated to the Project) are of interest for the wetland monitoring because runoff from Project areas could be carried over burned bare mineral areas rather than being trapped by mosses and other ground plants. A GIS is also used to map the percentage of the wetland's buffer that was burned in the 2013 wildfire.

## 2.6 WATER LEVEL INDICATORS

Water levels and water level variability in the off-system waterbodies were of interest for the wetland monitoring because these factors are the primary determinants for the distribution and abundance of off-system marsh and its habitat. However, water levels in the off-system waterbodies are not monitored with equipment.

During the annual aerial surveys, the apparent deviation of water levels relative to the median was visually evaluated for each waterbody. Indicators of relatively low water levels were the degrees of exposed aquatic vegetation and lake-bottoms. Indicators of relatively high-water levels were inundation of the upper beach or surface water presence within inland edge vegetation.



## 3.0 RESULTS

### 3.1 OVERVIEW

The 2020 surveys did not detect any new clearing since 2019 in the marsh habitat or marsh habitat buffers for any of the 41 surveyed wetlands (Map 2-2). At one wetland, Marsh 51, a disturbance (see Section 1.0 for definition) was recorded.

Of the 4.2 ha of Project clearing or disturbance within wetlands since 2014, 0.1 ha was in marsh habitat while 4.1 ha was in the marsh habitat buffer. With one minor exception (Marsh 51), the total area impacted at each wetland has remained unchanged since 2017.

To date, all recorded impacts in wetlands have been within the licensed Project footprint, and the vast majority were within the planned Project footprint (Map 2-1). Of the 4.2 ha of total wetland area impacted to date by the Project, 3.9 ha was within the planned Project footprint while 0.3 ha was within the possibly disturbed Project footprint.

### 3.2 INDIVIDUAL WETLANDS

Table 3-1 summarizes the main findings for the 13 wetlands within 100 m of Project impacts. Table 3-2 provides the distribution of impacts by Project area. Map 3-1 shows the locations of the monitored wetlands in relation to the Project components.

The following sub-sections present results for each of the monitored wetlands.

**Table 3-1: Impacts and potential future effects in the off-system marsh wetlands within 100 m of Project clearing or disturbance, as of September, 2020**

Wet-land ID <sup>1</sup>	Wetland Area (ha)			Area (ha) Impacted <sup>2</sup> by Project Clearing and Disturbance			Other Project Impacts up to 2020	2013 Burn in Buffer (%) <sup>3</sup>	Potential Additional Future Effects or Effects Outside of the Monitored Wetlands
	Total	Marsh Habitat	Buffer	Total	Marsh Habitat	Buffer			
3	5.0	1.0	4.0	0.364	0.105	0.260	None	90	None
17	135.1	97.4	37.7	-	-	-	None	85	Water flow from a road culvert
37	17.0	4.1	12.9	0.006	-	0.006	None	5	Likely none <sup>4</sup>
40	7.9	1.2	6.7	1.754	-	1.754	None	10	Likely none <sup>4</sup>
42	15.7	2.9	12.8	-	-	-	None	50	Likely none <sup>4</sup>
45	7.3	0.8	6.5	0.236	-	0.236	None	50	Likely none <sup>4</sup>
<b>47</b>	189.7	140.7	49.0	1.033	-	1.033	None	0	Runoff from dyke through drainage channels into marsh
<b>51</b>	25.7	10.5	15.2	0.023	-	0.023	Sediment from EMPA D16 into the buffer zone	20	Deposition of sediment or other materials into the marsh habitat buffer or other wetlands from EMPA
52	28.4	9.1	19.4	-	-	-	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	None
<b>57</b>	64.6	37.6	27.0	0.793	-	0.793	None	0	Hydrological effects from a road culvert
<b>60</b>	232.4	150.0	82.5	-	-	-	None	0	None
All	847.6	525.7	322.0	4.208	0.105	4.104			

Notes:

<sup>1</sup> Bold font identifies wetlands that were ground sampled in 2020.<sup>2</sup> All mapped Project clearing or physical disturbance in monitored wetlands. See ECOSTEM (2021) for the mapping.<sup>3</sup> Percentage of total buffer area that burned in the 2013 wildfire (which was unrelated to the Project).<sup>4</sup> The potential runoff from EMPA or dyke slope is declining. Evidence of runoff has not been recorded for past few years and colonizing vegetation may eventually prevent it.

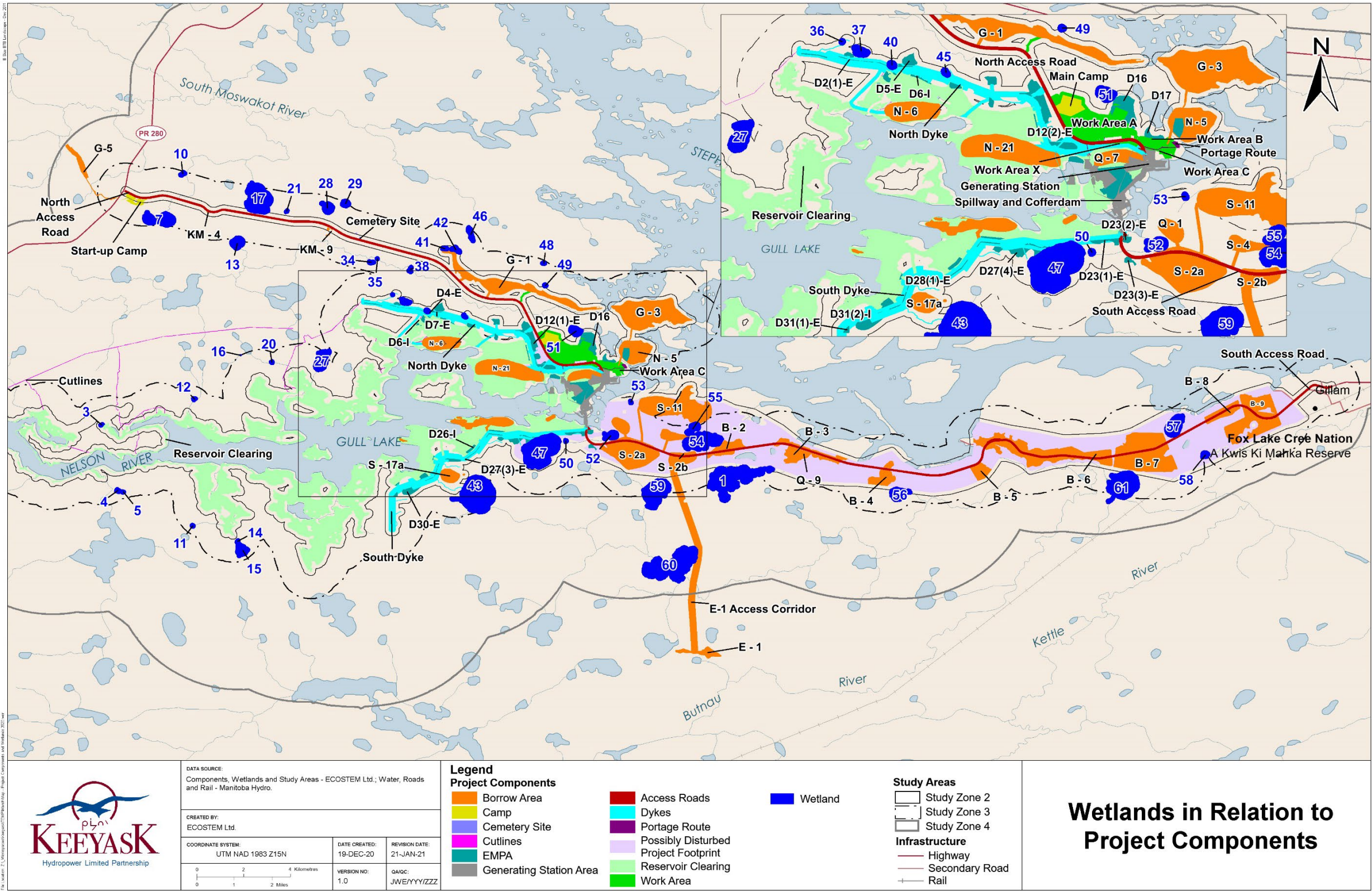


**Table 3-2: Project clearing or disturbance in the off-system marsh wetlands within 100 m of Project clearing or disturbance as of September, 2020, by Project area**

Wetland ID	Total Wetland Area (ha)	Area (ha) Impacted by Project Clearing and Disturbance <sup>1</sup>			Percent of Total Wetland Area Impacted
		Total	Planned Project Footprint	Possibly Disturbed Project Footprint	
3	5.0	0.364	0.117	0.247	7.2
17	135.1	-	-	-	-
37	17.0	0.006	-	0.006	0.0
40	7.9	1.754	1.754	-	22.2
42	15.7	-	-	-	-
45	7.3	0.236	0.236	-	3.2
47	189.7	1.033	1.015	0.018	0.5
51	25.7	0.023	-	0.023	0.1
52	28.4	-	-	-	-
53	5.5	-	-	-	-
54	113.1	-	-	-	-
57	64.6	0.793	0.793	0.00	1.2
60	232.4	-	-	-	-
All	847.6	4.208	3.914	0.294	0.5

Notes:

<sup>1</sup> All mapped Project clearing or physical disturbance in monitored wetlands. See ECOSTEM (2021) for the mapping.



Map 3-1: Monitored off-system marsh wetlands in relation to the Project components



### 3.2.1 WETLAND 3

Wetland 3 (Photo 3-1) is 5.0 ha in size (Table 3-1), and located about 1 km from the Nelson River. It is approximately 21 km west of the generating station site (Map 2-2). This wetland is directly connected to the Nelson River through a lake and then a short stream. Marsh habitat comprised 1.1 ha of the wetland's total area. The 2013 wildfire (see Section 2.4) burned approximately 90% of the marsh habitat buffer (*i.e.*, a 100 m buffer of the marsh habitat) included in Wetland 3.



