# Keeyask Generation Project

## Terrestrial Effects Monitoring Plan

# Wetland Loss and Disturbance Monitoring Report

**TEMP-2019-03**

KEEYASK

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

**2018 -2019**

# KEEYASK GENERATION PROJECT

## TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2019-03

## WETLAND LOSS AND DISTURBANCE MONITORING

Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

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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.

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

## 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 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 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.

## What was done?

Wetland mapping for the environmental assessment showed that the Project would affect some wetlands. Since it is impossible to avoid all of the wetlands in the area given the size of the Project footprint and the widespread nature of wetland habitat (i.e., peatlands), mitigation is planned to help reduce Project effects.

As construction proceeds, this monitoring study documents Project impacts on, and mitigation related to, the very important wetland types. This is to make sure the Project effects predictions are accurate and that no additional unanticipated 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. For these reasons, each monitored wetland includes the entire waterbody, plus a 100 m buffer of the waterbody.

In each year of construction, aerial and ground surveys are done at wetlands that are close to the Project construction areas. In September 2018, 42 wetlands were surveyed from a helicopter, and eight of these wetlands were also surveyed on the ground.

### What was found?

A total of 4.19 ha of Project clearing or disturbance was found within seven of the 42 wetlands surveyed by helicopter (i.e., marsh habitat or their buffers), with the vast majority (4.09 ha; 98%) of this being within the planned Project footprint. This was expected since a portion of these wetlands overlapped a permanent Project feature such as a dyke, a road or the future reservoir.

Six of the seven impacted wetlands had Project clearing only in a portion of their marsh habitat buffers. In one of these wetlands, 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 the seventh wetland had been disturbed by sediment deposition. All of this sediment deposition was in the marsh habitat buffer.

Future Project impacts were possible for eight of the wetlands located within 100 m of actual Project clearing or disturbance. At four of these wetlands, exposed mineral slopes between the wetland and a Project feature (e.g., dyke, excavated material placement area) had been created by either the 2013 wildfire (which was unrelated to the Project) or Project clearing. These exposed mineral slopes pose a risk in that future heavy rains could carry sediment or other materials into the marsh habitat. At five other 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 small portion of seven wetlands, it was expected that there would be some impacts at wetlands overlapping the planned Project footprint or to those close to active construction areas. Erosion control or other mitigation measures have been recommended where there are potential risks to an off-system marsh or its habitat.

### What will be done next?

Off-system marsh wetland monitoring, including the effectiveness of mitigation measures, will continue in 2019. Where needed, additional mitigation measures will be recommended after the 2019 surveys.

# ACKNOWLEDGEMENTS

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# STUDY TEAM

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

Fieldwork in 2018 was conducted by Nathan Ricard and Brock Epp.

Data analysis and report writing in 2018 were completed by Brock Epp and James Ehnes. GIS analysis and cartography was completed by Nathan Ricard and Brock Epp.

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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 *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 2018.

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.

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

# 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 2018. The monitoring methods were the same as in 2015 to 2017.

Prior to describing the activities, some terminology is defined 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), 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 over an area of at least 400 $m^2$ in size. Disturbance refers to either clearing smaller than 400 $m^2$, physical disturbance in intact vegetation (e.g., machinery trail, test pits, sediment deposition) or use of a pre-existing trail.

It is noted that, while the definition of clearing means that every cleared patch being referred to in this report is at least 400 $m^2$, the portion of a clearing that overlaps a wetland or its buffer can be much smaller than 400 $m^2$. 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).

As noted above, the Wetland Loss and Disturbance study is focusing on how the Project is affecting off-system marsh wetlands. Under natural and impacted 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 wetland areas that can support marsh (i.e., marsh habitat) actually have marsh in them at a given time. For this reason, the monitoring extends beyond the originally mapped patches of off-system marsh to also 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 where marsh habitat occurs are predominantly determined by a combination of water depths and water level variations (TE SV; KHLP 2012b). In Study Zone 4, off-system marsh was not found in water known or thought to be deeper than 2 m (ECOSTEM 2012). As EIS studies indicated that the waterbodies containing off-system marshes generally had a maximum depth of less than 2 m (ECOSTEM 2012 unpublished raw data), the entire waterbody was included as off-system marsh habitat.

Total precipitation over the preceding months and years has an important natural influence on the distribution and abundance of marsh through its influence on water depths and water level variations. 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 3 (Map 2-2). ECOSTEM (2013) provides an overview of key pathways and processes for Study Zone 3.

Marsh and its habitat can be strongly influenced by human impacts such as physical disturbance or hydrological alterations in the nearby areas. Activities within these surrounding areas can indirectly alter existing marshes or marsh habitat. For this reason, in addition to monitoring 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 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 the marsh habitat (i.e., an included 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; Map 2-1) were approved for Project use by Manitoba Conservation and Water Stewardship (now Manitoba Sustainable Development (MSD)). This is the third type of Project area. These subsequently approved areas primarily included the former Keeyask Infrastructure Project (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 trails were evaluated for potential effects by terrestrial specialists prior to their submission for approval to MSD, and their locations 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 evaluations of the subsequently approved areas was how these areas would alter predicted cumulative effects, which was largely related to the characteristics of the areas and the amount of the licensed Project footprint that was expected to remain undisturbed at the end of construction. 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 2017, the majority (58%) of the originally licensed Project footprint had not been impacted by the Project (ECOSTEM 2018a).

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

The last type of Project area for reporting clearing or disturbance includes any areas outside 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 Long-Term Effects on Wetlands study will monitor long-term direct and indirect Project effects on wetland function.

## 2.3 DATA COLLECTION

To verify the implementation and effectiveness of off-system marsh protection measures (i.e., the first study objective; Section 1.0), 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.

For the first study objective, the wetlands selected for monitoring were all off-system marsh wetlands located in Study Zone 3 (Map 2-2). Wetlands outside of Study Zone 2 (i.e., the areas of direct and indirect terrestrial habitat effects; Map 2-2) were 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 of this study, it is important to document when potential hydrological effects occur.

Studies completed for the environmental impact statement (EIS) had mapped the off-system marshes present in Study Zone 4 (Map 2-2) in 2012. Map 2-2 shows the 44 wetlands that are in Study Zone 3, and are being monitored to verify the implementation and effectiveness of off-system marsh protection measures. The total number of wetlands is two higher than in 2017 due to the addition of the Ellis Esker borrow area (E-1) and its access road to the actual Project

footprint. At the time of the EIS, this Project component was included in the possibly disturbed Project footprint as it was thought it was highly unlikely that it would be used.

Each of the 44 monitored wetlands was assigned a unique wetland identification number for the monitoring (e.g., Wetland 17).

In each construction year, aerial surveys are conducted of the monitored wetlands that may have been affected by the Project. These 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 images (DOIs) of the Project footprint. A 1 km distance was used because it is possible for hydrological effects to extend well beyond the immediate vicinity of an impact in a broad area dominated by peatlands (Section 2.1).

In the second stage of wetland selection, an aerial survey adds any other of the monitored wetlands that are within 1 km of Project clearing or disturbance that happened after the DOI was acquired.

Ground surveys are also conducted at a subset of the wetlands included in the aerial surveys. A wetland was also ground surveyed if project clearing occurred within 100 m of the wetland. Ground surveys searched for effects not visible from the air, documented mitigation measures implemented, and documented possible Project effects.

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

The spatial extent of impacts on the surveyed wetlands are mapped in a GIS using a combination of photos acquired from a helicopter and the most recent growing season DOI. 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 unrelated to the Project) were 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 used to map the percentage of the wetland's buffer that was burned in the 2013 wildfire.

In 2018, the first stage of wetland selection used a DOI acquired in July 2017 because a DOI from summer 2018 was not available prior to the aerial surveys. A total of 39 wetlands were identified for inclusion in the aerial surveys. Three additional wetlands within 1 km of Project impacts were identified during the second stage aerial surveys conducted on September 15 and 16, 2018. The final number of wetlands included in aerial surveys was 42. Thirteen of these 42 wetlands were within 100 m of existing clearing or disturbance.

