Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Invasive Plant Spread and Control Monitoring Report

TEMP-2022-05

KEEYASK

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KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2022-05

INVASIVE PLANT SPREAD AND CONTROL MONITORING

A Report 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.

Non-native plants are those plant species that are not naturally found in the Keeyask region. Invasive plants are the non-native plant species that can out-compete or even replace native plants.

Non-native plants can be introduced or spread in the Keeyask area by seeds that are brought into the Project site on vehicles, construction equipment, and footwear. There are measures in place under the Project's Environmental Protection Plan to help minimize this from happening. For example, washing any construction equipment that is coming to the Project site from areas outside the Keeyask region is a preventative measure.

This report describes the results of invasive and other non-native plant monitoring conducted during 2021, the eighth summer of Project construction.

Common tansy, an invasive plant found at the Keeyask site during construction

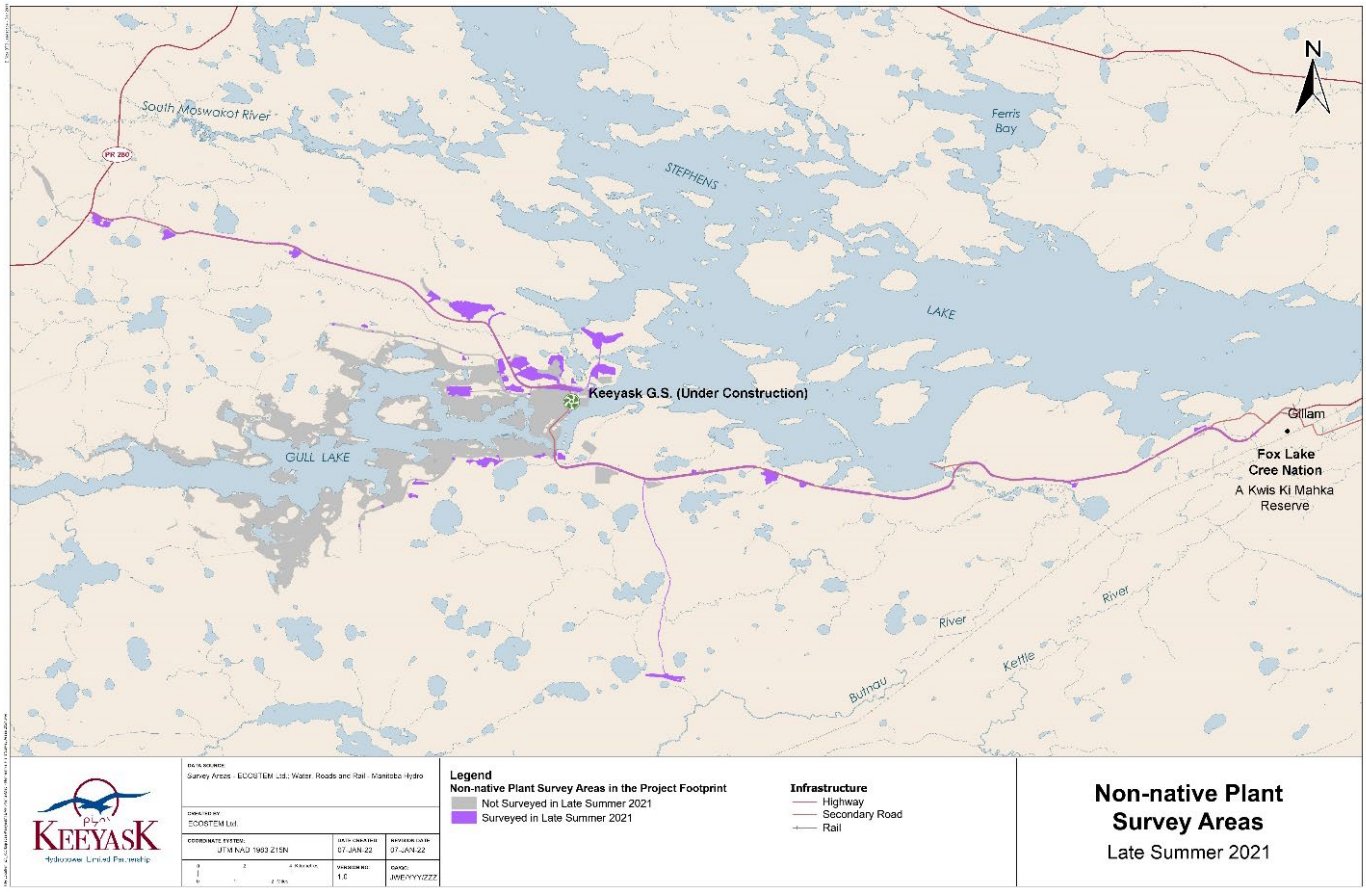
Why is the study being done?

Invasive and other non-native plants are of concern because they can crowd out native plants or prevent native plants from growing where they are normally found. In extreme cases, invasive plants can change the kind of vegetation, soils or other natural conditions. Non-native plants are also a concern because they could interfere with restoring native habitat in sites that are no longer being used by the Project.

Surveys are being done to determine how Project development is affecting how many non-native plants are present, where these plants are found, and to help decide where to carry out measures to control the plants that can become an issue at the Project site.

What was done?

In 2021, non-native plant surveys were carried out within most of the cleared Project areas between August 20 and 31 (see map below). Some cleared areas were not surveyed because the people doing the surveys could not safely access them due to construction activity.



What was found?

In late summer 2021, non-native plants covered 1.4% of the surveyed area. Total non-native plant cover and extent (the general area where plants were present) were slightly higher than they were in late summer 2020.

As was the case in 2020, non-native plant cover was highest (2.0%) within cleared areas that were either there before the Project (e.g., cutlines, borrow areas and ditches along the Butnau Road portion of the South Access Road) or had been previously developed as part of the Keeyask Infrastructure Project, and are now being used by the Project. By 2021, non-native plant cover in areas unique to the Project had also increased to a level similar to other areas (1.2%).

A total of 25 non-native plant species were found during the 2021 surveys, which was two fewer than recorded in 2020. No new species were recorded. Three of the species that were recorded in 2020, but were not observed in 2021 included canola, flixweed and black medick, while one species (ox-eye daisy) that was absent in 2020 was found again in 2021.

Lambs'-quarters was the most abundant (had the highest total cover) non-native plant species in 2021, while white sweet clover was the second most abundant.

Five of the seven most abundant species increased in cover between 2020 and 2021 (lamb's-quarters, common dandelion, white and yellow sweet clover and spotted lady's-thumb). Narrow-leaved hawks-beard and field sow-thistle, the other two abundant species, decreased in cover relative to 2020.