**Photo 3-1: Aerial view of Wetland 3 on September 13, 2020**

No Project clearing or disturbance was observed in Wetland 3 during the 2015 survey but by 2016, a band of trees ranging from approximately 1 to 10 m wide in the marsh habitat and buffer had been removed by reservoir clearing (Map 3-1; Figure 3-1). This clearing, which was located along the shoreline, impacted 0.36 ha of the total 5.0 ha Wetland 3 area (Table 3-2). Approximately 0.25 ha of this clearing was within the possibly disturbed Project footprint.



**Figure 3-1: Satellite imagery showing reservoir clearing (in yellow) at Wetland 3 (in blue) in 2019**

Approximately 0.26 ha of the cleared area was in the marsh habitat buffer and 0.10 ha was in the marsh habitat (Table 3-1). Cleared trees were visible where collapsed or collapsing peatlands outside of the planned Project footprint had become part of the marsh habitat (Photo 3-2).





**Photo 3-2: Cleared trees in Wetland 3 on August 31, 2017**

No further clearing or disturbance was observed in this wetland during the 2017 to 2020 surveys. It was noted in 2017 that water levels were lower than in previous years, but water levels appeared to be near the median in 2018 through to 2020.

### **3.2.2 WETLAND 17**

Wetland 17 (Photo 3-3) is 135.1 ha in size and located on the southwest shore of a small lake located near the kilometre 6 point of the north access road (NAR) (Map 3-1). Marsh habitat comprised 97.5 ha of the wetland's total area. Approximately 85% of the marsh habitat buffer burned in the 2013 wildfire.





**Photo 3-3: Aerial view of Wetland 17 on September 13, 2020**

Project disturbance or clearing had not been observed within Wetland 17 up to the time of the 2020 surveys (Figure 3-2). Ground surveys conducted from 2015 to 2017 found no incremental changes in the condition of the wetland (Photo 3-4).



**Figure 3-2: Satellite imagery showing Wetland 17 (in blue) in relation to the North Access Road (in yellow) in 2019**



**Photo 3-4: Ground photo of Wetland 17 on August 23, 2017**



Ground surveys were not conducted in 2018 through 2020 as the aerial surveys found no new clearing or activity nearby. Details about conditions observed in Wetland 17 in previous survey years are provided in ECOSTEM (2018).

### 3.2.3 WETLAND 37

Wetland 37 (Photo 3-5, Photo 3-6) is 17.0 ha in size, and located near the north dyke, adjacent to EMPA D3-E (Map 3-1). Marsh habitat comprised 4.1 ha of the wetland's total area. Approximately 5% of the marsh habitat buffer burned in the 2013 wildfire.



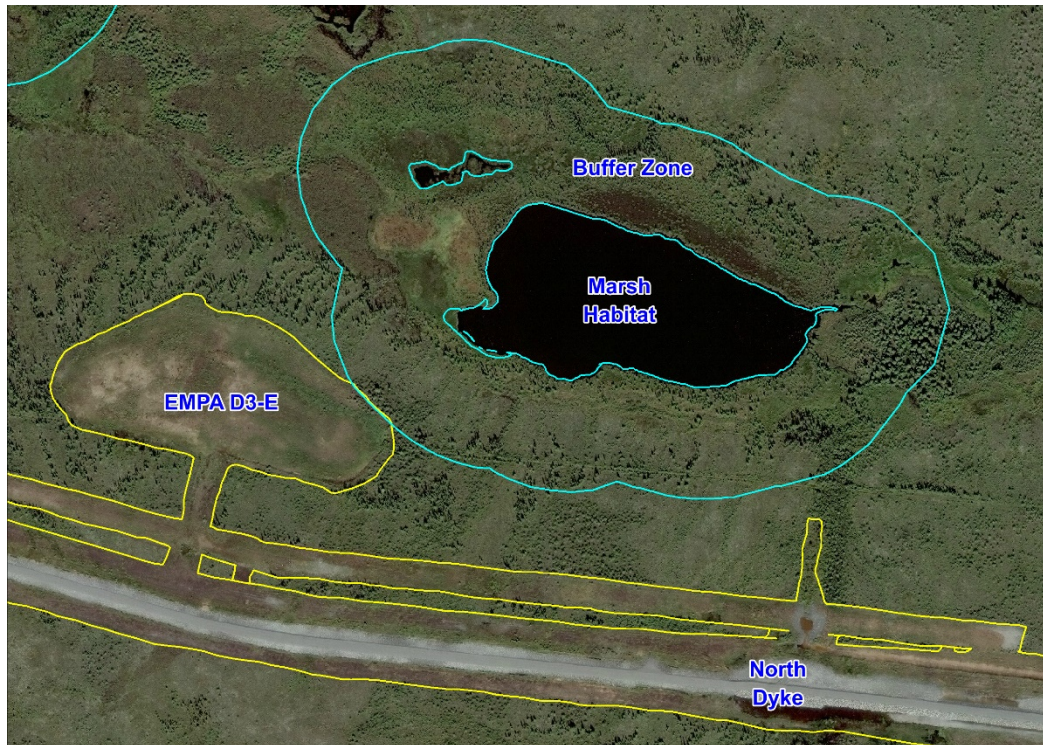
**Photo 3-5: Ground photo of Wetland 37 in 2019**



**Photo 3-6: Aerial photo of Wetland 37 in September 2020 looking north with EMPA D3-E to the west**

No Project clearing or disturbance was observed in Wetland 37 in 2015. The 2016 ground survey found that a very small amount of EMPA clearing in the possibly disturbed Project footprint (< 0.01 ha; Table 3-1; Figure 3-3) extended into the buffer portion of the wetland. Ground surveys from 2017 to 2020 found no further changes to the EMPA and no new impacts on the wetland were observed.





**Figure 3-3: Satellite image showing EMPA D3-E (in yellow) adjacent to the Wetland 37 (in blue) buffer in 2020**

The potential for sediment runoff from the EMPA into the wetland buffer is likely decreasing because the EMPA is becoming increasingly vegetated, which will help stabilize the soil (Photo 3-6). Evidence of runoff has not been recorded since 2016.

### 3.2.4 WETLAND 40

Wetland 40 (Photo 3-7) is 7.9 ha in size, and located along the north dyke, approximately 750 m east of Wetland 37 (Map 2-2). Marsh habitat comprised 1.2 ha of the wetland's total area. Approximately 10% of the marsh habitat buffer burned in the 2013 wildfire.

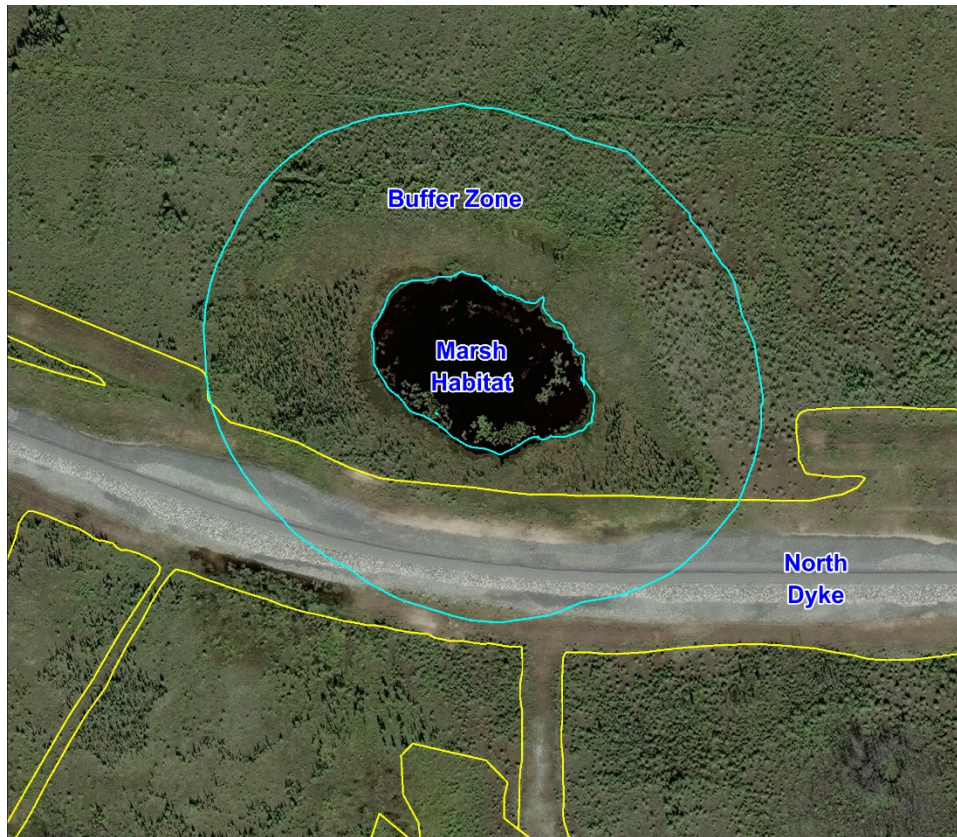




**Photo 3-7: Aerial view of Wetland 40 on September 13, 2020**

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

By the time of the 2016 survey, planned Project clearing for the dyke (Map 3-1) had extended through the buffer to approximately 3 m away from the southern portion of the marsh habitat (Figure 3-4). All of this 1.75 ha of clearing was within the planned Project footprint (Table 3-2). It was noted in 2017 that water levels in the marsh habitat at the time of the survey appeared to be lower than the median level based on exposed underwater portions of marsh vegetation. Surveys in 2018 through 2020 found that water levels appeared to be approximately at the median level (Figure 3-5).