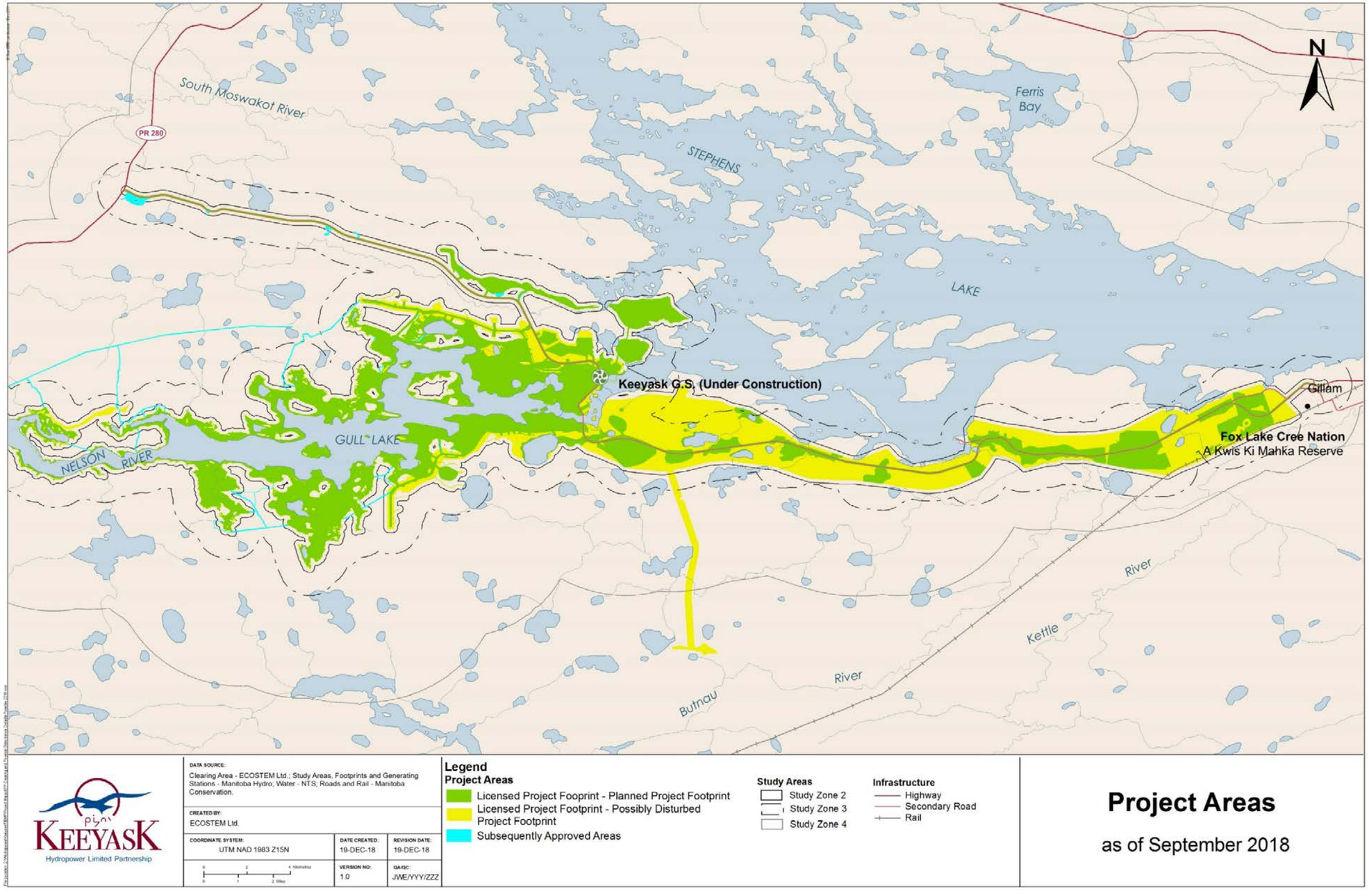
Ground surveys were conducted at eight wetlands (Map 2-2) on September 11 and 16, 2018. Five of the 13 wetlands within 100 m of existing clearing or disturbance were not ground-surveyed in 2018. There had been no new clearing or disturbance near wetlands 17, 52, 53 and

54 for several years, and there were no documented Project effects at these wetlands in the previously surveyed years; and, heavy construction activity near Wetland 47 prevented ground surveys at that location.

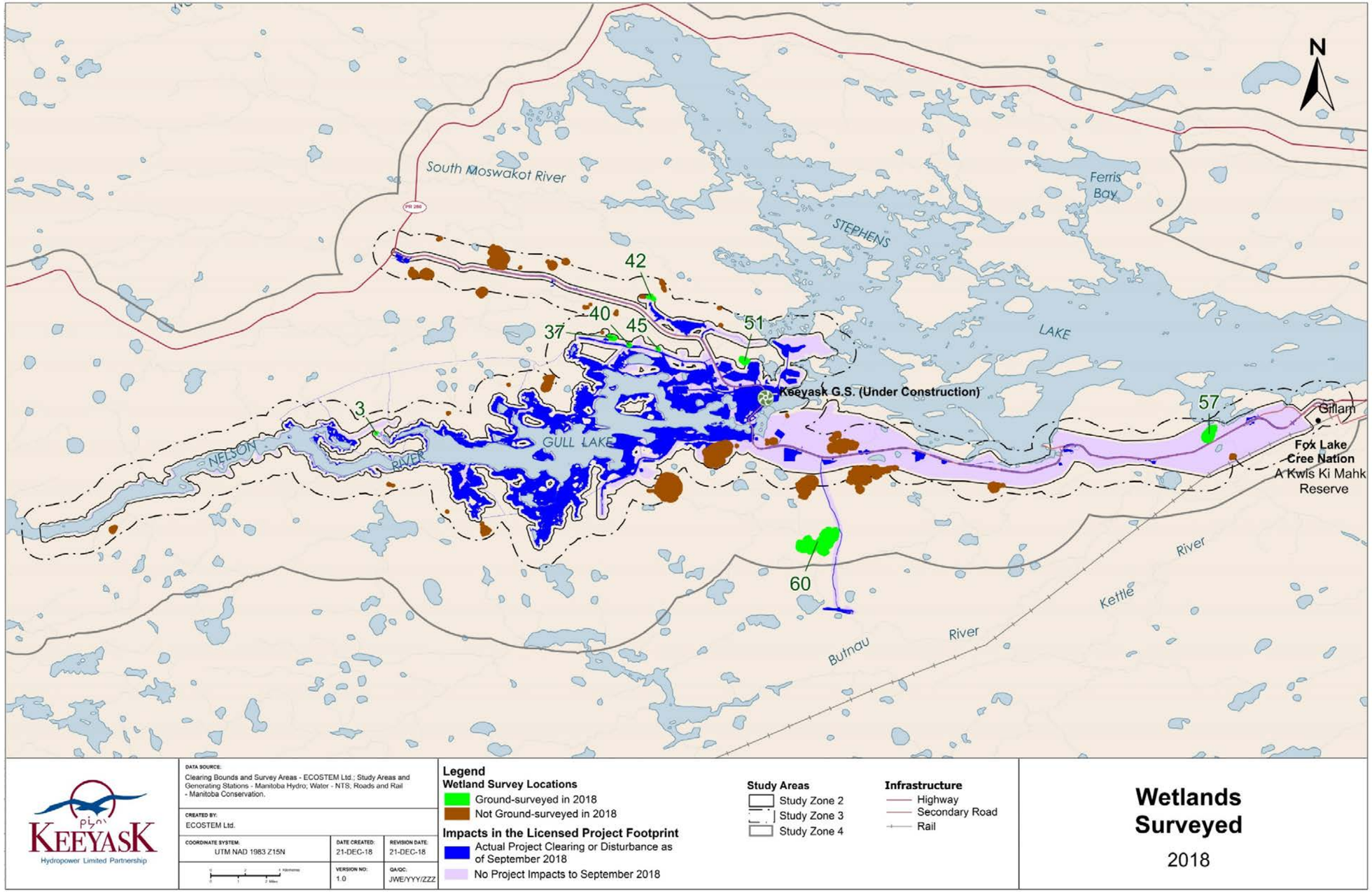
## 2.4 WATER LEVELS AND WEATHER DATA

Project related effects on water levels or water level variability were of interest for the wetland monitoring because these factors are primary determinants of the amounts of marsh wetland and marsh habitat. As water levels in off-system waterbodies are not monitored with equipment, the apparent water levels relative to the median were recorded at the time of the wetland surveys. The degree of exposed aquatic vegetation and lake-bottoms was the indicator of relatively low water levels while degree of flooded beach vegetation as the indicator of relatively high water levels.