Of the 25 non-native plant species found in 2021, scentless chamomile, ox-eye daisy and common tansy are the ones of highest invasive concern for the Project site. Ox-eye daisy was found at one site, while the other two species were found at several sites.

The species of highest invasive concern are being controlled by manually removing the plants as soon as they are found during the surveys. This approach has worked well to date. Scentless chamomile and common tansy were not found in 2021 at the sites where they had been removed in previous years.

Five of the 25 non-native plant species found in 2021 are of moderate invasive concern for the Project site. To minimize further spreading of these five species, herbicides were applied in a limited number of Project areas in early July 2021, followed by targeted mowing in the middle of August 2021. The 2021 herbicide treatment was less effective than in 2020, possibly because the areas were not able to be flagged in the field prior to the herbicide application, or possibly due to heavy rainfall that occurred shortly after. Monitoring in 2022 will evaluate the effectiveness of the 2021 mowing (since the mowing happened late in the 2021 growing season) and herbicide treatments in continuing to reduce non-native plant cover.

During the entire Project construction phase, monitoring found that changes in the total amount of non-native plant cover followed a pattern that varied with the major type of Project component (i.e., borrow areas and excavated material placement areas; camp and work areas; roads and dykes). This is because the overall type, amount, location and length of construction activity is different for each of these major Project components. Continuous high construction activity

generally prevents or limits non-native plants from becoming abundant. Once continuous high construction activity ends at a given site, non-native plants generally become increasingly more abundant for some time, but then gradually decrease because the growth of native plants is starting to push out the non-native plants. In areas that are no longer needed for the Project and receive rehabilitation efforts, total non-native plant cover is often highly reduced by these efforts.

What does it mean?

As expected, further spreading of some non-native plant species is happening during Project construction. However, all species combined still cover only 1.4% of the surveyed Project footprint. Monitoring results suggest that non-native plant cover may be either declining or expanding more slowly in some portions of the Project footprint since 2018. At the same time, non-native cover may be increasing in some portions of the Project footprint where construction activity has decreased. If these areas are like other Project areas, then non-native cover should decrease as the growth of native plants increases.

Given their potential to spread rapidly, the monitoring continued to evaluate whether or not there are practical ways to reduce invasive and other non-native plant species in the Project footprint, or to prevent them from spreading further. Many of these species are commonly found in disturbed areas in the Keeyask region, particularly along roadsides, making it difficult to prevent vehicles and people from accidentally spreading these species into the Project site.

Monitoring up to 2021 showed that immediate removal by hand was generally effective for species that do not have the ability to produce many new plants from roots left in the ground. Staff conducting the monitoring surveys will continue to remove plants by hand at sites where there are one to a few plants.

The herbicide treatment in early July 2021 appeared to be somewhat ineffective in reducing the overall cover of some species of high concern. Monitoring in 2022 will determine if the herbicide treatment and subsequent mowing is expected to continue to reduce or slow the spread of invasive plant cover in these sites.

During the construction phase, monitoring up to 2021 found that Project effects on non-native plants were consistent with EIS predictions. In particular, there is no evidence that Project development has spread non-native plants into areas outside of the Project footprint. Also, Project mitigation measures have been effective at controlling the non-native plant cover and confining most of the small area of non-native plant cover to the Project footprint.

What will be done next?

Additional invasive plant control recommendations will be developed for the 2022 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2022. Where appropriate, additional control measures will be recommended based on what is found during the monitoring.

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STUDY TEAM

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

Fieldwork in 2021 was conducted by Brock Epp and Gabriel Schmid of ECOSTEM Ltd.

Data analysis and report writing in 2021 were completed by Alanna Sutton, Brock Epp and James Ehnes. GIS analysis was completed by Brock Epp, Alanna Sutton and Alex Snitowski. Alex Snitowski completed the cartography.

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1.0 INTRODUCTION

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

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

Non-native plants are those plants that are growing outside of their country or region of origin. Invasive plants are non-native plants that can out-compete or even replace native plants. Invasive plants are of concern because they can crowd out other plant species and, in extreme cases, change vegetation composition or other ecosystem attributes. Invasive plants have been described as one of the greatest threats to natural areas in Canada (Canadian Food Inspection Agency 2008).

Non-native plant species that are not generally invasive may be problematic for some local conditions or may become so in the future with changing climate (Hellman *et al.* 2008). For example, well-established patches of non-native plants will be a consideration for areas where native habitat will be regenerated.

Since all invasive plants are non-native, this report generally uses “non-native” except when discussing species that are of higher invasive concern for the Project area.

The goals of the Invasive Plant Spread and Control study are to determine the degree to which the Project contributes to introducing and spreading invasive and other non-native plants, and to evaluate the effectiveness of mitigation measures. The overall objectives of the Invasive Plant Spread and Control study are to:

- Verify that appropriate seed mixtures were used where seeding is implemented as a rehabilitation or erosion control measure;
- Document the degree of invasive and other non-native plant introduction and spread;
- Recommend appropriate control and eradication programs; and,
- Verify the efficacy of any programs implemented to control or eradicate invasive plants.

The Invasive Plant Spread and Control study includes two components. The first component monitors non-native plant distribution and abundance in Project areas. In the event that control or eradication programs are needed, the second study component provides recommendations and monitors their effectiveness.

A previous monitoring study and report (ECOSTEM 2015) evaluated non-native plant spread during construction of the Keeyask Infrastructure Project (KIP), which ended in June 2014. This study is monitoring non-native plant distribution during Project construction and operation. To date, surveys have been conducted in each year during construction, from 2015 to 2021. Results for the monitoring conducted annually from 2015 to 2020 are provided in previous reports by ECOSTEM (2016, 2017, 2018b, 2019b, 2020 and 2021b respectively). This report presents the monitoring conducted in 2021.

2.0 METHODS

Section 3.3.2 of the TEMP details the methods for this study. The following summarizes the activities conducted in 2021.

2.1 PROJECT COMPONENTS

There were far too many individual Project footprint components to evaluate each one separately for patterns of non-native plant spread. Therefore, the Project footprint was subdivided and grouped into general components (Table 2-1) based on the general type of activity occurring there. Activity type may be an important influence on non-native plant spread or establishment. For example, the “Camp and Work Areas” Project component is dominated by foot and light vehicle traffic, with minimal to no ongoing excavation, while the “Borrow Areas” component is often characterized by ongoing excavation and heavy equipment traffic. For reservoir clearing areas, the ground vegetation and soils are generally undisturbed (with only taller vegetation removed), which means there is a poor seedbed for non-native plant colonization.

It should be noted that because the subdivision of the Project footprint into activity types is generalized, there may be small areas within a specific footprint that are from a different activity type. Nevertheless, this categorization aids in the interpretation of broad patterns and trends across the Project site. Map 2-1 shows the locations of the Project components as well as some of their constituent features.