**Figure 3-4: Satellite imagery showing dyke clearing (in yellow) at Wetland 40 (in blue) in 2020**





View along the shores of Wetland 40



Regenerating peatland between marsh and dyke clearing

**Figure 3-5: Ground photos of Wetland 40 on September 9, 2019**

The 2016 surveys noted that a shallow slope leading from the dyke clearing to the water's edge should be monitored for the potential to transport sediment from the exposed mineral of the dyke into the marsh. In 2017, it was recommended that a sediment fence be installed between the dyke clearing and the wetland at the base of the slope. None had been installed as of September 2020, however no clearing, sedimentation or runoff from the dyke was observed during surveys.

A peatland with black spruce seedlings and saplings was continuing to regenerate between the dyke clearing and the marsh (Figure 3-5). As regeneration progresses, this peatland is expected to become an increasing barrier to potential runoff. These areas will be monitored for any future runoff effects.

### 3.2.5 WETLAND 42

Wetland 42 (Photo 3-8) 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 G-1 (Map 2-2). Marsh habitat comprised 2.9 ha of the wetland's total area. Approximately 50% of the marsh habitat buffer burned in the 2013 wildfire.



**Photo 3-8: Aerial view of Wetland 42 on September 13, 2020**

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



Aerial surveys in 2016 found that clearing for Borrow Area G-1 had expanded northwest towards Wetland 42 since 2015 (Map 3-1). At the time of the 2016 surveys, clearing was still approximately 90 m away from the marsh habitat buffer (Figure 3-6). Project disturbance within the wetland was not visible in the DOIs or aerial photos.



**Figure 3-6: Satellite imagery showing proximity of Borrow Area G-1 clearing (in yellow) to Wetland 42 (in blue) in 2019**

During the 2016 aerial survey, it was noted that there was a significant slope extending downwards from the Borrow Area G-1 clearing to the southern edge of the wetland. A sediment control recommendation was not made given that the band of undisturbed vegetation between the exposed mineral area and the marsh buffer was approximately 90 m wide.

Up to the time of the 2020 surveys, there was no clearing or excavation in the adjacent borrow area and there were no signs of erosion along the slope to the wetland. Ground surveys in 2018 found that the peat bank at the base of the slope adjacent to the wetland was beginning to slump and break apart (Photo 3-9). This slumping was attributed to melting permafrost in the peat related to having been recently burned in the wildfire.





**Photo 3-9: Slumping peat bank adjacent to Wetland 42 on September 16, 2018**

The band of intact vegetation will continue to be monitored in order to determine if there is any erosion or surface runoff from the slope into the marsh, but the risk for this continues to decline due to the vegetation regeneration occurring in Borrow Area G-1.

### **3.2.6 WETLAND 45**

Wetland 45 (Photo 3-10) is 7.3 ha in size, and located along the north dyke, approximately 1.5 km east of Wetland 40 (Map 2-2). Marsh habitat comprised 0.8 ha of the wetland's total area. Approximately 50% of the marsh habitat buffer 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.



**Photo 3-10: Aerial view of Wetland 45 on September 13, 2020**

At the time of the 2015 ground survey, north dyke clearing extended approximately 3 m into the buffer on the south side of Wetland 45 for about 60 m. By the time of the 2016 ground survey, north dyke clearing had extended approximately 25 m into the marsh habitat buffer (Figure 3-7; Map 3-1). All of this 0.24 ha of clearing was within the planned Project footprint (Table 3-2) and no other Project impacts were noted at that time. All of the dyke clearing within Wetland 45 was also within the above noted burned area.





**Figure 3-7: Satellite imagery showing North Dyke clearing (in yellow) at Wetland 45 (in blue) in 2020**

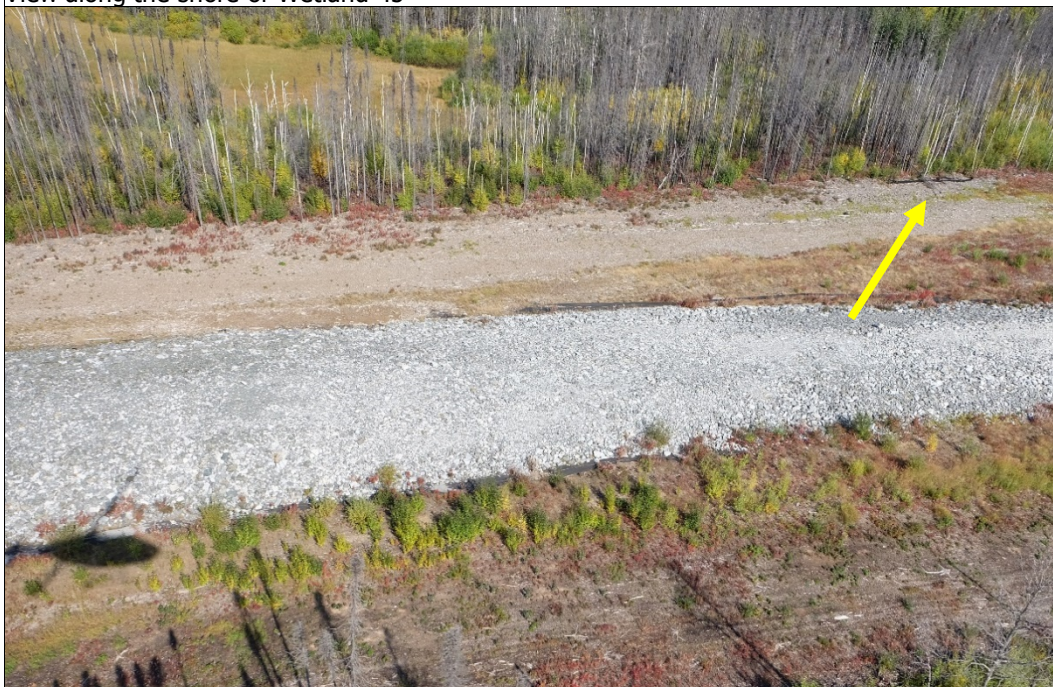
No further clearing was recorded within the marsh habitat buffer between 2016 and 2020.

An approximately 15% slope running through the dyke clearing area to the marsh habitat creates the potential for surface runoff to carry material into the marsh habitat. In addition to the slope containing exposed mineral material in the cleared area (Figure 3-8), the entire slope had been burned with some areas having virtually all vegetation removed. In 2017, it was recommended that staff evaluate and implement sediment control measures such as sediment fence where needed as a preventative measure (e.g., a sediment fence at the base of the dyke). A short sediment fence was installed at one location (Figure 3-8).





View along the shore of Wetland 45



Sediment fence installed at bottom of North Dyke slope near Wetland 45 (yellow arrow)

**Figure 3-8: Ground and aerial photos of Wetland 45 on September 9, 2019**

At the time of the 2020 surveys, no runoff or sedimentation was seen entering the marsh habitat. In addition to the existing sediment fences, a small ridge between the wetland and the dyke may be serving as a natural barrier to sediment transport further downslope. Additional sediment fences appear to be unnecessary at this time. These areas will be monitored for any future runoff effects.

### **3.2.7 WETLAND 47**

Wetland 47 (Figure 3-9; Photo 3-11) is 189.1 ha in size, and located approximately 100 m southeast of EMPA D27(4)-E (Map 2-2). Marsh habitat comprised 140.1 ha of the wetland's total area. None of the marsh habitat buffer burned in the 2013 wildfire.





Water accumulation north of Wetland 47 in the future reservoir area in 2019



Same area in September, 2020, following reservoir impoundment

**Figure 3-9: Satellite imagery comparing water accumulation north of Wetland 47 (in blue) in the future reservoir area (in yellow) in 2019 (pre-impoundment) and 2020 (post-impoundment)**





**Photo 3-11: Aerial view of Wetland 47 on September 13, 2020**

Project clearing or disturbance in this wetland was not observed during the 2015 aerial survey. In 2016, a small amount of clearing within the possibly disturbed Project footprint (0.02 ha in total) extended into the northwestern and northeastern edges of Wetland 47 (Map 3-1), all of which was in the marsh habitat buffer. Approximately half of this clearing was for an EMPA, and the other half was for a cutline.

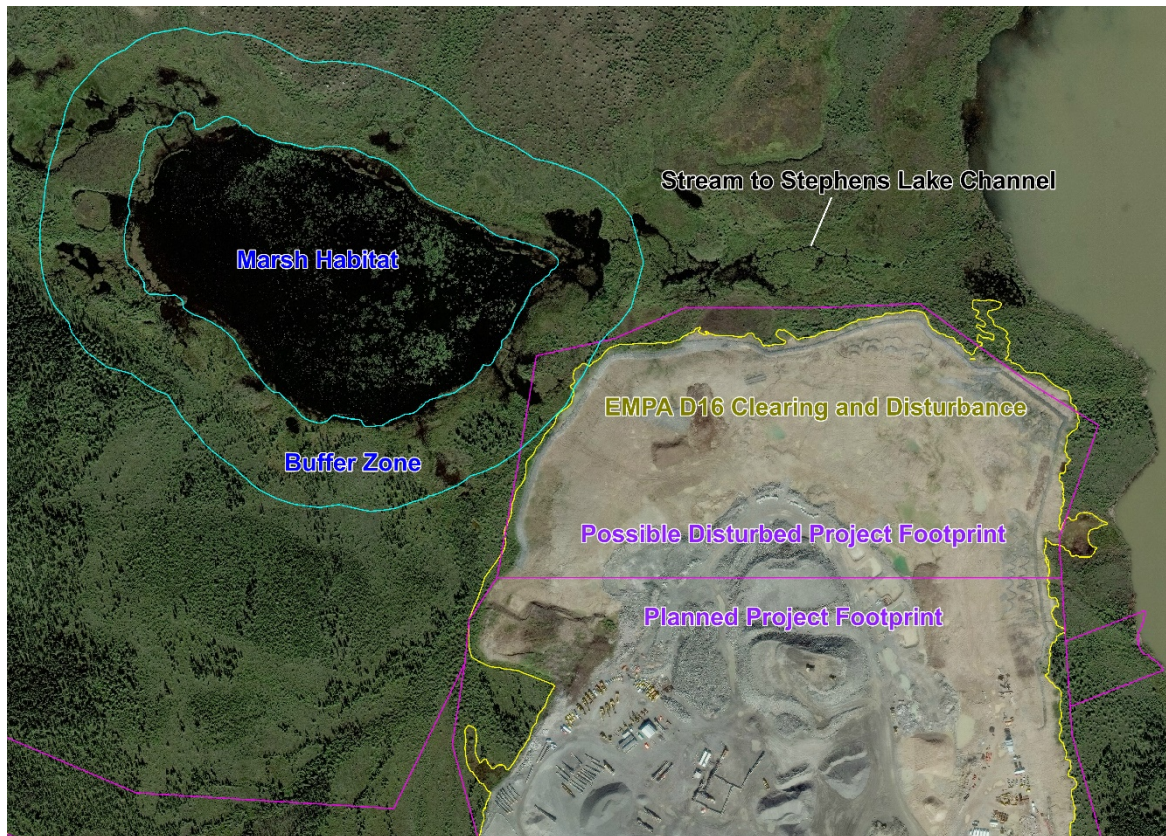
As of August 2017, a total of 1.03 ha of Wetland 47 was cleared, 1.01 ha of which was in the planned Project footprint (Table 3-2). No further clearing had occurred within the possibly disturbed Project footprint. At the northwestern edge, South Dyke clearing occurred within 50 m of the shoreline (Figure 3-9). A runnel, draining water through the wetland north of the dyke into the lake, was cleared and blocked by the dyke where it was within the planned Project footprint. Water had started to accumulate in the reservoir clearing area north of the dyke by the time of the 2019 aerial surveys. This water build-up did not cause any further disturbance once the reservoir was impounded in early September, 2020 (Figure 3-9).