As noted in Section 2.1, total precipitation over the preceding months and years has an important natural influence on the distribution and abundance of marsh. Initial attempts to relate water levels observed in the monitored waterbodies to precipitation data 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 exists for the next closest weather station, which is at the Kelsey dam site. 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 of the relevant data will be available.




**Map 2-1: Project areas as of September 2018**




**Map 2-2: Monitored off-system marsh wetlands, also showing those that were ground-surveyed in 2018**

# 3.0 RESULTS

Aerial surveys conducted on September 15 and 16, 2018 found that 13 of the 44 wetlands being monitored during construction were within 100 m of Project clearing or disturbance at the time of the surveys (Map 2-2). These included Wetlands 3, 17, 37, 40, 42, 45, 47, 51, 52, 53, 54, 57 and 60. Figure 3-1 to Figure 3-7 provide aerial views of these 13 wetlands.

Project impacts were not expected for five of the 13 wetlands that were within 100 m of Project clearing or disturbance because no new clearing or other impacts had been recorded in or near them for several years (see Section 2.3). As the 2018 aerial surveys confirmed the absence of additional clearing or impacts near these five wetlands, ground surveys were not conducted in them. Ground surveys were conducted in the remaining eight wetlands that were within 100 m of Project clearing.

No new clearing occurred in any of the buffers or marsh habitat of the other wetlands between the 2017 and 2018 off-system marsh monitoring surveys. No clearing occurred within the buffer of the new wetland (Wetland 60) being monitored within 100 m of the Ellis Esker access corridor clearing. Clearing recorded in the 2018 surveys came within one meter of Wetland 60.

One marsh habitat buffer that had been disturbed by sediment runoff in 2017 was still receiving sediment in 2018. At Wetland 51, sediment from an excavated material placement area (EMPA) adjacent to the marsh habitat buffer was bypassing silt fences that had been installed along the perimeter of the EMPA.

Table 3-1 summarizes the main findings for the wetlands being monitored by this study. Of the 4.19 ha of Project clearing or disturbance within wetlands, 0.10 ha was in marsh habitat while the rest was in the marsh habitat buffer. This was unchanged from 2017.

To date, all recorded impacts in wetlands have been within the licensed Project footprint, with the vast majority being in the planned Project footprint. Of the 4.19 ha of impacted area, 3.91 ha was within the planned Project footprint while 0.28 ha was within the possibly disturbed Project footprint (Table 3-2).

**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, 2018**

| Wetland ID[1] | Wetland Area (ha) | | | Area (ha) Impacted[2] by Project Clearing and Disturbance | | | Other Project Impacts up to 2018 | 2013 Burn in Buffer (%)[3] | 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 | Runoff from EMPA slope |
| **40** | 7.9 | 1.2 | 6.7 | 1.754 | - | 1.754 | None | 10 | Runoff from dyke slope through vegetated area |
| **42** | 15.7 | 2.9 | 12.8 | - | - | - | None | 50 | Runoff from borrow area clearing through vegetated area |
| **45** | 7.3 | 0.8 | 6.5 | 0.236 | - | 0.236 | None | 50 | Runoff from dyke clearing through burned area |
| 47 | 189.7 | 140.7 | 49.0 | 1.033 | - | 1.033 | None | 0 | Runoff from dyke through drainage channels into marsh |
| **51** | 25.7 | 10.5 | 15.2 | 0.005 | - | 0.005[4] | None | 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 |
| **57** | 64.6 | 37.6 | 27.0 | 0.793 | - | 0.793 | None | 0 | Hydrological effects from a road culvert |
| **60** | 232.4 | 150.0 | 82.5 | - | - | - | None | 0 | None |
| All | 847.6 | 525.7 | 322.0 | 4.190 | 0.105 | 4.086 | | | |

Notes:
[1] Bold font identifies wetlands that were ground sampled in 2018.
[2] All mapped Project clearing or physical disturbance in monitored wetlands. See ECOSTEM (2019) for the mapping.
[3] Percentage of total buffer area that burned in the 2013 wildfire (which was unrelated to the Project).
[4] Area is an arbitrary value to capture sediment deposited in patches of standing water intermingled in surface peat.

**Table 3-2: Project clearing or disturbance in the off-system marsh wetlands within 100 m of Project clearing or disturbance as of September, 2018, by Project area**

| Wetland ID | Total Wetland Area (ha) | Area (ha) Impacted by Project Clearing and Disturbance[1] | | |
|---|---|---|---|---|
| | | Total | Planned Project Footprint | Possibly Disturbed Project Footprint |
| 3 | 5.0 | 0.364 | 0.117 | 0.247 |
| 17 | 135.1 | - | - | - |
| 37 | 17.0 | 0.006 | - | 0.006 |
| 40 | 7.9 | 1.754 | 1.754 | - |
| 42 | 15.7 | - | - | - |
| 45 | 7.3 | 0.236 | 0.236 | - |
| 47 | 189.7 | 1.033 | 1.015 | 0.018 |
| 51 | 25.7 | 0.005 | - | 0.005[2] |
| 52 | 28.4 | - | - | - |
| 53 | 5.5 | - | - | - |
| 54 | 113.1 | - | - | - |
| 57 | 64.6 | 0.793 | 0.793 | 0.00 |
| 60 | 232.4 | - | - | - |
| All | 847.6 | 4.190 | 3.914 | 0.276 |

Notes:
[1] All mapped Project clearing or physical disturbance in monitored wetlands. See ECOSTEM (2019) for the mapping.
[2] Area is an arbitrary value to capture sediment deposited in patches of standing water intermingled in surface peat.

Wetland 3 (September 16)

Wetland 17 (September 16)

**Figure 3-1: Aerial views of Wetlands 3 and 17 on September 16, 2018**

Wetland 37

Wetland 40

**Figure 3-2: Aerial views of Wetlands 37 and 40 on September 16, 2018**

Wetland 42

Wetland 45

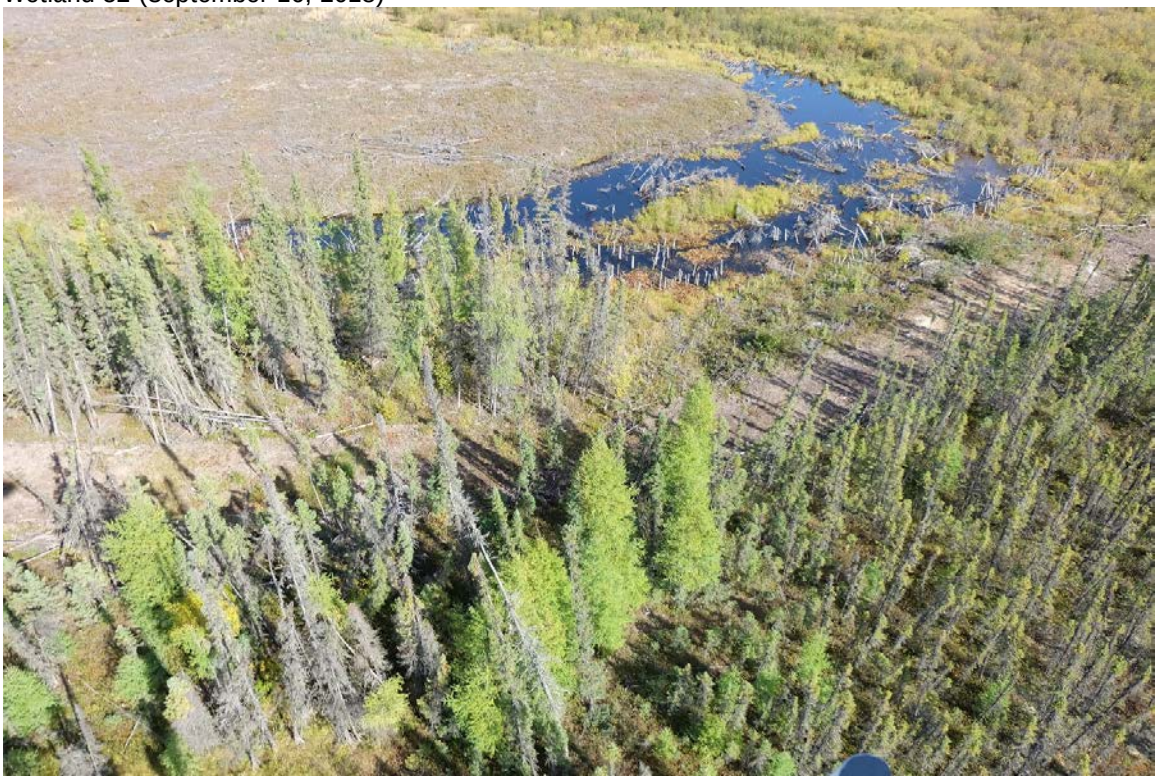
**Figure 3-3: Aerial views of Wetlands 42 and 45 on September 16, 2018**