A second level of analysis was based on the length of time since an area was first cleared, the current level of construction activity, and the projects it was used for (e.g., portions of areas cleared for the Keeyask Infrastructure Project (KIP) are also being used for the Project). All of these factors can influence non-native plant distribution and abundance. The categories used for the second level of analysis included:

- Areas used either for the KIP only or minimally affected by the Project;
- Areas used by both the KIP and the Project; and
- Areas used only by the Project.

Areas used for the KIP only are included because they were developed prior to the Project and may be an important seed source for the spreading of non-native plants into other nearby areas.

Table 2-1: General Project components and their associated activity prior to 2021 surveys

Project Component	Description	Activity
North Access Road	Road and right of way	Light and heavy vehicle traffic
South Access Road	Road and right of way	Light and heavy vehicle traffic
Camp and Work Areas	All camps, work areas and attached excavated material placement areas	Foot and light vehicle traffic, or heavy vehicle traffic for a short period or limited area
Borrow Areas	All borrow areas accessible by road, cleared or excavated, and attached excavated material placement areas	**Active:** Clearing, excavation and heavy equipment traffic **Inactive:** Regenerating vegetation
North Dyke	North dyke clearing, associated excavated material placement and borrow areas, and north channel rock groin	Clearing, excavation, light and heavy vehicle traffic
South Dyke	South dyke clearing and associated excavated material placement and borrow areas	Clearing, excavation, light and heavy vehicle traffic
Generating Station Areas	Generating station, spillway, dam and coffer dam infrastructure, and associated excavated material placement areas	Excavation, construction, heavy and light vehicle traffic
Reservoir Clearing Area[1]	Vegetation clearing in the reservoir areas that are close to Project areas that will be outside of the reservoir	Clearing only, flooding

Notes: [1] Most of this component was flooded when the reservoir was impounded from August 31 to September 5, 2020.

2.2 DATA COLLECTION

2.2.1 FIELD METHODS

Late summer (typically mid to late August) non-native plant surveys have been conducted annually from 2014 (KIP footprints only) to 2021. Early summer (typically late June to early July) surveys were also conducted annually from 2014 (KIP footprints only) to 2019. Surveys in the Nelson River shore zone were conducted in 2019.

From 2014 to 2016, a full non-native plant survey of all accessible cleared areas was completed twice annually, in the early summer and in late summer. Surveys were conducted twice in order to collect information that would help characterize seasonal patterns in the distribution of non-native plants. Results from the late summer surveys were expected to overestimate non-native plant distribution and abundance for the entire Project footprint.

Starting in 2017, the early summer survey was less detailed than the late summer survey. After three consecutive years of data, the seasonal patterns in the distribution of non-native plants was established. The purpose of the early summer survey shifted to provide a rapid, spatially focused survey that still allowed for early detection and response to non-native plants that had spread into new areas. For this reason, the 2017 to 2019 early summer surveys were spatially focused on two types of areas: (i) the areas that were newly cleared since the previous year; and, (ii) the areas that were cleared as of August the previous year, and that had few to no non-native plants. Further details on methods and rationale are provided in the 2018 report (ECOSTEM 2018b). The results from the early summer surveys were not expected to be representative of non-native plant distribution and abundance for the entire Project footprint.

By 2018, Project clearing was nearly complete (ECOSTEM 2019a), and by August 2019 non-native plants had become established in nearly all the previously cleared areas that were accessible for surveys (ECOSTEM 2020). In each year since 2018, results from the previous late summer survey had already provided the bulk of the information needed to select sites for treatment in the current summer. For these reasons, starting in 2020, it was determined that an early summer survey was not required.

With the exceptions of the North and South Access roads and Dykes, surveys of the Project footprint were not conducted in areas where non-native plants were expected to be completely or virtually absent based on results from similar types of areas and in previous years. The two predominant types of areas that were not surveyed were the portions of the Project footprint that were not safe to access due to construction or wildlife activity, and the cleared future reservoir area. Inclusion of the zero or very low values from these areas would have reduced the non-native plant percentages for the entire Project footprint.

Late summer surveys were conducted from August 20 to 31, 2021 at the locations shown in Map 2-2.

In 2021, most of the non-native plant cover was recorded and mapped in the field using electronic tablets which were introduced to the fieldwork methods during the 2019 late summer surveys. The information recorded using this method was the same as the information recorded prior to 2019 to maintain comparability with results from previous years. Advantages to utilizing the electronic data collection method over the previous method included:

1. Reduction in recording error;
2. Improvements in field data gathering efficiency (i.e. reduced time); and
3. Reduced data entry and GIS processing time.

In situations where weather conditions or the survey method (e.g. helicopter surveys) did not support effective use of the tablets, the surveyor reverted to the same data recording method used for late-summer surveys in 2018. As a result, non-native plant cover was recorded in two different ways for the 2021 surveys; however, the data collected were the same, and were combined for the resulting cover maps. Both data collection methods are detailed below.

Late summer non-native plant surveys were conducted in the portions of the Project footprint that had been cleared or disturbed prior to the surveys and were safe to access. A botanist and trained

environmental technician conducted surveys on foot and by truck within the cleared areas that were both safe to survey and were not undergoing clearing at the time of the surveys. Due to safety-related access restrictions, some active construction areas, or portions thereof, could not be surveyed in 2021.

Three approaches to selecting survey locations were employed, depending on the nature of the footprint.

For the North and South Access roads, as well as the North and South Dykes, a combination of systematic sampling on foot and mobile truck-based surveys were employed. Permanent sample locations were established every 2 km along each road and dyke. Non-native plants were sampled at every stop except where construction or haul truck activity made stopping unsafe. At each stop, a 100 m transect on each side of the road or dyke (*i.e.*, two 100 m transects at each stop) was surveyed by foot. Additionally, the sides were scanned while driving approximately 40-50 km/h between each stop and observations of species of high concern or unusual conditions were recorded. It was expected that smaller patches and individual plants would not be recorded. Note that North and South Dyke non-native plant extent and cover up to 2019 are not directly comparable to those for 2020 and 2021 as the field methods changed when the dykes became fully accessible by vehicle (see ECOSTEM (2020)).

The Ellis Esker access corridor was surveyed by a combination of helicopter and foot surveys due to its length, and inaccessibility by non-construction vehicles. The helicopter was flown at a low altitude above the centre of the corridor, and the surveyor recorded locations of non-native plants. Foot surveys were conducted where needed to confirm plant identification, or to map more complicated patches of plants.