While no further clearing had occurred between the 2017 and 2020 surveys, construction traffic along the South Dyke was near the wetland. Aerial surveys found no apparent effects in the marsh habitat due to runoff from the dyke clearing and infrastructure (Figure 3-9).

Water levels in Wetland 47 have fluctuated considerably since 2017, possibly because the newly constructed South Dyke was altering water inputs. Compared to the median observed in 2018, water levels appeared to be lower in 2017 and 2019 and approximately at median in 2020, based on the degrees of exposed lake-bottom and aquatic vegetation.

### 3.2.8 WETLAND 51

Wetland 51 is 25.7 ha in size and located immediately northwest of EMPA D16 (Map 2-2, Figure 3-10). Marsh habitat comprised 10.5 ha of the wetland's total area. Approximately 20% of the marsh habitat buffer burned in the 2013 wildfire.



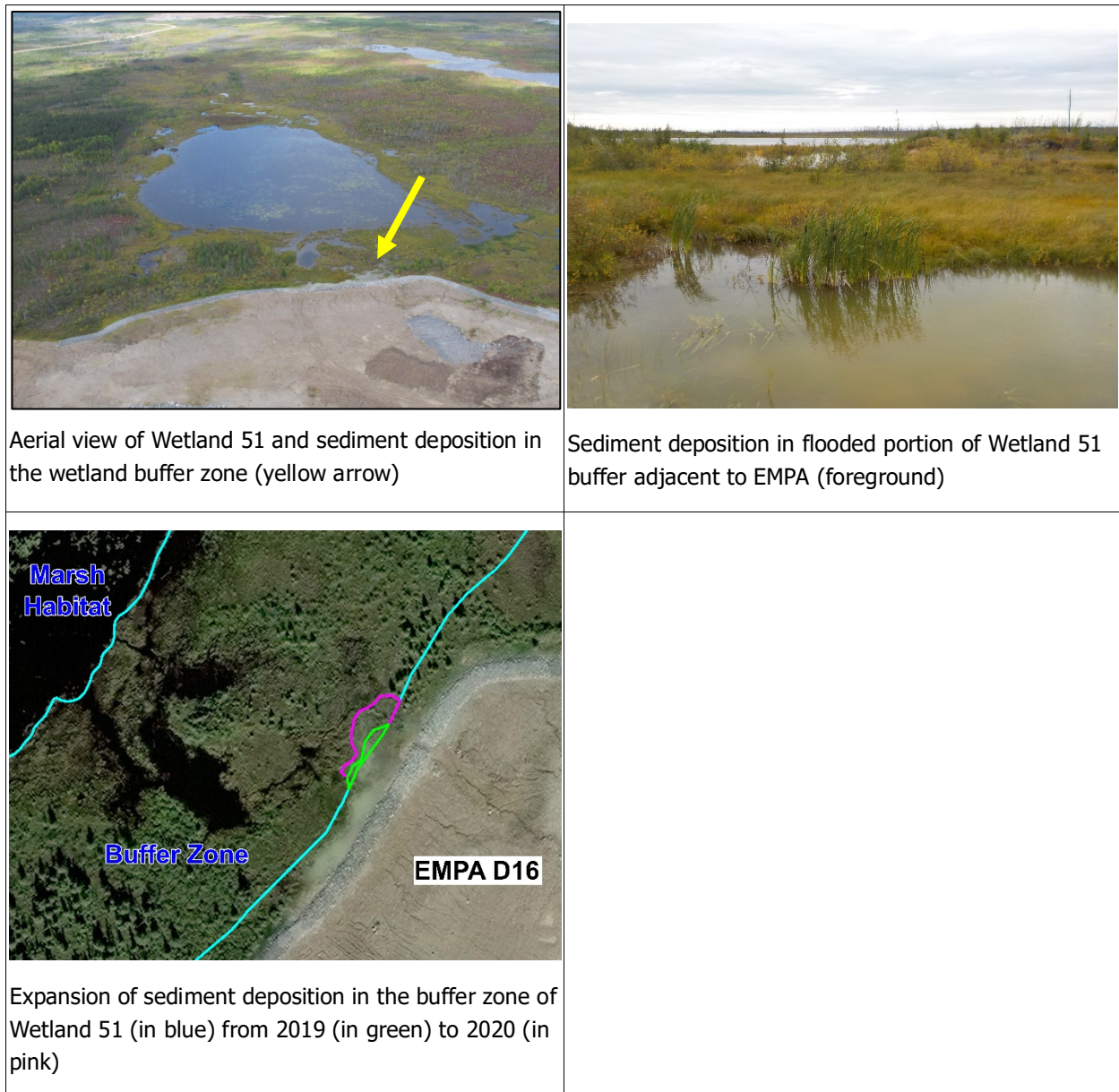
**Figure 3-10: Wetland 51 (in blue) in 2020 satellite imagery showing adjacent EMPA, stream to Stephens Lake channel, 2020 Project clearing and disturbance (yellow line), and the boundaries of licensed Project footprint (purple line)**

Ground surveys in August 2015 identified EMPA clearing within 25 m of the edge of Wetland 51. All of this clearing was within the planned Project footprint.

Various disturbances have been observed in the area between the EMPA and the wetland since 2015 (e.g., machinery rutting, sediment deposition). Several measures were implemented to mitigate erosion and sediment deposition in this area such as slope grading, installation of soil berms and sediment fences as well as the placement of straw wattles within erosion channels.

Up to the time of the 2019 survey, the installation of straw wattles within the channels had slowed but not stopped sediment deposition into the water adjacent to the wetland. This resulted in sediment reaching into the wetland buffer in an area of 0.005 ha (Figure 3-11).





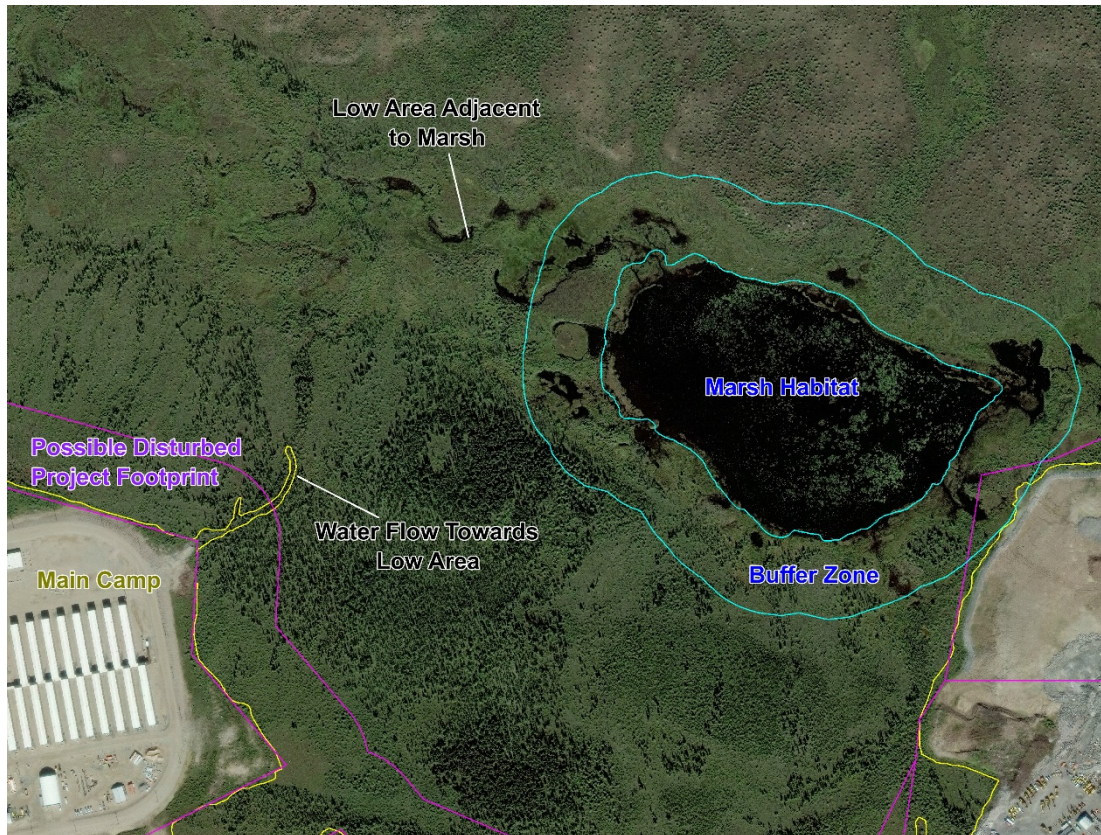
**Figure 3-11: Sediment deposition in buffer zone of Wetland 51 in 2020**

By late summer of 2020, the rock barrier that had been constructed on the northern edge of EMPA D16 was extended along the western edge to form a sediment barrier between the EMPA and Wetland 51. A gap in this barrier allowed sediment to continue flowing past the straw wattles and be deposited into the wetland buffer zone (see ECOSTEM (2021) for further details). The area of sediment deposition within the wetland buffer zone increased by approximately 0.02 ha by September 2020 (Figure 3-10; Figure 3-11).