Wetland 47

Wetland 51

**Figure 3-4: Aerial views of Wetlands 47 and 51 on September 16, 2018**

Wetland 52 (September 16, 2018)



Wetland 53 (September 19, 2017)

**Figure 3-5: Aerial views of buffers in Wetlands 52 and 53**

Wetland 54 (west end)

Wetland 57

**Figure 3-6: Aerial views of Wetlands 54 and 57 on September 16, 2018**

Looking east

Looking west from Ellis Esker access road clearing

**Figure 3-7: Aerial views of Wetland 60 on September 16, 2018**

## 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 2-2). This wetland has a direct surface water connection 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 2.0) burned approximately 90% of the marsh habitat buffer (*i.e.*, a 100 m buffer of the marsh habitat) included in Wetland 3.

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

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 3-8). 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.

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 (Figure 3-8).

No further clearing or disturbance was observed in this wetland during the 2017 or 2018 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.

**Figure 3-8: Cleared trees in Wetland 3 on August 31, 2017**

## 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 located near the kilometer 6 point of the north access road (NAR). Marsh habitat comprised 97.5 ha of the wetland's total area. Approximately 85% of the marsh habitat buffer burned in the 2013 wildfire.

Project disturbance or clearing had not been observed within Wetland 17 up to the time of the 2018 surveys (Map 3-1). Ground surveys conducted from 2015 to 2017 found no incremental changes in the condition of the wetland. Ground surveys were not conducted in 2018 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 (2018b).

Future surveys will continue to monitor these locations.

**Figure 3-9: Ground photo of Wetland 17 on August 23, 2017**

## 3.3 WETLAND 37

Wetland 37 (Figure 3-2) 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.

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) extended into the buffer portion of the wetland. Ground surveys in 2017 and 2018 found no further changes to the EMPA since the previous survey, and no new impacts on the wetland were observed.

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 (Figure 3-10).

View along the shores of Wetland 37 (September 16)

Aerial view of Wetland 37 looking northeast with EMPA D3-E in foreground (September 15)

**Figure 3-10: Ground and aerial photos of Wetland 37 in 2018**

## 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 2-2). Marsh habitat (Figure 3-11) comprised 1.2 ha of the wetland's total area. Approximately 10% of the marsh habitat buffer burned in the 2013 wildfire.

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 3-12). All of this 1.75 ha of clearing was within the planned Project footprint (Table 3-2). By September, 2018, development of the north dyke within the cleared area continued, but no impact to the wetland was observed. 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. In 2018 water levels appeared to be approximately at the median level.

It was also noted in 2016 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 silt fence be installed between the dyke clearing and the wetland at the base of the slope. As of September 2018, a fence had not yet been installed.

No sedimentation or runoff from the dyke was observed as of the 2018 surveys. The mineral slope facing the marsh remained shallow, and it appeared that risk of sedimentation due to runoff was low under current conditions. A peatland with black spruce seedlings and saplings was regenerating between the dyke clearing and the marsh (Figure 3-11). As regeneration progresses, this peatland will likely serve as an increasing barrier to potential runoff. These areas will be monitored for any future effects from runoff.

View along the shores of Wetland 40

Regenerating peatland between marsh and dyke clearing

**Figure 3-11: Ground photos of Wetland 40 on September 16, 2018**


**Figure 3-12: Satellite imagery showing dyke clearing (all within the planned Project footprint) at Wetland 40 in 2018**

## 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 kilometer 14, at the northwestern end of Borrow Area KM15 (Map 2-2). Marsh habitat comprised 2.9 ha of the wetland's total area (Figure 3-13). Approximately 50% of the marsh habitat buffer 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 (Map 3-1). At the time of the 2016 surveys, clearing was still approximately 90 m away from the marsh habitat buffer. 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 extending downwards from Borrow Area KM15 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 2018 surveys, there were no signs of erosion along the slope to the wetland. Also, there were no apparent changes in the undisturbed vegetation between the wetland and the cleared area in G-1, and no new clearing or excavation in the nearby portion of G-1. Ground surveys found that the peat bank at the base of the slope adjacent to the wetland was beginning to slump and break apart (Figure 3-14). This was likely due to melting permafrost in the recently burned peat plateau bog. 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.

**Figure 3-13: Marsh habitat in Wetland 42 on September 16, 2018**

**Figure 3-14: Slumping peat bank adjacent to Wetland 42 on September 16, 2018**

## 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 2-2). 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.

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. All of this clearing was within the planned Project footprint. No other Project clearing or disturbance was observed next to this wetland in 2015.

By the time of the 2016 ground survey, north dyke clearing had extended approximately 25 m into the marsh habitat buffer (Figure 3-15 and Figure 3-16; 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.

As of September, 2018, no further clearing had occurred within the marsh habitat buffer, although dyke construction continued within the cleared area.

A 15% slope through the dyke clearing area to the marsh habitat creates 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 3-16), the entire slope had been burned with some areas having virtually all vegetation removed. At the time of the 2018 surveys, no runoff or sedimentation was seen entering the marsh habitat. It was noted that there was a small hill between the wetland and the dyke, which may serve as a natural barrier to potential future runoff. In 2017, it was recommended that a silt fence be installed at the base of the dyke as a preventative measure. A short segment of fence was installed at one location following a recommendation that site staff evaluate and implement sediment control measures such as silt fence where needed (Figure 3-16). These areas will continue to be monitored for potential runoff effects.


**Figure 3-15: Satellite imagery showing North Dyke clearing (all within the planned Project footprint) at Wetland 45 in July 2018**

View along the shore of Wetland 45

Silt fence installed at bottom of North Dyke slope near Wetland 45

**Figure 3-16: Ground and aerial photos of Wetland 45 on September 16, 2018**

## 3.7 WETLAND 47

Wetland 47 (Figure 3-4; Figure 3-17) 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.

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, both of which were within the possibly disturbed Project footprint.

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 3-17). Part of a runnel, draining water through the wetland into the lake, was cleared where it was within the planned Project footprint, and woody debris had accumulated in the channel, but this did not appear to block water flow into the uncleared wetland.

While no further clearing had occurred by September 2018, the South Dyke was under construction near the wetland. Ground surveys were not conducted in 2018 due to heavy construction activity nearby. Aerial surveys found no apparent effects in the marsh habitat due to runoff from the dyke clearing and infrastructure (Figure 3-17).

In 2017, it was noted that water levels in the wetland were lower than the median based on exposed aquatic vegetation and lake-bottom. In 2018, water levels appeared to be approximately at the median.

**Figure 3-17: View along the Wetland 47 shore on September 16, 2018. Yellow arrows indicate drainage channels identified in 2017**

## 3.8 WETLAND 51

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

Ground surveys in August 2015 identified clearing for an EMPA within 25 m of the edge of Wetland 51 (Map 3-1), all of which was within the planned Project footprint.

Project disturbances recorded 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 that flows into Wetland 51 were 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).