For the remaining areas (which accounted for the majority of the surveyed area), field surveys traversed all cleared areas using a combination of perimeter and meandering walks. The perimeter of each cleared area was generally surveyed because the non-native plants tended to be clustered in these locations. For the remainder of a cleared area, the surveyor walked to all remaining vegetation patches that had the potential to include non-native plants. The exception to this was areas that posed safety concerns (primarily related to the presence of heavy construction activity).

Data recorded at each location included spatial coordinates, species spatial extent and species abundance. Additional notes were also recorded and photos were taken.

Non-native plant spatial extent at a location was recorded either as a point with an associated number of individuals or as a patch of plants with an associated percent foliage cover. The “point with number of individuals” method was typically used in locations where there was less than 20 individual plants covering a very small area, while a patch (typically 20 or more plants) was used where there was a large number of plants, and/or the plants covered a large area. Regardless of the data collection tools used (see below), patches are recorded in one of two general methods: (1) as a point with an estimated radius (in meters), which typically applied to small, roughly circular patches in open areas where the boundaries were visible from a single location. These points were later converted to polygons in the GIS. (2) As a patch, spatially defined by a polygon in the

field. This method was used for large patches where the boundaries could not be discerned from a single location. The method by which the polygons are defined varied depending on the data collection tools used (see Section 2.2).

Once a non-native species patch was defined, the percent plant cover was estimated for each species present and recorded into one of the seven classes listed in Table 2-2. In 2021 a new cover class, “trace”, was added to capture more common, typically lower-concern non-native plants with very low cover in an area. In previous years these were generally recorded as multiple points.

Table 2-2: Cover class and associated percent cover ranges used for non-native plant surveys

Cover Class	Percent Cover Range
Trace[1]	>0 - 0.1%
Very sparse	0.2 - 2%
Sparse	3 - 10%
Low	11 - 25%
Moderate	26 - 50%
High	51 - 75%
Very high	76 - 100%

Notes: [1] New cover class in 2021.

2.2.2 TABLET-BASED DATA COLLECTION

Non-native plant cover data was collected electronically using Samsung Galaxy Tab A tablets during foot-based surveys, when weather conditions allowed the tablets to operate. These tablets have a built-in GPS receiver, which facilitated mapping non-native plant cover directly in the field using Collector for ArcGIS. To help digitize the boundaries of the plant patches, the most recently available remote sensing imagery was uploaded as a base-map on the tablet prior to the surveys.

Two layers were prepared for field data collection, one for point type features (plant individuals) and “point with radius” patch types, and another for defined polygons. When individuals or patches with a radius were encountered, a new point feature was added in Collector as close to the centre of the patch as possible for the species. When a larger patch was encountered, a polygon was digitized in Collector, either by using the streaming function, and walking around the patch boundary, or by manually drawing the patch polygon using the base imagery as a reference. After either feature was created, the point or patch attributes were filled in using the form that had been set up for use in Collector. If more than one non-native plant species occurred at the same point, or within the same patch, the feature was copied, and the species and cover attributes were updated.

2.2.3 PAPER-BASED DATA COLLECTION

Paper-based data collection methods were used when rainfall was too heavy for the tablet's touch-screen input to work, or during higher-speed truck, helicopter, or boat-based data recording.

Non-native plant spatial extent at a site was recorded using field notes in conjunction with waypoints and tracks acquired using a GPS (Garmin Map 62 or Map 78). The notes included the same point and patch attributes that were recorded when the tablets were used.

For non-native plant individuals and small patches (less than 20 plants), a GPS waypoint was recorded as close to centre of the patch as possible. For larger patches, defined polygons were recorded in one of three ways:

1. **Point:** Used for small patches (20 or more plants) that had a relatively regular shape. Typically applied to small patches in open areas where the boundaries were visible from a single point. In these situations, a GPS waypoint was taken at the patch center whenever possible, with an associated ocular estimate of patch radius (in meters) for circular patches or the dimensional length (e.g. 2m x 4m) for rectangular patches.
2. **Band:** Used for patches too large to be recorded as a point and that were linear with a relatively constant width. In these situations, the length of the band of the non-native species (e.g. along a ditch) was walked while a GPS recorded a track log for the species. An estimate of the average band width in meters was recorded. For some wider bands, the band width was recorded using distinct features such as a specific impact area (e.g. width of the transmission line right-of-way).
3. **Defined Area:** Used if the patch could not be recorded as a point or a band. In these situations, the surveyor generally walked around the perimeter of a large homogeneous patch with non-native species cover while recording a GPS track log for the patch. Alternately, the surveyor walked through the area in a zig-zag transect so that the points generally corresponded to the boundaries of the patch. The former method was used when the non-native species could be observed throughout the patch from the outer boundaries, which typically occurred in open barren, or low vegetation areas. The latter method was used in heavily vegetated areas where non-native plants were not visible over a long distance. In this method, waypoints were added while recording the species tracklog to indicate if there was a change in cover.

2.3 TOTAL AREA SURVEYED

In 2021, ground searches were not possible in several locations for safety reasons. Locations not surveyed due to construction activity included all of Borrow Areas S-2a and B-6, portions of Work Area A (particularly around the rock crusher), the two South Access Road (SAR) survey stops in the vicinity of the Butnau marina and a small area on the downstream portion of the spillway. Based on previous results (ECOSTEM 2017; WRCS and ECOSTEM 2017), it is unlikely that many non-native plants would have established in areas with a high volume of construction

activity, including ongoing excavation, material stockpiling and vehicle traffic. Borrow Area B-5 was not surveyed because it was fully covered by ponded water, and Borrow Area Q-1 was not vehicle accessible because the access road was decommissioned. Finally, portions of the generating station area and north channel rock groin upstream of the dam that were surveyed in previous years, but were inundated during reservoir impoundment from August 31 to September 5, 2020, were not surveyed.

To reduce the influence of changing total area surveyed when making year-to-year comparisons, non-native plant cover is expressed as a percentage of the total area surveyed, rather than as an absolute area. Surveying certain areas in one year but not another does materially impact between-year comparisons of total non-native plant cover, and tends to bias toward higher cover estimates. The reason for this is that an area typically is not surveyed because of active construction. Monitoring results (ECOSTEM 2017, 2018b, 2019b, 2020, 2021b) and field experience indicate that areas under active construction have lower total non-native plant cover than less active areas, decreasing the size of the denominator without a proportional decrease in total non-native cover. Additionally, the differences in area surveyed from year to year are small compared to the overall area surveyed.

Late summer non-native plant surveys in 2021 covered approximately 695 ha (12%) of the cleared or disturbed Project footprint (Table 2-3; Table 2-4). The percentage of the Project footprint surveyed increased to 52% when recently cleared or very large footprint components utilizing different sampling methods footprint components were excluded (i.e., the future reservoir area and the North and South Access roads and dykes). The reservoir area accounted for 65% of the Project footprint in 2021, including all Project and KIP areas.