Significant water flow from a drainage culvert at the northeastern corner of the Main Camp caused a channel to form in the previously undisturbed adjacent forest by September 2020. This channel of water flowed northeast towards a low area directly adjacent to Wetland 51 (Figure 3-12; see



ECOSTEM (2021) for further details). At the time of the survey, this disturbance was approximately 185 m away from entering the low-lying area adjacent to the wetland. Although no effects were observed during aerial surveys of this area, this disturbance has the potential to affect water levels in the marsh. Ground surveys in 2021 will continue to monitor for adverse effects in the area.



**Figure 3-12: Extent of water flow from culvert (in yellow to the west) with potential to affect Wetland 51 (in blue) as of September, 2020**

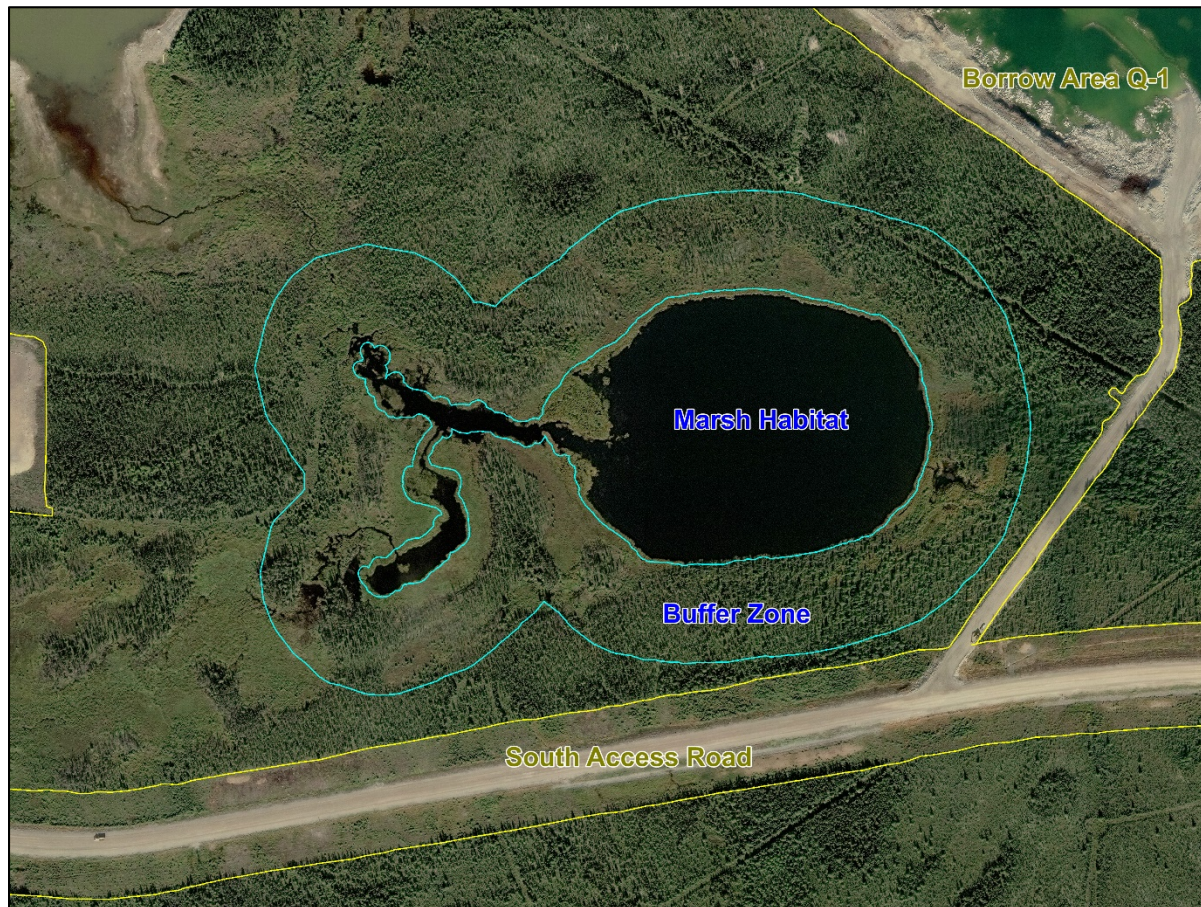
Peat bank slumping was observed around a small peat plateau bog between the wetland and EMPA slope in 2017. There did not appear to be any incremental change to the bog between 2017 and 2020. It was unclear if potential water regime changes due to the EMPA caused or accelerated this slumping, or if the slumping was due to massive ground ice melting that is occurring throughout the Keeyask region as a delayed response to past climate warming (ECOSTEM 2011).

The substantial amount of floating-leaved vegetation in the waterbody in 2015 was absent at the time of surveys from 2016 to 2019. This vegetation was apparent again in September 2020. It is uncertain whether these changes are the result of indirect Project effects, herbivory from muskrats and/or beavers, or a combination of both. The construction synthesis report will evaluate the causes, using all relevant data available.



### 3.2.9 WETLAND 52

Wetland 52 (Figure 3-13) is 28.4 ha in size and located south of Gull Rapids (Map 2-2). Marsh habitat comprised 9.1 ha of the wetland's total area. None of this wetland's buffer was burned in the 2013 wildfire.



**Figure 3-13: Satellite imagery showing proximity of Project clearing (in yellow) to Wetland 52 (in blue)**

There was no observed clearing or disturbance in or near Wetland 52 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 entered the marsh habitat buffer.

Project clearing or disturbance within Wetland 52 has not been observed during the surveys from 2016 to 2020 (Map 3-1). Potential hydrological impacts from the SAR were being monitored, but to date none have been observed. Consequently, ground surveys were not conducted at Wetland 52 in 2020. See ECOSTEM (2018) for specific observations made in previous survey years.

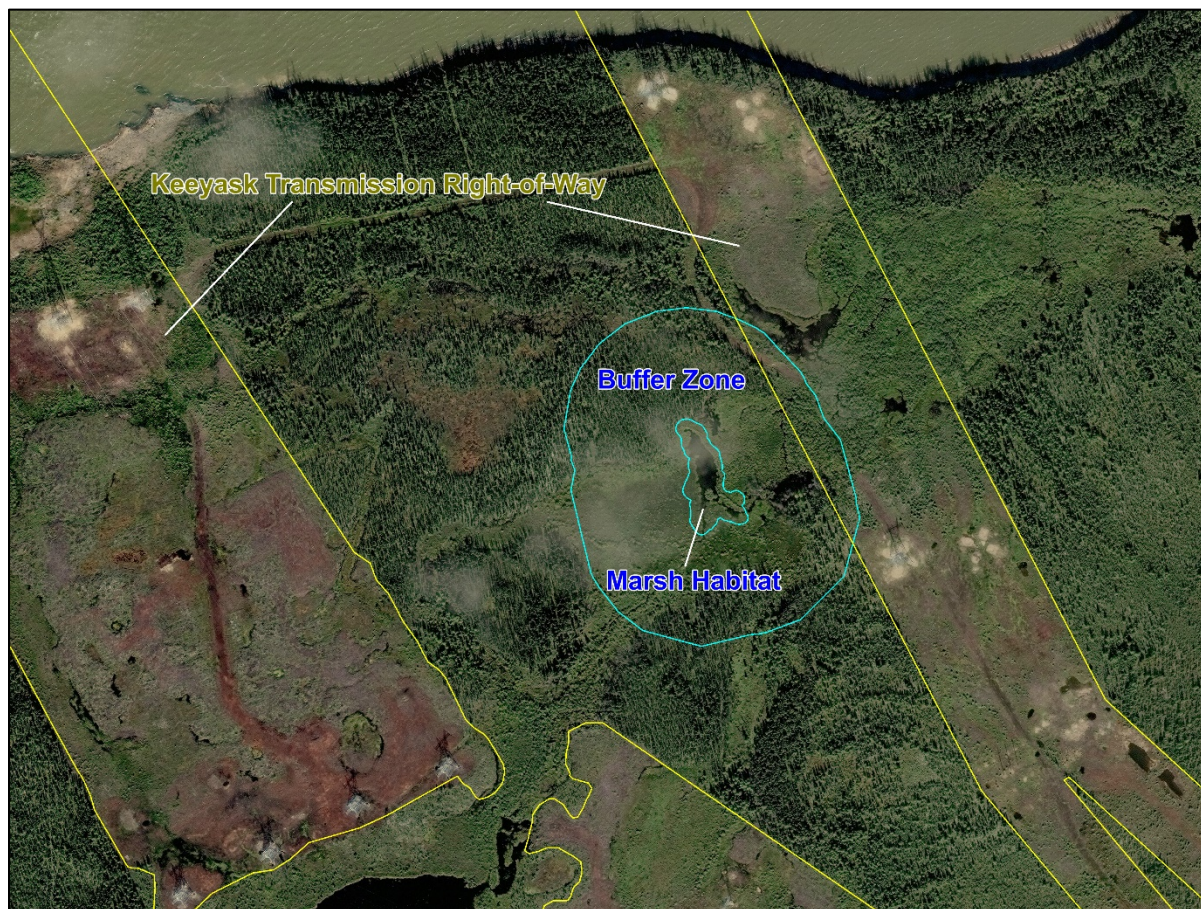


### 3.2.10 WETLAND 53

Wetland 53 is 5.5 ha in size. It is located on the south side of the Nelson River, just downstream of the future generating station (Map 2-2). Marsh habitat comprised 0.3 ha of the wetland's total area. None of the marsh habitat buffer burned in the 2013 wildfire.