No Project clearing, disturbance or other impacts were observed within Wetland 51 in 2016. By the time of the 2016 ground survey, some EMPA D16 banks had been graded, creating gentler slopes on the northwestern edges. The slope grading had removed the heavy machinery rutting and soil berm that was present in 2015, and the silt fence that was previously present had also been removed. These slopes were within the licensed Project footprint and came within approximately 2 m of the Wetland 51 boundaries. There was no sedimentation into the wetland at the time if the 2016 survey. In that year's annual report (ECOSTEM 2017), it was recommended that sediment control measures be placed at strategic locations along the northwestern, northern and eastern EMPA banks to prevent further spread towards Wetland 51 or towards the Stephens Lake/Nelson river channel.

As of late summer 2017, the only additional Project impact within Wetland 51 was sediment deposition into the buffer portion of the wetland. There was no apparent vegetation mortality within Wetland 51 between the EMPA slope and shoreline.

This sediment deposition into the buffer portion of the wetland was ongoing as of September 2018, despite the installation of silt fences at the base of the EMPA slope. The apparent affected area has not increased since 2017. While the EMPA D16 slopes adjacent to the buffer in Wetland 51 had been graded, erosion channels had developed in the slope. Flow from the larger channels undermined or overtopped the silt fences at a couple locations, and were continuing to deposit sediment into the water adjacent to the wetland (Figure 3-19). While sediment had not covered any of the wetland vegetation within the marsh buffer, sediment may have been deposited underwater in the wetland. As mapping submerged sediment was not undertaken, an approximated area of 0.005 ha was used to record the impact.

Recent slumping of peat banks was observed around a small peat plateau bog between the wetland and EMPA slope in 2017 (Figure 3-19). There did not appear to be any incremental change to the bog between 2017 and 2018. 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).

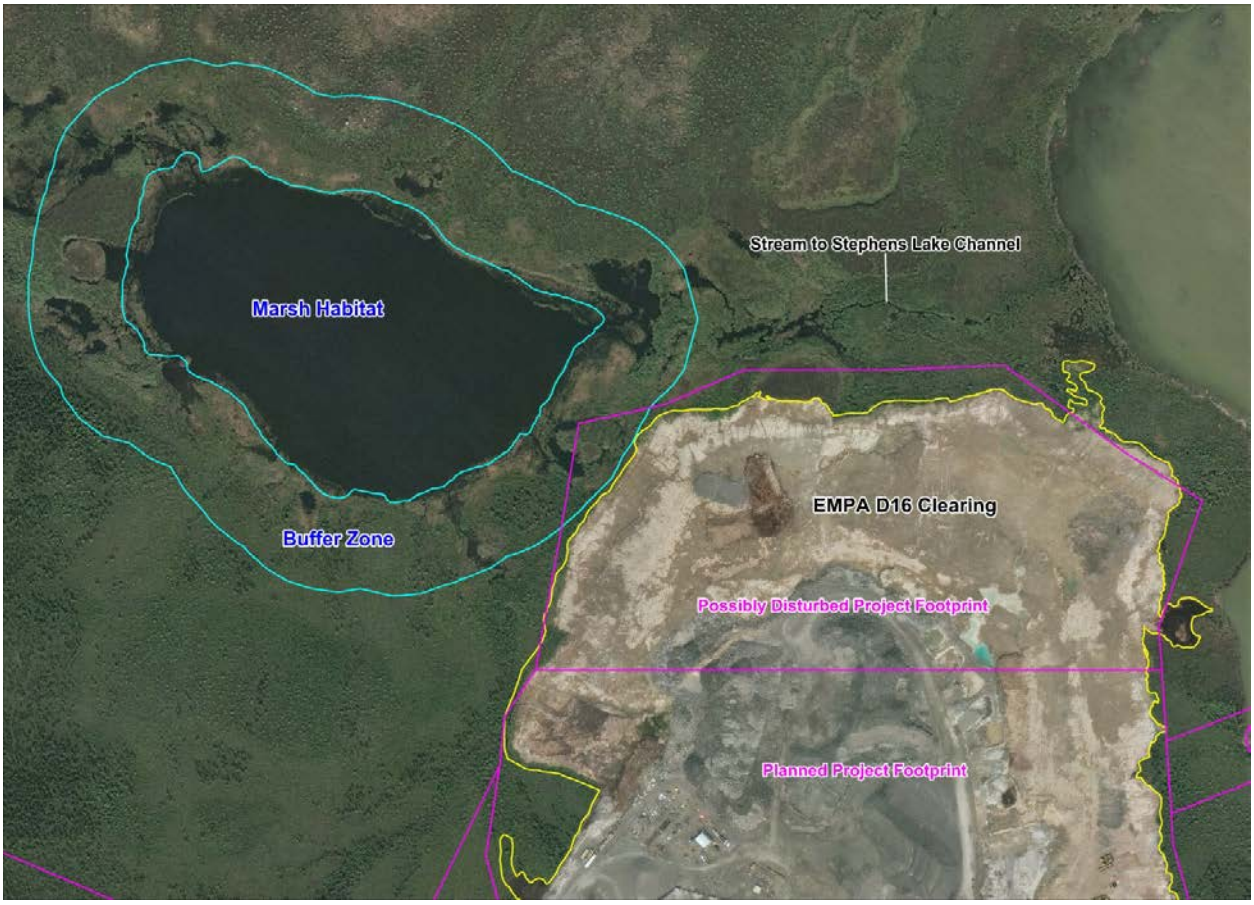



**Figure 3-18: Wetland 51 in 2018 satellite imagery showing adjacent EMPA, stream to Stephens Lake channel, 2018 Project clearing (yellow line), and the boundaries of licensed Project footprint (purple line)**

Aerial view of EMPA D16 slope near the east shore of Wetland 51, showing erosion channels and sediment entering marsh habitat buffer


Sediment from EMPA D16 passing under a silt barrier and entering Wetland 51 buffer

**Figure 3-19: Aerial and ground photos of Wetland 51 in September 2018**


Upper quadrant of photo shows sediment from EMPA D16 overwhelming a silt barrier and entering Wetland 51 buffer

**Figure 3-19: Continued...**

# 3.9 WETLAND 52

Wetland 52 (Figure 3-5) 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.

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 was not observed within Wetland 52 during the surveys from 2016 to 2018 (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 2018. See ECOSTEM (2018b) for specific observations made in previous survey years.

Monitoring for potential Project effects will continue.


**Figure 3-20: Aerial view of Wetland 52 showing peat plateau bog between the SAR and the wetland on September 15, 2018**

# 3.10 WETLAND 53

Wetland 53 (Figure 3-5) 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 that was observed during the 2015 aerial surveys. This clearing was for the Keeyask Transmission Project ROW, which is a separate project (Figure 3-21).

Ground surveys in 2016, 2017 and 2018 found no expansion of the impacts that were present in 2015. No new Project-related clearing, disturbance or other impacts were observed in 2018. For specific observations related to the clearing documented in 2015, see ECOSTEM (2018b).

**Figure 3-21: Aerial photo of Wetland 53 (upper left) on July 6, 2018**

# 3.11 WETLAND 54

Wetland 54 (Figure 3-6) 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. Ground surveys in 2016 and 2017, and aerial surveys in 2018 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 (2018b).


**Figure 3-22: View of Wetlands 54 and 55 in July, 2018 satellite imagery**

## 3.12 WETLAND 57

Wetland 57 is 64.6 ha in size, and nestled between the Butnau Road and Stephens Lake, with its buffer overlapping 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 construction of the SAR had cleared 0.21 ha in the southern edge of the buffer, and all of this was within the planned Project footprint. 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.

Ground surveys in 2017 and 2018 found no additional clearing or disturbance in the marsh habitat buffer or marsh habitat.

In terms of other potential Project impacts, the wetland drains through a channel into a ditch along the SAR. The observed water levels in the waterbody in 2016 and 2017 were very low compared to those observed in 2015. In 2018 the water levels were similar to those observed in 2015. The most likely reason for the changes was that between 2017 and 2018 a beaver dam that was constructed in the drainage channel to the SAR ditch, raising water levels in the wetland, which is upstream of the dam. Based on this, one possible cause for the low water levels observed in 2016 and 2017 was the construction of the SAR. Improved drainage through the new culvert under the road may have increased the rate of outflow from the wetland, lowering water levels.