The total area surveyed in 2021 was 78 ha higher than in 2020, primarily because construction activity had ceased in some Project areas and they became accessible for surveys. The largest of these accessible Project components included Borrow Areas N-5 and N-21, and EMPA D27. The westernmost portion of the SAR itself was also accessible during the 2021 survey.

Overall, the locations included in the 2021 and 2020 surveys were similar for most of the Project components (Table 2-3). As noted above, most of the exceptions were due to changing levels of construction activity.

Table 2-3: Total area (ha) surveyed for non-native plants by year and Project component

Project Component	Early Summer Survey								Late Summer Survey							
	2014	2015	2016	2017	2018	2019	2020	2021	2014	2015	2016	2017	2018	2019	2020	2021
North Access Road[1]	9	9	9	-	-	-	-	-	10	9	8	10	9	8	9	9
South Access Road[1]	-	-	9	306	268	127	-	-	-	-	10	16	13	14	13	14
Camp and Work Areas	126	109	163	19	6	16	-	-	138	111	186	182	185	173	179	186
Borrow Areas	112	119	323	79	131	200	-	-	120	131	329	334	329	369	330	367
North Dyke[1]	-	-	52	88	108	12	-	-	1	-	56	120	124	138	51	53
South Dyke[1]	-	-	38	7	3	2	-	-	-	-	21	4	8	2	35	66
Generating Station Area	-	-	20	10	0	10	-	-	-	-	10	6	-	-	1	-
Reservoir Clearing Area[2]	-	-	56	0	-	-	-	-	-	-	-	0	-	-	-	-
Total surveyed area	*247*	*237*	*669*	*509*	*516*	*367*	-	-	*269*	*251*	*620*	*671*	*668*	*703*	*618*	*695*
Total footprint area [3]	*540*	*1,438*	*3,643*	*5,372*	*5,716*	*5,759*	*5,798*		*540*	*1,438*	*3,643*	*5,372*	*5,716*	*5,759*	*5,798*	*5,783*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Sampled area consists of a systematic sample of the road (Section 2.2.1). In addition, cleared areas were scanned for large patches while driving between stops.

[2] Most of the reservoir clearing area was converted to aquatic habitat after impoundment in 2020.

[3] Approximately 75 ha of KIP borrow areas not used by the Project are included in these totals.

Table 2-4: Percentage of Project footprint area included in the non-native plant surveys by year and Project component

Project Component	Early Summer Survey								Late Summer Survey							
	2014	2015	2016	2017	2018	2019	2020	2021	2014	2015	2016	2017	2018	2019	2020	2021
North Access Road[1]	5	5	5	-	-	-	-	-	5	5	4	5	5	4	5	5
South Access Road[1]	-	-	3	94	82	39	-	-	-	-	3	5	4	4	4	4
Camp and Work Areas	68	48	71	8	3	7	-	-	75	49	81	78	78	73	75	78
Borrow Areas	90	35	74	16	24	36	-	-	96	38	76	68	60	66	55	62
North Dyke[1]	-	-	28	45	54	6	-	-	3	-	30	61	62	69	26	27
South Dyke[1]	-	-	31	4	2	1	-	-	-	-	17	2	4	1	17	33
Generating Station Area	-	-	9	4	0	4	-	-	-	-	4	3	-	-	0	-
Reservoir Clearing Area[2]	-	-	3	0	-	-	-	-	-	-	-	0	-	-	-	-
All surveyed areas[3]	*46*	*17*	*18*	*9*	*9*	*6*	-	-	*50*	*17*	*17*	*12*	*12*	*12*	*11*	*12*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Sampled area consists of a systematic sample of the road (Section 2.2.1). In addition, cleared areas were scanned for large patches while driving between stops.

[2] Most of the reservoir clearing area was converted to aquatic habitat after impoundment in 2020.

[3] Approximately 75 ha of KIP borrow areas not used by the Project are included in these totals.

2.4 MAPPING

This report includes detailed non-native plant distribution and abundance mapping derived from the non-native plant cover estimates. These maps show plant patches, by cover class, in the surveyed portions of the Project footprint. The mapping detail is the same as that in the 2020 annual report (ECOSTEM 2021b).

The analysis evaluated non-native plant distribution and abundance in the context of precise clearing and disturbance mapping produced for 2021 (see ECOSTEM 2022a). The primary focus of this report is on the patterns and changes observed in 2021. A detailed comparison of non-native plant spread over all construction years will be provided at the end of Project construction in the monitoring synthesis report.

Species spatial extent and cover data collected using the note-based method was converted into GIS polygons. Where the patch extent method (Section 2.2) was used to record non-native species in the field, patch polygons were created from the GPS tracklogs. After polygons were created from the note-based method data, they, along with the point data, were merged with the point and polygon features produced in the field using the tablets.

Polygons for sites where plants were recorded as individuals in the field were created by applying a fixed radius buffer around the site coordinate. The radius applied for each species at each point was a fixed value for the species multiplied by the number of plants recorded. The radius for one plant of a particular species was the estimated typical area covered by an individual plant (Appendix 1, Table 8-1). Since there were situations where plants were close enough to each other to have overlapping buffers, this method slightly overestimates total non-native plant cover.

The non-native plant mapping provided two measures of plant cover in the footprint components. One measure was the overall spatial extent of one or more non-native plant species, which also indicated species distribution. The other measure was the area covered by each species (approximate plant cover), which was used to indicate abundance. Non-native plant cover will usually be lower than plant extent due to less than complete canopy closure within most of the mapped patches.

Non-native plant cover was derived from the patch cover class (Table 2-2) for sites recorded using the “patch method” or from multiples of individual plant area (Appendix 1, Table 8-1) for sites recorded using the “number of individuals” method. The area covered by a species in a mapped patch was calculated by multiplying the patch area by the midpoint of the percent cover class (Table 2-2). For example, a 10 m^2 non-native plant patch with sparse cover for Species A would have a derived area of: 10 m^2 x 6.5% = 0.65 m^2 for Species A.

Factors that affected how the data generated from the mapping were interpreted included GPS accuracy, interpreter bias and variability, total plant cover and access. For GPS accuracy, non-native patch mapping relied on GPS waypoints and track logs for positioning. Depending on the terrain and satellite signal, accuracy of the GPS could vary by several meters during and between

surveys. The same patch, mapped during different surveys, may show different positions or extents from track logs and waypoints even if its boundaries remained unchanged. Such year-to-year differences were expected to be small relative to the size of the footprint surveyed.