Clearing in the marsh habitat buffer was observed during the 2015 aerial surveys. This clearing was for the Keeyask Transmission Project right-of-way (RoW), which is a separate project (Figure 3-14; Photo 3-12). See ECOSTEM (2018) for details.

Surveys from 2016 to 2020 found no new impacts or indirect expansion of the impacts that were present in 2015.



**Figure 3-14: Satellite imagery showing Keeyask Transmission Project clearing (in yellow) in the Wetland 53 (in blue) buffer zone**





**Photo 3-12: Aerial photo of Wetland 53 on September 13, 2020**

### **3.2.11 WETLAND 54**

Wetland 54 (Photo 3-13) is 113.1 ha in size, and located along the north side of the SAR, north of Borrow Area S-2b (Map 2-2). Marsh habitat comprised 70.1 ha of the wetland's total area. None of the marsh habitat buffer burned in the 2013 wildfire.

Surveys in 2015 and 2016 found clearing and disturbance in the marsh habitat buffer, but this was for the Keeyask Transmission Project RoW (Figure 3-15). Ground surveys in 2016 and 2017, and aerial surveys from 2018 to 2020 found no expansion of the impacts recorded in 2015 and 2016. 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. Specific observations regarding the impacts observed in 2015 and 2016 are provided in ECOSTEM (2018).





**Photo 3-13: Aerial view of Wetland 54 (western end) on September 13, 2020**



**Figure 3-15: Satellite imagery showing Keeyask Transmission Project clearing (in yellow) in the Wetland 54 (in blue) buffer zone**



### 3.2.12 WETLAND 57

Wetland 57 is 64.6 ha in size and nestled between the Butnau Road and Stephens Lake. Its buffer overlaps the road to the south and a dyke to the north (Map 2-2). Marsh habitat comprised 37.6 ha of the wetland's total area. None of the marsh habitat buffer burned in the 2013 wildfire.

Ground surveys in 2015 found that SAR construction had cleared 0.21 ha in the southern edge of the buffer, and all of this was within the planned Project footprint (Figure 3-16). No clearing or disturbance was found in the marsh habitat.

Ground surveys in 2016 found that clearing in the marsh habitat buffer had increased to 0.79 ha (Table 3-2), which was 0.58 ha higher than in 2015. All of the clearing was still within the planned Project footprint and no clearing or disturbance was found in the marsh habitat.

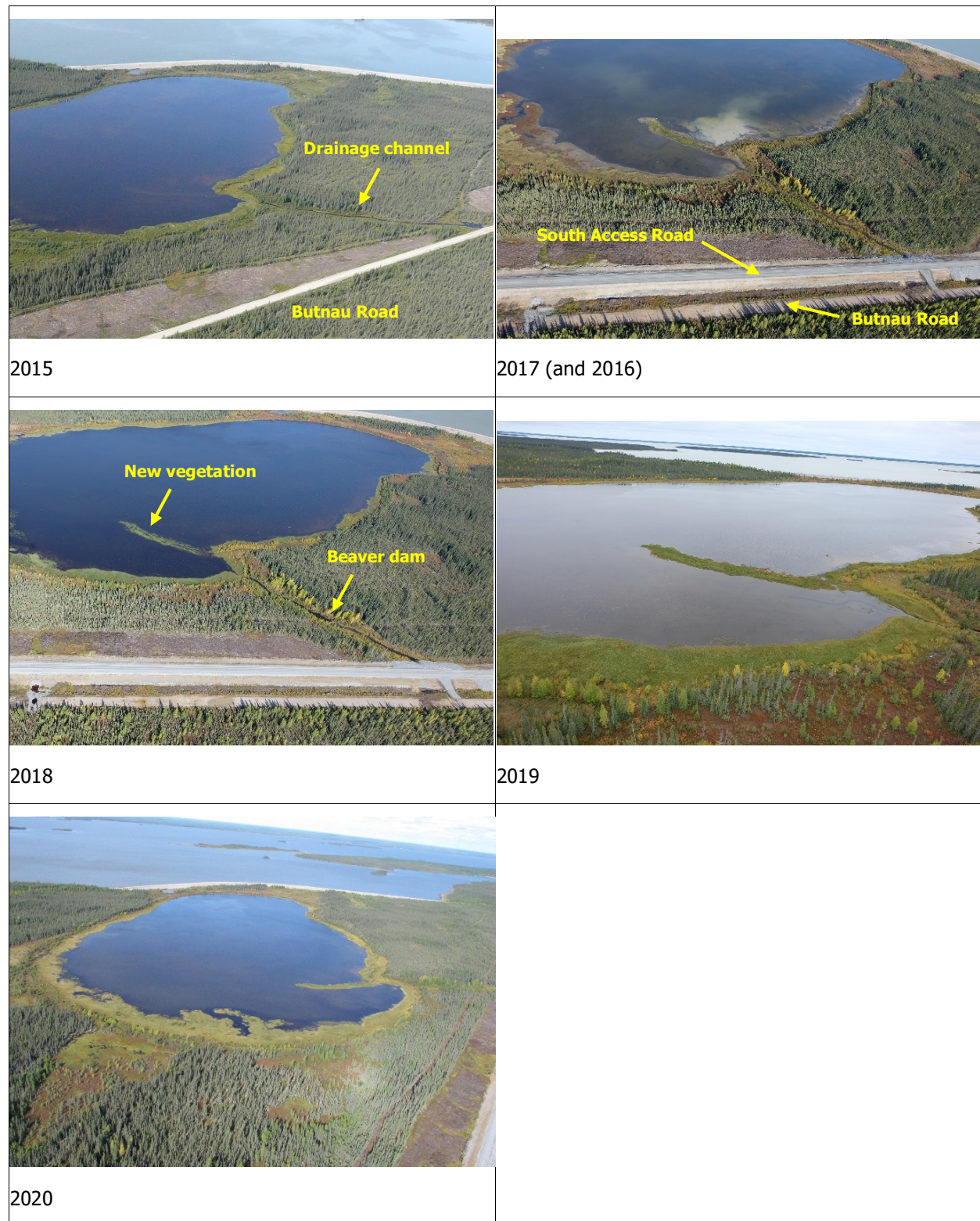


**Figure 3-16: Satellite imagery showing South Access Road clearing (in yellow) in the Wetland 57 (in blue) buffer zone**

Surveys from 2017 to 2020 found no additional clearing or disturbance in the marsh habitat buffer or marsh habitat.

At the time of the 2016 and 2017 surveys, the water levels in the Wetland 57 waterbody were very low compared to those observed in 2015 (Figure 3-17). This wetland drains through a natural channel into a ditch along the SAR (Figure 3-17).





**Figure 3-17: Aerial view of Wetland 57 showing varying water levels from 2015 to 2020**

At the time of the 2018 surveys, water levels increased to levels similar to those observed in 2015, while in 2019 they were slightly lower than observed in 2018. At the time of the 2019 surveys, the beaver dam had been breached and water was flowing freely from the wetland towards the SAR.

Water levels in 2020 were slightly lower than in 2019 (Photo 3-14) and the beaver dam within the drainage channel had not been rebuilt.

An expansion of shore zone wetland vegetation was observed during the 2017 monitoring. New vegetation was establishing on the lake bottom exposed by low water levels, and in the shallow water. The extent of shore zone vegetation has remained approximately the same or increased from 2018 to 2020.



**Photo 3-14: Marsh habitat upstream of beaver dam in Wetland 57 on September 10, 2020**

### **3.2.13 WETLAND 60**

Wetland 60 is 232.4 ha in size. It is located approximately 6.6 km south of Stephens Lake, just west of the access road corridor for the Ellis Esker borrow area (E-1) (Figure 3-18; Map 2-2). Marsh habitat comprised 150 ha of the wetland's total area. None of the marsh habitat buffer burned in the 2013 wildfire.





**Figure 3-18: Satellite imagery showing proximity of Project clearing (in yellow) to Wetland 60 (in blue)**

Wetland 60 was monitored for the first time in 2018. The wetland is situated well outside of Study Zone 3 because this study zone was a buffer of the planned and possibly disturbed areas at the time the EIS was completed. At that time, it was thought the use of the Ellis Esker borrow area was highly unlikely (even so, its potential effects were assessed in the EIS).

Surveys from 2018 to 2020 did not find any apparent effects of Project clearing on the marsh vegetation or hydrology (Photo 3-15). Impacts from the clearing were minimal, presumably because the road clearing and construction activity took place in the winter when the ground was frozen.





**Photo 3-15: Ground view of marsh habitat (background) and marsh buffer (foreground) at Wetland 60 on September 10, 2020**

In terms of other potential Project impacts, a natural drainage channel into the wetland ran through the clearing (Figure 3-19). There is a possibility that the vegetation clearing, past construction activity or future revegetation activity could alter water flow into the wetland through localized changes to the moisture regime or soil compaction. Although surveys in 2020 found that the access road corridor was being actively used by ATVs, the channel itself did not appear to be substantially disturbed and the adjacent vegetation appeared to be unaffected (Figure 3-19). This may have been due to the fact that the ATVs appeared to only be using one path in the center of the right-of-way. If usage continues, there is the potential for alternate paths through the channel to be made, creating a disturbance outside of previously cleared bounds.