The wetland will continue to be monitored in 2019.

Beaver dam in drainage channel of Wetland 57

Marsh habitat upstream of beaver dam

**Figure 3-23: Ground photos of Wetland 57 on September 11, 2018**

## 3.13 WETLAND 60

Wetland 60 is 232.4 ha in size. It is located south of Stephens Lake, just west of the access road corridor for the Ellis Esker borrow area (E-1) (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.

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).

Wetland 60 was added to the wetlands being monitored once the Ellis Esker area was cleared. Mapping of the Project clearing on the DOI found that the clearing came within one meter of the buffer zone, which was likely within less than the positional error range of the DOI. Aerial and ground surveys in 2018 did not find any apparent effects of Project clearing on the marsh vegetation or hydrology. Impacts from the clearing were minimal, presumably because the road clearing and construction activity took place in the winter when the ground was frozen.

In terms of other potential impacts, Project clearing extended over a drainage channel into the wetland. There is a possibility that the vegetation clearing or continued construction activity could alter water flow into the wetland through localized changes to the moisture regime or soil compaction. However, this is unlikely if construction activity is limited to the winter months.

Ellis Esker access road clearing adjacent to Wetland 60 buffer

Marsh habitat (background) and marsh buffer (foreground)

**Figure 3-24: Aerial and ground views of Wetland 60 on September 15, 2018**

## 3.14 REMAINING WETLANDS

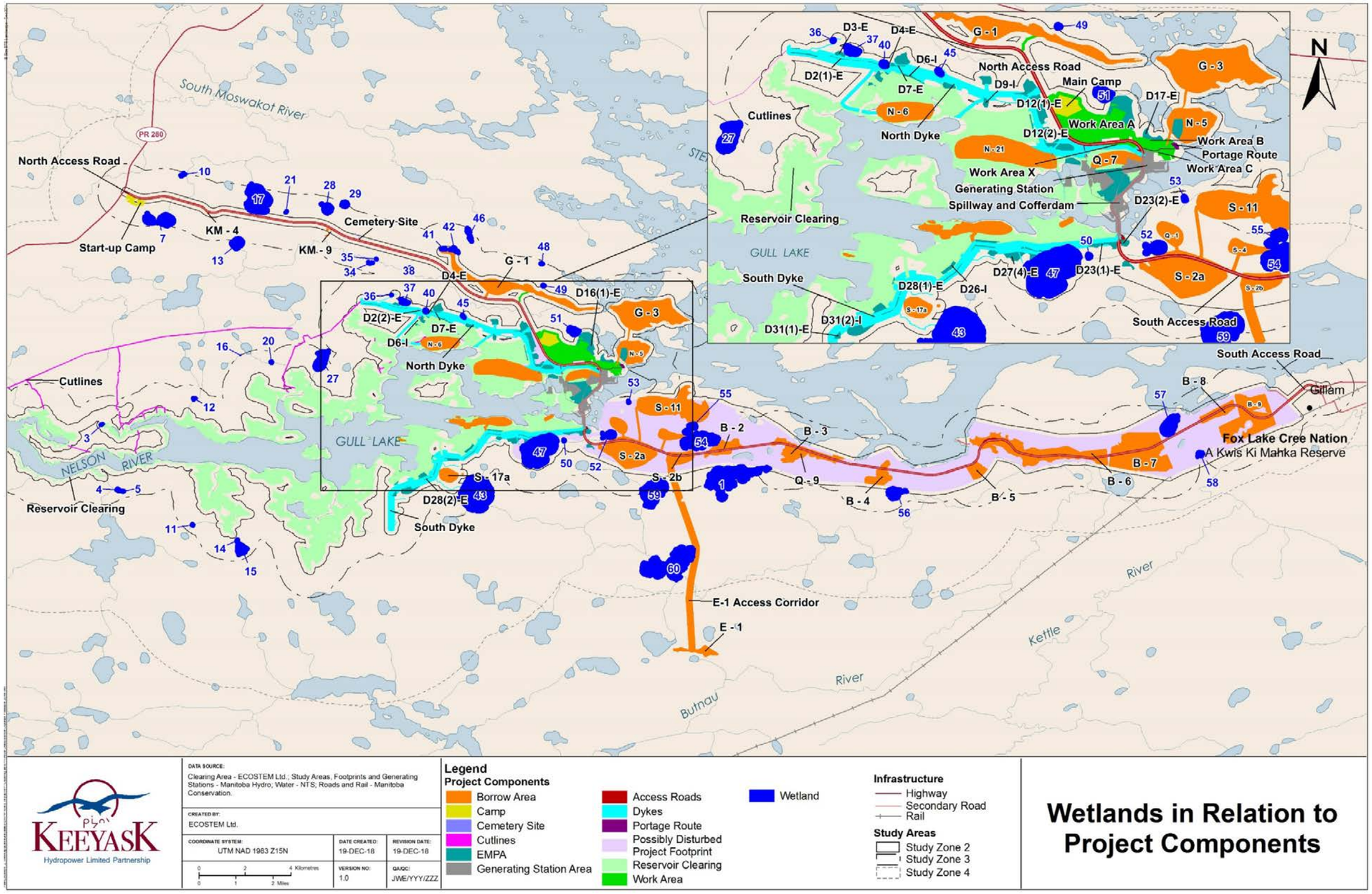
Figure 3-25 shows the state of two of the remaining 31 wetlands visited during the aerial surveys. These wetlands were not closely surveyed because they were more than 100 m from existing Project clearing or disturbance.

Monitoring in 2019 will determine if any of these 31 wetlands have been impacted by the Project since the 2018 surveys.

Wetland 38

Wetland 36

**Figure 3-25: Aerial photos of Wetlands 38 and 36 on September 16, 2018**




DATA SOURCE:
Clearing Area - ECOSTEM Ltd.; Study Areas, Footprints and Generating Stations - Manitoba Hydro; Water - NTS; Roads and Rail - Manitoba Conservation.

CREATED BY: ECOSTEM Ltd.

| COORDINATE SYSTEM: | DATE CREATED: | REVISION DATE: |
|---|---|---|
| UTM NAD 1983 Z15N | 19-DEC-18 | 19-DEC-18 |
| 0 2 4 Kilometres / 0 1 2 Miles | VERSION NO: 1.0 | QA/QC: JWE/YYY/ZZZ |

KEEYASK Hydropower Limited Partnership

**Legend**

**Project Components**
- Borrow Area
- Camp
- Cemetery Site
- Cutlines
- EMPA
- Generating Station Area
- Access Roads
- Dykes
- Portage Route
- Possibly Disturbed Project Footprint
- Reservoir Clearing
- Work Area
- Wetland

**Infrastructure**
- Highway
- Secondary Road
- Rail

**Study Areas**
- Study Zone 2
- Study Zone 3
- Study Zone 4

**Wetlands in Relation to Project Components**

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

# 4.0 DISCUSSION

## 4.1 WATER LEVELS IN OFF-SYSTEM WATERBODIES

Project related effects on water levels or water level variability were of interest for the wetland monitoring because these factors are primary determinants of the amounts of marsh wetland and marsh habitat. As water levels in off-system waterbodies are not monitored with equipment, the apparent water levels relative to the median were recorded at the time of the wetland surveys. The degree of exposed aquatic vegetation and lake-bottoms was the indicator of relatively low water levels while degree of flooded beach vegetation as the indicator of relatively high water levels.

During the aerial surveys conducted in 2016 and 2017, it was noted that water levels in off-system waterbodies throughout Study Zone 3 (Map 2-2) appeared to be lower than their median levels. The 2018 monitoring found that the water levels in these same waterbodies appeared to have risen to approximately median levels.

The lower water levels observed in off-system waterbodies in 2016 and 2017 were likely due to natural factors rather than being related to Project development. The widespread extent of lower water levels suggested they were due to weather. As described in Section 2.4, this suggestion could not be supported with precipitation data because both of the weather stations within 125 km of the Project have large amounts of missing data. The construction synthesis report will examine possible approaches to developing precipitation data for the Project area as this report is produced when all of the relevant data will be available.