While efforts were made to calibrate plant cover estimates between the different individuals conducting the surveys, some individual bias is always inherent in this measurement method. Furthermore, even for the same individual, there may have been differences in the approach taken to map a particular patch of non-native plants in one year compared with the previous year. For example, an area with very sparse cover of a particular species may have been recorded as a series of individual points during one survey and as a single patch with very sparse cover during another survey (generally because the number and extent of individual points changed). While the actual cover and number of plants may have been the same between surveys (when limiting the comparison to the same spatial extent as the previous year), the current year patch limits and plant cover class could be different. Consequently, results for the area covered by a species could reflect the mapping approach, and not actually a change in non-native plant extents. To minimize this effect, whenever possible, the same individuals were used to conduct the surveys over the monitoring period, and an effort was made to subdivide the areas surveyed by each individual in the same way each time. This element of the field methods was not expected to create a large bias in the overall results even though there could be relatively large differences at specific sites.

As cleared areas regenerate, native vegetation cover may obscure non-native plants, confounding estimates of cover. This could result in a bias toward underestimating non-native plant cover in areas with dense or taller native plants. This could also result in a seasonal bias in which non-native plant cover for some species was underestimated during spring surveys because the plants were small and obscured by other vegetation.

During construction, some areas could not be safely accessed at the time when surveys were conducted due to construction activity (e.g., portions of Work Area A). While effort was made to observe these areas from a distance, it is possible that non-native plants were present but not recorded (note that this does not refer to sites where non-native plants definitely could not be seen if present; such areas are not included as part of the surveyed area). This could result in total cover being underestimated for certain areas in some years. However, any bias was expected to be small as the areas surveyed from a distance were typically in active borrow areas (i.e., the new substrate was recently exposed). Because the total area surveyed varies due to these reasons, the results are related to total area surveyed, rather than total footprint area, increasing comparability of results from different surveys.

The introduction of the “Trace” cover class in 2021 introduced an upward bias in the 2021 spatial extent metric when compared to previous years. Areas previously mapped with scattered individual points were represented by a polygon in 2021. While this change is expected to reduce individual surveyor bias in future years, spatial extent in 2021 is not directly comparable to spatial extent prior to 2021 as it will be slightly higher for the identical plant extent.

Due to the above factors (particularly the first two), derived species cover, rather than polygon extents, were considered to be a more meaningful measure for interpreting changes in non-native

plant abundance between years. Non-native species polygon extents should only be considered as an indication of overall distribution as well as a very broad measure of area covered.

2.5 NON-NATIVE PLANT CONTROL

Several areas were recommended for herbicide application and mowing based on the 2020 monitoring results (see Section 4.2 for details). The areas were those which contained invasive species of high concern that had high potential to spread into other areas. Manitoba Hydro treated these areas with herbicides on July 9, 2021 (see Section 4.0 for details).

On July 15 to 18, 2021, a botanist visited the areas that were recommended for herbicide control. The botanist identified if the target species was present in these areas and confirmed if they were treated by herbicide. Notes were taken on the effectiveness of the herbicide. If the botanist identified patches of plants that were missed by the herbicide, or where the herbicide effectiveness was low, the patches were marked with wooden stakes, purple flagging tape and/or pin flags to delineate areas for a follow-up mowing treatment.

Follow-up mowing was carried out at the marked patches on September 10, 2021.

Surveys were conducted in the herbicide-treated and mowed areas during the late summer survey to document the treatment efficacy. Non-native plants in the treatment areas were recorded according to the standard survey methods. In addition to the standard data, the percent of dead foliage for each non-native species in the patch was also recorded. Photos of the treated patches of plants were taken. A patch was considered to be treated with herbicide if there was evidence of herbicide damage on any of the vegetation in the patch. This may be different than the actual area sprayed because the effects of the herbicide can be systemic, and may extend beyond the application area for rhizomatous species. Mowed patches were identifiable because mowing occurred just prior to the invasive plant surveys.

2.6 INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

2.6.1 BACKGROUND

The Project's EIS and EnvPPs include standard control or eradication measures for invasive and other non-native plants, including:

- Contractors that will be using equipment and machinery that was recently used more than 150 km from the Project area will wash that equipment and machinery prior to transport to the Project area.

- Areas that are rehabilitated using a seed mixture will be seeded with a mixture that only contains native and/or non-invasive introduced plant species.
- Areas where there are patches of noxious weeds will be flagged for avoidance if they are not contained in active construction areas.
- Exposed areas shall be revegetated as quickly as possible following construction to prevent soil erosion and the establishment of noxious weeds.

This monitoring study provides additional control or eradication recommendations during construction monitoring. The following summarizes the approach taken to make recommendations regarding which non-native species to prioritize for management, and the types of locations that management efforts will focus on. Appendix 2 details the approach.

It is widely recognized that it is not practical to attempt to eradicate or even control all non-native plant species (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011). For example, some species are already too widespread and well-established to implement an approach that removes plants at a faster rate than they reappear in the same sites and establish in new sites. Many of the non-native species recorded during Project monitoring are commonly found in disturbed areas throughout the Province (e.g., field sow-thistle (*Sonchus arvensis*) and white sweet clover (*Melilotus albus*)), particularly along roadsides, making it difficult to prevent them from being spread by human or natural sources.

To prioritize and develop management recommendations for non-native plants in the Project area, the focus is on the plant species of highest invasive concern and the situations where there are practical ways to reduce these species or prevent further spreading. The primary sources used to classify the potential for a non-native plant species to have substantial adverse effects on ecosystems or biodiversity in the Project area were the ISCM (2022), White *et al.* (1993), the Provincial *Noxious Weeds Act* (Government of Manitoba 2017a) and the Federal Weed Seeds Order (Government of Canada 2016). While the federal *Plant Protection Act* was also relevant from a regulatory perspective, few of the species currently on its list occur in Manitoba, and those that do are limited to a few locations in the southern portion of the province.

The primary additional sources of information that assisted with evaluating potential invasiveness in the Project area, and with developing management recommendations, included the Biology of Canadian Weeds Series (Canadian Weed Science Society 2019a), the Biology of Invasive Alien Plants in Canada (Canadian Weed Science Society. 2019b), Manitoba Agriculture (2019) and results from the EIS or monitoring studies for this and other projects in northern Manitoba. The last of these sources also provided some information regarding patterns of distribution and abundance in the Project region.

A limitation for some of the sources used to determine a plant's degree of invasiveness was that they did not include data from the Keeyask region. The observed degree of invasiveness for the species included in these sources was generally obtained in regions subject to much different climates than that occurring in the Project region. Local invasiveness can differ greatly from that observed in other regions (Carlson *et al.* 2008).