Surveys in 2021 will monitor for any adverse effects in this area and within the wetland habitat.





Ellis Esker access road and channel to wetland in 2019



Ellis Esker access road and channel to wetland in 2020

**Figure 3-19: Aerial views of the Wetland 60 channel in 2019 and 2020**



### 3.2.14 REMAINING WETLANDS

Figure 3-20 shows the state of two of the remaining 28 wetlands visited during the aerial surveys. These wetlands were not closely surveyed because they were more than 100 m from existing Project clearing or disturbance, and there were no visible Project effects in them.



Wetland 38



Wetland 36

**Figure 3-20: Aerial photos of Wetlands 38 and 36 on September 13, 2020**



## **4.0 DISCUSSION**

### **4.1 WATER LEVELS IN OFF-SYSTEM WATERBODIES**

Water levels and water level variability in the off-system waterbodies are the primary determinants of the distribution and abundance of off-system marsh and its habitat. In the Project area, the two predominant potential drivers for changes to water levels were precipitation and Project-related effects on hydrology.

Total precipitation over the preceding months and years has a major influence on water level variations in waterbodies. The pathways and nature of precipitation effects can be quite complex as they are also controlled by subsurface topography, surficial material stratigraphy and ground ice in broad areas dominated by peatlands, such as Study Zone 4. ECOSTEM (2013) provides an overview of key pathways and processes for the Project region.

Based on water level indicators (Section 2.6), water levels at the time of the monitoring surveys appeared to be relatively low in 2016 and 2017, and then around median levels from 2018 to 2020.

Initial attempts to relate the annual differences in water levels to precipitation were unsuccessful due to serious limitations to the available weather data. For example, the closest weather station, which is at Gillam, is missing total precipitation data for 48% of the days in 2015 (including entire consecutive summer months) and 18% of the days in 2016. A similar, but less pronounced, situation was the case for the next closest weather station, which is at the Kelsey generating station site.

The widespread distribution of relatively low water levels in September 2016 and 2017, including in off-system waterbodies that were far from the Project footprint, suggested they were likely due to natural factors (i.e., precipitation) rather than being related to Project development. The construction synthesis report will explore possible approaches to developing precipitation data for the Project area (e.g., estimating missing data or using a more distant weather station) as this report is produced when all relevant data will be available.

### **4.2 WETLAND IMPACTS AND MITIGATION**

This section focuses on wetlands where new or ongoing Project impacts were found during the 2020 monitoring, and on wetlands with potential future impacts that merit mitigation or a particular focus during ongoing monitoring. Appendix 1 summarizes all mitigation recommendations provided to date for all wetlands.

There is a possibility that construction may have altered water flows and water levels at Wetlands 47 and 57. Over time, altered water flows and levels may change the amounts of marsh and its

habitat in these wetlands. Both wetlands will continue to be monitored for changes to marsh habitat.

The year-to-year pattern of water levels at Wetland 57 was different from the overall pattern across all of the monitored wetlands (Section 4.1). Construction of the SAR was a possible cause for the low water levels observed in Wetland 57 in 2016 and 2017. As this wetland drains through a channel into a ditch along the SAR (Figure 3-17), it is possible that the SAR ditch increased drainage from the lake. The higher water levels in Wetland 57 in 2018 were attributed to a beaver dam that was constructed in the drainage channel between 2018 and 2019. By 2019, the beaver dam had been breached and water was flowing freely from the wetland towards the SAR. Other notable potential contributors to the inter-annual water level variations included variations in precipitation and variations in groundwater flow under the dyke that prevents Stephens Lake from inundating the areas surrounding this wetland. The construction synthesis report will evaluate whether, and to what degree, the water level changes were related to the Project, using all relevant data available.

Surface water drainage flowing from the Main Camp has the potential to transport sediment or nutrient-enriched water into Wetland 51. Surveys in 2021 will monitor for these potential impacts, and also the effectiveness of mitigation recommended by other monitoring (ECOSTEM 2021).

At Wetland 51, sediment continued to run off the west slopes of the nearby EMPA (D16) into the wetland buffer zone. Despite the implementation of several mitigation measures from 2016 to 2019 (see Appendix 1 for details), the sediment deposition was still occurring in 2020. It is recommended that sediment containment structures be reinforced or repaired to prevent further sediment deposition into the wetland buffer. Revegetation of the EMPA slopes adjacent to the wetland would stabilize the soil, and should reduce sediment transport. It is also recommended that revegetation of EMPA D16 slopes be set as a high priority area for rehabilitation.

Wetland 60 has not been impacted by use of the Ellis Esker corridor.

New project disturbance or clearing was not observed at the remaining 11 wetlands that were within 100 m of actual Project clearing or disturbance at the time of the 2020 surveys. However, potential future impacts that merit a particular focus during future monitoring were noted for wetlands 47, 51, 57 and 60.

While ground surveys at Wetlands 37, 40, 42 and 45 were discontinued in 2019, future aerial surveys may detect impacts that merit subsequent ground surveys.



## 5.0 SUMMARY AND CONCLUSIONS

As has been the case since 2017, the 2020 monitoring found that there have been no new Project clearing in any of the 44 monitored wetlands. Ongoing disturbance was recorded in one wetland (Wetland 51). In Wetland 51, previously recorded sediment deposition from EMPA D16 into standing water adjacent to the marsh habitat buffer was continuing, and was spreading further into the wetland buffer zone.

As of 2020, Project clearing or disturbance within the monitored wetlands totalled 4.2 ha. Clearing accounted for the vast majority (99.5%) of this total. All of the recorded clearing or disturbance was at seven of the 44 wetlands being monitored.

Of the 4.2 ha of total Project clearing or disturbance, 0.11 ha (2.5% of the impacted area) was in marsh habitat, and all of this area was in one wetland within the future reservoir area. The remaining 4.1 ha of impacts were within the marsh habitat buffers of seven of the wetlands.

All of the Project clearing or disturbance was within the licensed Project footprint, including 3.91 ha (93%) in the planned Project footprint, and 0.29 ha in the possibly disturbed Project footprint.

Potential future Project impacts were identified for four of the monitored wetlands. At Wetland 47 and 57, construction may have altered water flows into the wetland, affecting water levels. New ATV usage adjacent to Wetland 60 (not related to the Project) may have potential to affect this wetland in the future. Water flow from a culvert at the northwest corner of the Main Camp has the potential to reach a small stream that flows into Wetland 51.

To date, there have been no unexpected effects on the off-system marsh wetlands being monitored by this study. While there has been some clearing or disturbance within seven of the monitored wetlands, these impacts were expected as the wetlands overlapped the licensed Project footprint.

Mitigation recommendations have been made to avoid or minimize potential future Project effects on the monitored wetlands.

Monitoring fieldwork for the off-system marsh wetlands will continue in 2021. No major changes to field methods are anticipated.

## 6.0 LITERATURE CITED

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## **APPENDIX 1: MITIGATION RECOMMENDATIONS**

This appendix collates and summarizes the off-system marsh wetland mitigation recommendations made during the TEMP construction monitoring.

**Table 6-1: Summary of Mitigation Recommendations**

Wetland	Recommendation <sup>1</sup>	Mitigation or Follow-up Implemented
Wetland 37	<p>2015: Evaluate and implement sediment control measures where needed to prevent sediment from entering the site along the north dyke.</p> <p>2016, 2017 and 2018: Limit further clearing along northeastern edge of EMPA (D3-E) that overlaps buffer. Monitor for potential effects from slope runoff.</p> <p>2019 and 2020: The potential for runoff from EMPA is declining. Monitor only if new construction activity or disturbance occurs nearby.</p>	<p>No additional clearing has occurred along the northeastern edge of the EMPA.</p> <p>No mitigation recommended. In 2021, ground survey only if air surveys detect new construction activity or disturbance.</p>
Wetland 40	<p>2015: Add sediment fence between the north dyke clearing and marsh at the base of the dyke. Evaluate and implement sediment control measures where needed.</p> <p>2016, 2017 and 2018: Evaluate and implement sediment control measures such as sediment fence where needed. Avoid northward extension of the existing dyke clearing, if possible.</p> <p>2019 and 2020: The potential for runoff from the dyke is declining. Monitor only if new construction activity or disturbance occurs nearby.</p>	<p>No additional northward clearing has occurred near the wetland buffer.</p> <p>No mitigation recommended. In 2021, ground survey only if air surveys detect new construction activity or disturbance.</p>
Wetland 42	<p>2017 and 2018: Monitor intact vegetation between Borrow Area G-1 and wetland for any erosion or surface runoff from the slope into the marsh.</p> <p>2019 and 2020: The potential for runoff from the borrow area is declining. Monitor only if new construction activity or disturbance occurs nearby.</p>	<p>No mitigation recommended. In 2021, ground survey only if air surveys detect new construction activity or disturbance.</p>
Wetland 45	<p>2015: Sediment fence be added between the north dyke clearing and marsh at the base of the slope. Evaluate and implement sediment control measures where needed.</p> <p>2016, 2017 and 2018: Evaluate and implement sediment control measures such as sediment fence where needed. Avoid northward extension of the existing clearing, if possible.</p> <p>2019 and 2020: The potential for runoff from the dyke is declining. Monitor only if new construction activity or disturbance occurs nearby.</p>	<p>No additional northward clearing has occurred near the wetland buffer.</p> <p>Between 2017 and 2018, sediment fencing was installed at the base of the dyke bank adjacent to the wetland.</p> <p>Mitigation no longer recommended. In 2021, ground survey only if air surveys detect new construction activity or disturbance.</p>