## 4.2 WETLAND IMPACTS AND MITIGATION

The following paragraphs summarize observed Project impacts on each of the off-system marsh wetlands, and potential future impacts that merit mitigation or a particular focus during ongoing monitoring. Mitigation recommendations are summarized in Appendix 1.

Wetland 3 was the only wetland where clearing or disturbance extended through the marsh habitat buffer and into marsh habitat. Here, a band of taller vegetation was removed along the shoreline during clearing for the future reservoir. All of these impacts were within the licensed Project footprint, with the majority of them being in the planned Project footprint.

Project clearing or disturbance extended into the possibly disturbed Project footprint at Wetlands 3, 37 and 47. At Wetlands 37 and 47, a very small amount of clearing from an adjacent EMPA extended into the marsh habitat buffer but not into the marsh habitat. 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 EMPA clearing be avoided, to the extent

possible, to minimize additional impacts on these wetlands. For Wetland 47, it is also recommended that the drainage channels passing through the clearing into the wetland be monitored for sediment runoff by site staff during dyke construction.

At Wetland 57, a small amount of the SAR clearing extended into the marsh habitat buffer but not into the marsh habitat. Possible hydrological effects were also observed for this wetland. The observed water levels in the marsh habitat were very low in 2016 and 2017 in comparison with 2015. As noted in Section 4.1, this was likely due to natural factors rather than the Project. By 2018, water levels in this wetland were similar to those in 2015. While the natural factors that contributed to generally higher water levels throughout Study Zone 3 in 2018 may have also contributed to the higher water levels in this wetland, higher levels were also partly attributed to a beaver dam having been constructed in the channel draining the wetland. Additional future hydrological effects are possible because the waterbody in this wetland drains through a channel into a SAR ditch and through a culvert under the road. Median water levels could rise if the culvert becomes blocked.

At Wetland 51, sediment was continuing to run off the west slopes of the EMPA into the water adjacent to the buffer. As the situation between this EMPA and the marsh area is somewhat complex, several mitigation measures had been recommended and implemented for strategic locations in 2016 and 2017 (see Appendix 1 for details). Nevertheless, the impacts continued into 2018. In light of this, and due to its proximity to waterbodies connected to the Nelson River, it is recommended that additional sediment control measures be considered for the northwestern and northern banks of EMPA D16 to prevent further sediment deposition. 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.

Project disturbance or clearing was not observed at the remaining nine wetlands that were within 100 m of actual Project clearing or disturbance at the time of the 2018 surveys. However, eight of these nine wetlands had potential future impacts that merited either a mitigation recommendation or a particular focus during ongoing monitoring (see Appendix 1).

At Wetland 17, the marsh habitat is downslope from and within 100 m of the NAR, so there is potential for effects from road-related surface runoff or hydrological alterations. Monitoring in 2017 and aerial surveys in 2018 found no additional Project-related effects in or near this wetland. Surveys in 2019 will determine whether anything has changed.

Cleared mineral slopes exist near Wetlands 40, 42 and 45, creating the potential for runoff and sediment deposition from existing Project clearing into the adjacent marsh habitat. Wetland 45 had additional mineral material exposed following the 2013 wildfire. It is also recommended that the care taken by construction crews to date when working near all three of these wetlands should be continued. It is also recommended that expansions of the existing dyke clearing be minimized to the extent feasible to limit additional impacts on these wetlands.

A sediment control recommendation was not made for Wetland 42 given the amount of undisturbed vegetation and ground cover between the exposed mineral area and the marsh habitat.

This report makes two recommendations for Wetlands 40 and 45. Site staff should continue to evaluate and implement sediment control measures where needed to prevent sediment and other runoff from entering the marsh habitat. Additionally, it is recommended that an expansion of the existing clearing (see Figure 3-2 and Figure 3-15) be avoided or minimized, if possible, to minimize additional impacts on these wetlands. In 2017, it was recommended that a silt fence be installed between the dyke clearing and Wetlands 40 and 45. A silt fence was installed at Wetland 45, and there was no evidence of runoff depositing silt at Wetland 45. Based on the 2018 surveys, a silt fence no longer appears to be needed for Wetland 40. There has been limited recent construction activity near both wetlands, and revegetation of the dyke bank adjacent to the wetlands is ongoing. Silt fences should be considered if the slope of the dyke bank needs to be increased in the future.

To date, Wetland 52 has not been impacted by Project clearing or disturbance. Possible hydrological effects were noted for this wetland in 2016 when water from an SAR culvert was observed pooling in a natural depression between the SAR and the marsh habitat. At that time, it appeared that it was ground ice rather than increased inflows from the SAR culvert that was creating the pooling. This observation has been supported up to 2018 by vegetation and substrate indicators of median water levels in comparison with other waterbodies in the study area (see Section 4.1). If there was additional flow into the marsh habitat from this culvert, it appeared that the drainage outlet from this wetland was passing such flows into a bay on the Nelson River. Continued monitoring of this site will be done to help evaluate if inflows from this culvert are affecting this wetland.

Wetlands 53 and 54 had not been impacted by Project clearing or disturbance at the time of the 2018 surveys. The impacts visible in the September 2018 satellite imagery were from ROW clearing for the Keeyask Transmission Project, which is a separately licensed project with an associated terrestrial monitoring program. It is noted that the transmission ROW clearing in the marsh habitat buffer may interact with Project effects in the future. Monitoring in 2019 will include revisiting the cleared area 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 the growth of additional vegetation.

While Project clearing or disturbance had not impacted Wetland 60 as of September 2018, clearing came within one meter of the wetland buffer zone. This clearing created the potential for erosion and the transport of sediment and other material down the slope into the marsh habitat. It is recommended that additional clearing or disturbance near this wetland be avoided or minimized, if possible. This site will continue to be monitored.

# 5.0 SUMMARY AND CONCLUSIONS

During the Project construction phase, the wetland function monitoring is focusing on direct Project effects, which primarily consist of clearing, disturbance or potential hydrological alterations.

Forty-two of the 44 wetlands being monitored by this study were surveyed from a helicopter in September, 2018. These aerial surveys confirmed that the number of impacted wetlands had not changed since the 2017 surveys.

Eight of the thirteen monitored wetlands that were within 100 m of existing Project clearing or disturbance, and were not separated from these areas by a wide band of natural ground cover and vegetation, were also surveyed on the ground in 2018. The remaining five wetlands were not ground surveyed due to access restrictions, or because there was no evidence of possible Project impacts on the wetland for several years.

Aerial and ground surveys in 2018 found that there had been no new Project clearing in any of the monitored wetlands since the 2016 surveys. In one of the monitored wetlands, previously recorded disturbance (i.e., sediment deposition into standing water adjacent to the marsh habitat buffer) was continuing.

Of the 4.19 ha of total Project clearing or disturbance within wetlands, 0.11 ha (2.6% of the impacted area) was in marsh habitat (in one wetland within the future reservoir area) while the rest was in the marsh habitat buffer (in seven of the monitored wetlands). All of these impacts were within the licensed Project footprint, with 3.91 ha (93%) in the planned Project footprint and 0.28 ha in the possibly disturbed Project footprint.

Future Project impacts were a possibility for eight of the wetlands located within 100 m of actual Project clearing or disturbance. At four of these wetlands, exposed mineral slopes between the wetland and a Project feature (e.g., dyke, or excavated material placement area) had been created by either the 2013 wildfire (which was unrelated to the Project) or Project clearing. These exposed mineral slopes pose a risk in that future heavy rains could carry sediment or other materials into the adjacent marsh habitat. At five of the eight 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.

To date, there have been no unanticipated effects on the off-system marsh wetlands being monitored by this study. While there has been some clearing or disturbance within four of the wetlands, this was expected as they overlapped the licensed Project footprint.

A number of mitigation recommendations were made to avoid or minimize additional future Project effects on the monitored wetlands.

## 5.1 NEXT STEPS

Monitoring fieldwork for the off-system marsh wetlands will continue in 2019. 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 (Table 6-1) the off-system marsh wetland mitigation recommendations made during the TEMP construction monitoring.

At Wetlands 37 and 47, it is recommended that an extension of the existing EMPA clearing be avoided, to the extent possible, to minimize additional impacts on these wetlands (Figure 6-1 and Figure 6-2). For Wetland 47, it is also recommended that the drainage channels passing through the clearing into the wetland be monitored for sediment runoff by site staff during dyke construction.