Of the sources used for ranking a species' degree of invasiveness listed above, ISCM (2022) and White *et al.* (1993) were considered the most relevant ones because their focus is on impacts to ecosystems and biodiversity. The Provincial *Noxious Weeds Act* and the Federal Weed Seeds Order were developed to address impacts on the agricultural economy or the viability of agricultural operations. An upshot of this agricultural focus is that these regulations do not list some species known to be of concern for impacts on native ecosystems and biodiversity (e.g., purple loosestrife). Conversely, these regulations also list some native boreal plant species (e.g., foxtail barley) as weeds since they can be problematic for agriculture. Native boreal species appearing on these lists were not considered to be invasive for the Project area.

2.6.2 INVASIVE CONCERN CLASSIFICATION

The non-native plant species recorded during monitoring to date were classified into one of four levels of invasive concern for the Project area (Table 2-5). Level 1 was the highest level of invasive concern for the Project. Level 1 species included ISCM Category 1 and 2 species.

The second highest level of invasive concern for the Project (Level 2 species) included ISCM "other" species of concern and/or the non-native species that White *et al.* (1993) classify as being principal or moderate invasives in Canada. These species also have the potential to crowd out native species in many of the conditions where non-native plants are found.

The third highest level of invasive concern (Level 3 species) included non-native species that White *et al.* (1993) classify as minor invasives in Canada and/or the species that government sources classify as noxious weeds or weed seed species.

The fourth and lowest level of invasive concern (Level 4 species) included all of the remaining non-native plant species not already included in another level. Species at the third and fourth levels may become problematic in some locations and/or conditions (*e.g.*, changed climate). They will also be a consideration when developing revegetation plans for areas being rehabilitated to native habitat types.

Table 2-6 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project footprint to date.

Table 2-5: Levels of invasive concern for plants in the Project footprint

Invasive Concern Level	Plant Species Included
Level 1	Species the ISCM classifies as "Category 1" or "Category 2"
Level 2	Species the ISCM classifies as "other" or White et al. (1993) classify as "high" or "moderate" invasives
Level 3	Species that either White et al. (1993) classify as "minor" invasives, or government sources classify as noxious weeds or weed seed species[1]
Level 4	All remaining non-native plant species

Notes: [1] The government regulations list some native boreal plant species (e.g., foxtail barley) as weeds since they focus on species that are problematic for agriculture. Native boreal species appearing on these lists are not considered to be invasive for the Project area.

Table 2-6: Classification of non-native plant species recorded in the Project footprint into levels of invasive concern

Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White et al. Category[4]	Noxious Weed[5]	Weed Seed[6]
Level 1	Scentless chamomile	*Tripleurospermum inodorum*	Category 2		Tier 2	Secondary
	Ox-eye daisy	*Leucanthemum vulgare*	Category 2		Tier 2	Primary
	Common tansy	*Tanacetum vulgare*	Category 2		Tier 2	
Level 2	Canada thistle	*Cirsium arvense*	Other	Moderate	Tier 3	Primary
	Field sow-thistle	*Sonchus arvensis*	Other		Tier 3	Primary
	Common burdock	*Arctium minus*	Other		Tier 3	
	Tufted vetch	*Vicia cracca*	Other			
	White sweet clover	*Melilotus albus*		Moderate		
	Yellow sweet clover	*Melilotus officinalis*		Moderate		
Level 3	Wormwood	*Artemisia absinthium*		Minor	Tier 3	
	Alfalfa	*Medicago sativa*		Minor		
	Lamb's-quarters	*Chenopodium album*			Tier 3	
	Common dandelion	*Taraxacum officinale*			Tier 3	
	Narrow-leaved hawks-beard	*Crepis tectorum*			Tier 3	
	Flixweed	*Descurainia sophia*			Tier 3	
	Curled dock	*Rumex crispus*				Secondary
Level 4	Canola	*Brassica napus*				
	Shepherd's-purse	*Capsella bursa-pastoris*				
	Wormseed mustard	*Erysimum cheiranthoides*				
	Pineapple-weed	*Matricaria discoidea*				
	Bird's-foot trefoil	*Lotus corniculatus*				
	Black medick	*Medicago lupulina*				
	Spotted lady's-thumb	*Persicaria maculosa*				
	Common plantain	*Plantago major*				
	Common timothy	*Phleum pratense*				
	Smooth catchfly	*Silene csereii*				
	Alsike clover	*Trifolium hybridum*				
	Red clover	*Trifolium pretense*				
	White clover	*Trifolium repens*				
	Wheat	*Triticum aestivum*				

Notes: [1] See Table 2-5 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2022). [4] White *et al.* (1993). [5] Government of Manitoba (2017b). Number in column is the Tier in the Act (see text). [6] Government of Canada (2016).

2.6.3 GENERAL APPROACH TO MANAGEMENT

The generally preferred overall strategy for addressing invasive (called "weedy" in some publications) non-native plants is a combination of prevention, early detection and eradication because this is generally considered to be the most economical and effective way to manage invasive plants (e.g., Clark 2003; Coastal Invasive Species Committee 2016).

For application, the generally preferred approach for dealing with individual plants or small patches of Level 1 non-native species appearing in new areas is to eradicate them as soon as they are discovered. Ideally, this is accomplished by manually removing the plant(s) including roots, removing the soil from around the base of the plant, immediately placing all plant and soil material into a double layer of garbage bags, and disposing of all of the collected material (preferably by burning it). The following describes how the application of this strategy evolved over time during Project monitoring.

When Level 1 plants were found within the Project footprint during the 2015 and 2016 surveys, their locations were reported to Manitoba Hydro environmental site staff, who carried out their removal and disposal using the preferred method described above.

Partway through the 2017 surveys, it was decided that, going forward, ECOSTEM survey staff would manually remove and dispose of the Level 1 plants using the preferred approach described above. Immediate removal was intended to minimize the possibility for these plants to disperse seed or become well-established. Since this decision was made during the 2017 field season, some sites were not treated in this manner during 2017. As the 2017 surveys progressed, Level 2 plants were also immediately removed and disposed of at some sites, provided that the number of plants was low enough that it was practical to do so. This final approach was followed during the 2018 to 2021 surveys.

For the remaining sites with Level 2 plants, key sites were identified for herbicide application. The key sites were selected based on where invasive plants were most prolific and had the highest potential for being spread to other Project areas due to vehicles or footwear picking up seeds and carrying them elsewhere.

To assess the efficacy of herbicide and mowing treatments, foliage damage and mortality was used as an indicator for the approximate boundaries for where herbicides or mowing were actually applied in the treated sites. When possible, surveys were conducted soon enough after application (less than one month) that the plant remains should still have been present and identifiable to species. This indicator assumed that some degree of mortality would occur on any plants that were contacted by the herbicides. Some treated plants may occur outside of the mapped treated area due to factors such as variability in application rates or a particular species' tolerance to the chemicals used. Section 4.2 provides details.