Wetland	Recommendation <sup>1</sup>	Mitigation or Follow-up Implemented
Wetland 47	<p>2016 and 2017: Avoid a southeastern extension of the existing south dyke clearing, if possible.</p> <p>2017 and 2018: Monitor the drainage channels passing through the clearing into the wetland during south dyke construction.</p> <p>2019 and 2020: Monitor water levels in wetland and for potential effects from altered water flows. See Figure 6-1.</p>	<p>No additional southward clearing has occurred near the wetland buffer.</p> <p>No additional mitigation recommended at this time.</p>
Wetland 51	<p>2015: Inspect and enhance sediment control measures along the northern edges of the EMPA (D16). Erect a sediment fence around the north and northwest side of the EMPA.</p> <p>2016 and 2017: Sediment fence be placed between the EMPA and marsh and water channel along the northwest, north and northeast edges of the EMPA at strategic locations. Place any additional excavated materials to the southwest of the placement area, or well back from the top of the bank.</p> <p>2018 and 2019: Consider additional sediment control measures along the northwestern banks of the EMPA to prevent continued sediment deposition into wetland.</p> <p>2020: Reinforce or repair sediment containment structures to prevent further sediment deposition into the wetland buffer. Revegetate EMPA D16 slopes adjacent to the wetland to stabilize soil. See Figure 6-2.</p> <p>2020: Potential for disturbances from drainage at Main Camp to reach wetland. Monitor for adverse effects from Main Camp area reaching wetland.</p>	<p>In fall 2017, material in EMPA D16 was re-sloped and additional sediment fencing was installed.</p> <p>Between 2017 and 2018, additional sediment fencing was installed at the base of the slope adjacent to the wetland. Rock barriers and woody debris armouring placed around northern and eastern edges of EMPA D16 in spring, 2018. Sediment fences on western edge of EMPA D16 removed and straw wattles placed into erosion channels in April 2019.</p> <p>Rock barriers extended along western edge of EMPA D16 in 2020. Gap left in rock barrier at wetland edge.</p>
Wetland 52	<p>2016, 2017, 2018, 2019 and 2020: Monitor water levels and condition of marsh outlet for runoff effects from SAR.</p>	<p>No mitigation recommended at this time.</p>
Wetland 57	<p>2016: Investigate possible causes for low water levels during 2017 surveys.</p> <p>2019 and 2020: Continue to monitor for water level changes and wetland development.</p>	<p>Field surveys in 2018 suggested that the low water levels may have been one of, or a combination of, natural water level variability and altered drainage due to construction of the SAR. A beaver dam increased water levels in the wetland in 2018. Breaching of the beaver dam in 2019 lowered water levels slightly since 2018.</p>

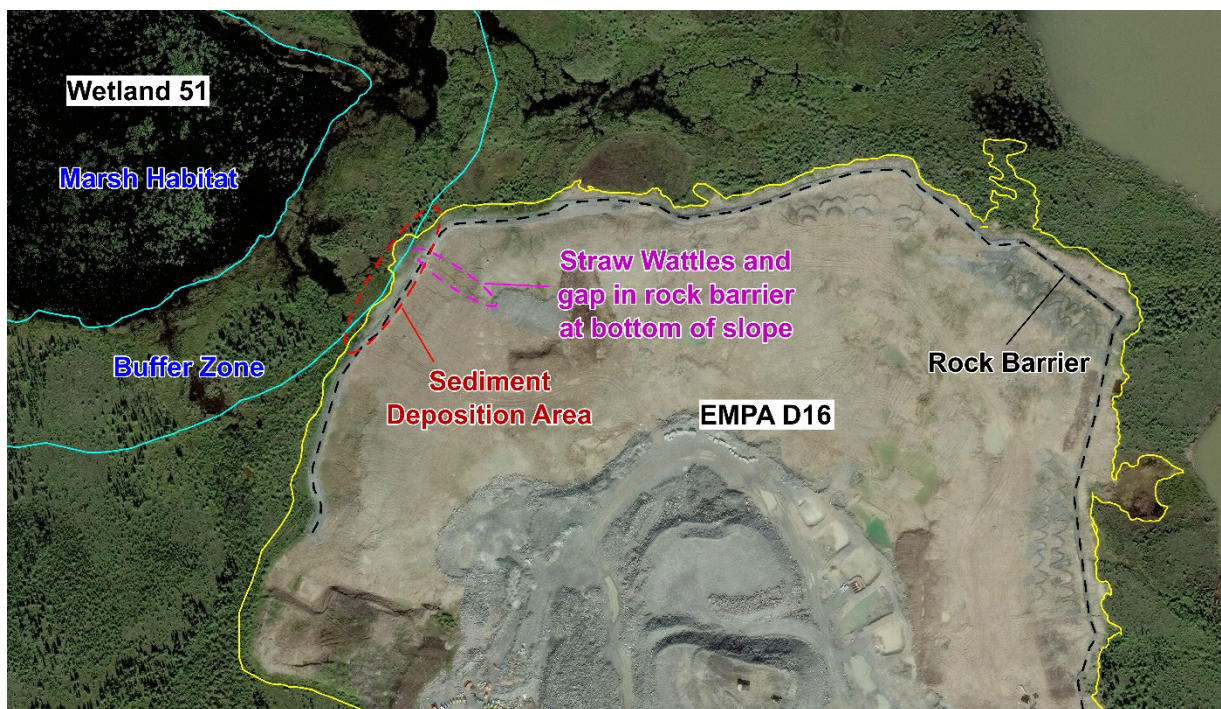
Wetland	Recommendation <sup>1</sup>	Mitigation or Follow-up Implemented
Wetland 60	2018 and 2019: Monitor wetland for runoff effects from the Ellis Esker access corridor. Avoid additional clearing or disturbance near this wetland. 2020: Potential for disturbance in wetland from adjacent ATV use. See Figure 6-3. Monitor for adverse effects to wetland habitat.	No mitigation recommended at this time.

Notes: <sup>1</sup> Recommendations in addition to continued monitoring. The number at the beginning of a line indicates the year that the recommendation was made. See ECOSTEM (2016; 2017; 2018; 2019; 2020) for the 2015, 2016, 2017, 2018 and 2019 recommendations, respectively.



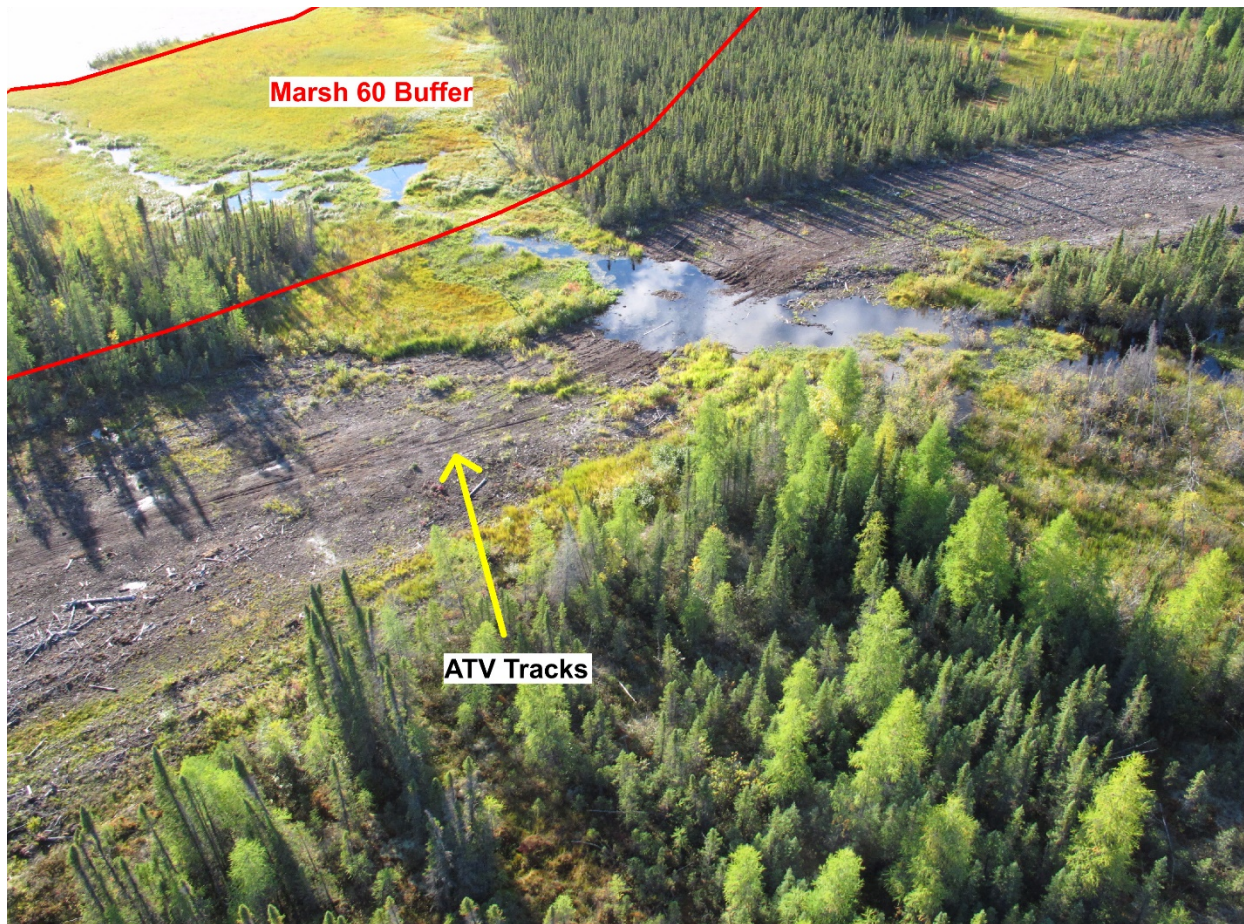


**Figure 6-1: Mitigation areas and recommendations for Wetland 47**



**Figure 6-2: Mitigation areas and recommendations for Wetland 51**





**Figure 6-3: Evidence of ATV use in Ellis Esker access corridor near Wetland 60**