At Wetland 51, it is recommended that sediment control measures be reinforced along the northwestern EMPA banks to prevent further deposition into the wetland buffer (Figure 6-3). Due to the continued deposition of sediment through the existing silt fences and because the wetland flows into a waterbody connected to the Nelson River, it is recommended that other sediment control measures be considered for the northwestern banks of EMPA D16 to prevent further deposition. 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. Ongoing sediment deposition and mitigation options for the northern and eastern banks of the EMPA are addressed in another report (ECOSTEM 2019).

At Wetlands 40, 42 and 45, it is recommended that construction staff continue to take care when working in these areas. It is also recommended that extensions of the existing dyke clearing be avoided, if possible, to limit additional impacts on these wetlands (Figure 6-1, Figure 6-4 and Figure 6-5).

This report makes one additional recommendation for Wetlands 40 and 45. Site staff should continue to observe sediment deposition and implement sediment control measures where needed to prevent sediment and other runoff from entering the marsh habitat.

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

| Wetland | Recommendation[1] | Mitigation Implemented |
|---|---|---|
| Wetland 37 | 2015: Evaluate and implement sediment control measures where needed to prevent sediment from entering the site along the north dyke.<br>2016, 2017 and 2018: Limit further clearing along northeastern edge of EMPA (D3-E) that overlaps buffer. Monitor for potential effects from slope runoff. See Figure 6-1. | No additional clearing has occurred along the northeastern edge of the EMPA. |
| Wetland 40 | 2015: Add silt fence between the north dyke clearing and marsh at the base of the dyke. Evaluate and implement sediment control measures where needed.<br>2016, 2017 and 2018: Evaluate and implement sediment control measures such as silt fence where needed. Avoid northward extension of the existing dyke clearing, if possible. See Figure 6-1. | No additional northward clearing has occurred near the wetland buffer.<br>Monitoring in 2019 will document if any sediment control measures were installed. |
| Wetland 42 | 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. See Figure 6-4. | |
| Wetland 45 | 2015: Silt fence be added between the north dyke clearing and marsh at the base of the slope. Evaluate and implement sediment control measures where needed.<br>2016, 2017 and 2018: Evaluate and implement sediment control measures such as silt fence where needed. Avoid northward extension of the existing clearing, if possible. See Figure 6-5. | No additional northward clearing has occurred near the wetland buffer.<br>Between 2017 and 2018, sediment fencing was installed at the base of the dyke bank adjacent to the wetland.<br>Monitoring in 2019 will document if any sediment control measures were installed. |
| Wetland 47 | 2016 and 2017: Avoid a southeastern extension of the existing south dyke clearing, if possible.<br>2017 and 2018: Monitor the drainage channels passing through the clearing into the wetland during south dyke construction. See Figure 6-2. | No additional southward clearing has occurred near the wetland buffer. |

| Wetland | Recommendation[1] | Mitigation Implemented |
|---|---|---|
| Wetland 51 | 2015: Inspect and enhance sediment control measures along the northern edges of the EMPA (D16). Erect a silt fence around the north and northwest side of the EMPA.<br>2016 and 2017: Silt 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. See Figure 6-3.<br>2018: Consider additional sediment control measures along the northwestern and northern banks of the EMPA to prevent continued sediment deposition into wetland. | In fall 2017, material in EMPA D16 was re-sloped and additional sediment fencing was installed.<br>Between 2017 and 2018, additional sediment fencing was installed at the base of the slope adjacent to the wetland. |
| Wetland 52 | 2016, 2017 and 2018: 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. | Field surveys in 2018 suggested that the low water levels may have been one of, or a combination of, natural water level variability, altered drainage due to construction of the SAR. A beaver dam increased water levels in the wetland in 2018. |
| Wetland 60 | 2018: Monitor wetland for runoff effects from the Ellis Esker access corridor. Avoid additional clearing or disturbance near this wetland. See Figure 6-6. | |

Notes: [1] 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; 2018b) for the 2015, 2016 and 2017 recommendations, respectively.

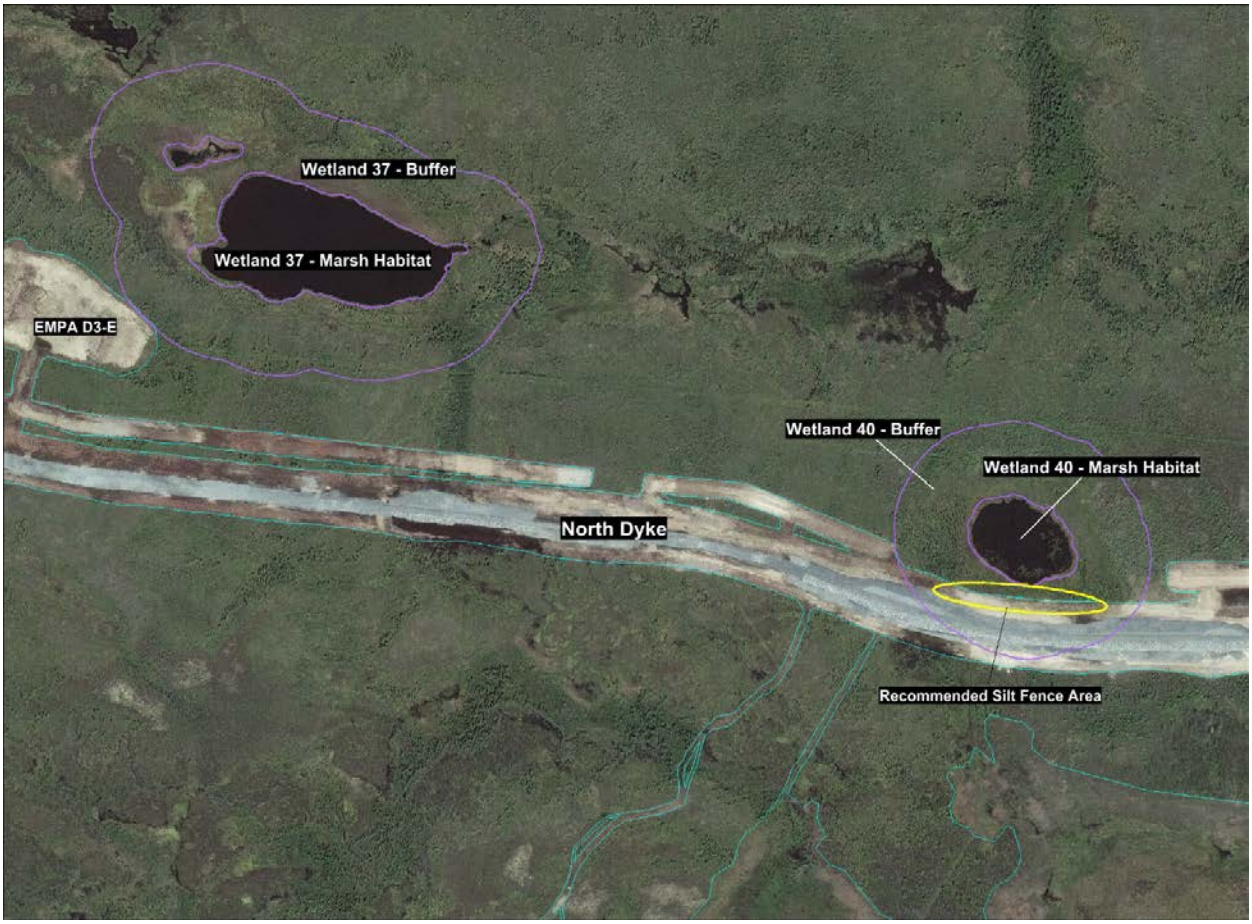


**Figure 6-1: Mitigation areas and recommendations for Wetlands 37 and 40**


**Figure 6-2: Mitigation areas and recommendations for Wetland 47**


**Figure 6-3: Mitigation areas and recommendations for Wetland 51**


**Figure 6-4: Mitigation areas and recommendations for Wetland 42**


**Figure 6-5: Mitigation areas and recommendations for Wetland 45**


**Figure 6-6: Mitigation areas and recommendations for Wetland 60**