2.7 SPECIES TREATED SEPARATELY

Native and non-native populations of reed canarygrass (*Phalaris arundinacea*) exist in North America. According to genetic analysis of herbarium specimens, the native reed canarygrass population was widespread in North American as of the early 20th century, extending from Alaska to New Brunswick (Jakubowski *et al.* 2012).

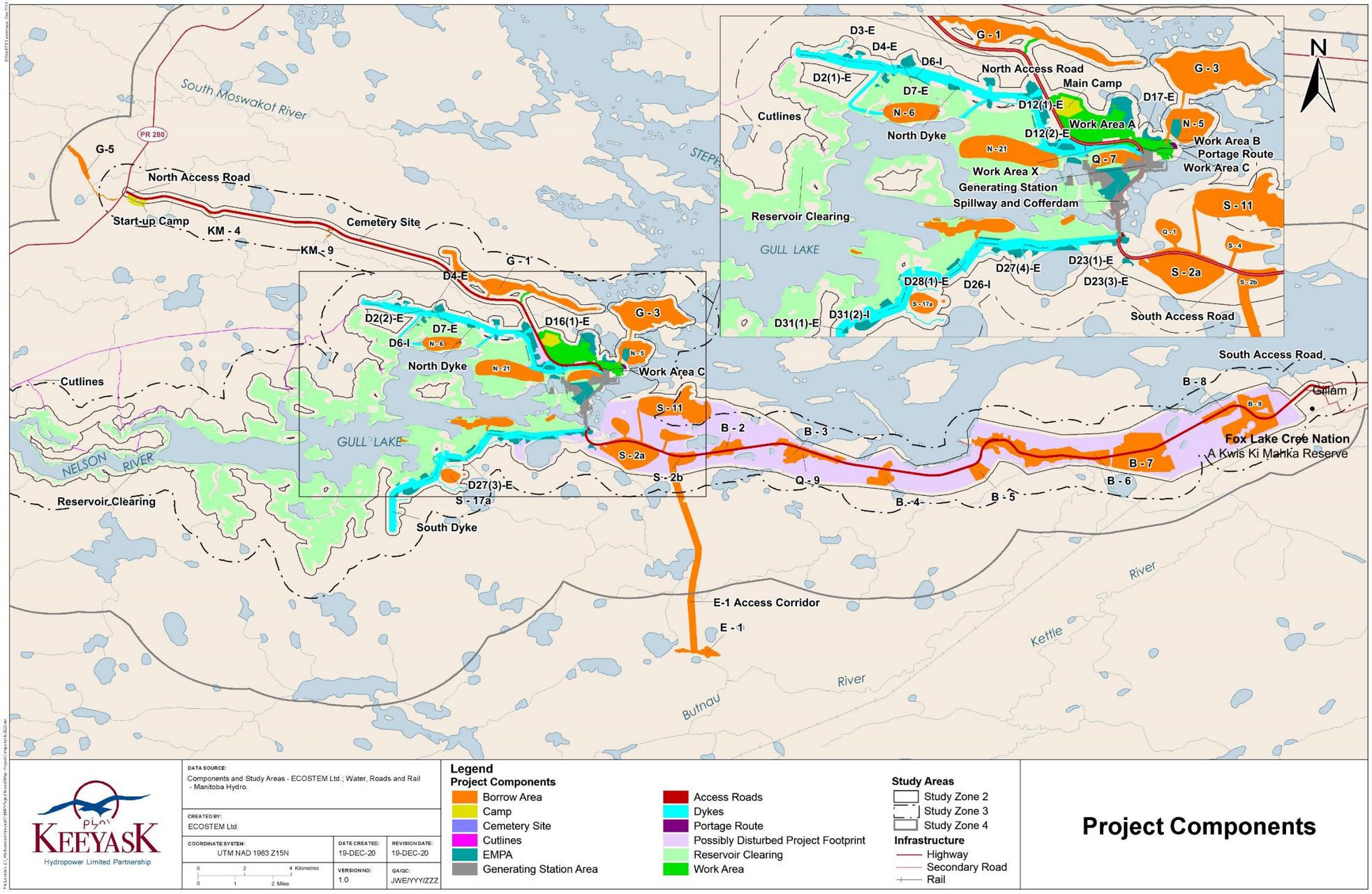
The non-native reed canarygrass population has been introduced from Eurasia on multiple occasions (Lavergne and Molofsky 2004; Lavergne and Molofsky 2007; Brodersen *et al.* 2008; Calsbeek *et al.* 2011). Genetic analysis concluded that the native and Eurasian populations are genetically distinct (Jakubowski *et al.* 2012). Additionally, non-native plants readily hybridize with native plants (Lavergne and Molofsky 2004).

Plants from the non-native or hybridized populations can be very aggressive, to the extent of crowding out native species. White *et al.* (1993) consider reed canarygrass to be a principal invasive plant in Canada.

In the field, it is almost impossible to determine whether plants belong to the native, non-native or hybridized population (ISCM 2022b). Some authors state that genetic analysis is the only reliable way to make this determination (Hayley 2012). As genetic analysis would be unduly onerous in many situations, some studies classify plants as native or non-native based on whether or not they are exhibiting invasive behavior (Maurer *et al.* 2003; Brodersen *et al.* 2008).

With regard to the Project footprint, evidence to date indicates that the recorded plants are likely from the native population. There is some evidence to suggest that the northern distribution limit of the non-native population in Manitoba is south of Thompson (Lavergne and Molofsky 2004; ISCM 2022). Also, more than a decade of monitoring data from the Wuskwatim Generation Project, which is also in northern Manitoba, has not demonstrated aggressive spread of the plants found there. Finally, the plants observed at Keeyask have not suggested aggressive spreading behaviour to date.

Based on the preceding information, the reed canarygrass plants recorded during Project monitoring to date are assumed to be from the native population. However, it is still possible that some or all plants occurring in the Project footprint are actually from the non-native or hybridized population but past conditions have limited invasive behavior. For this reason, field surveys still recorded reed canarygrass using the same methods as used for other non-native plants. Reed canarygrass observations and results are provided in Appendix 5 in the event that the recorded plants do become invasive in the Project area.



DATA SOURCE:
Components and Study Areas - ECOSTEM Ltd.; Water, Roads and Rail - Manitoba Hydro.

CREATED BY: ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	19-DEC-20	19-DEC-20
0 2 4 Kilometres / 0 1 2 Miles	VERSION NO: 1.0	QA/QC: JWE/YYY/ZZZ

KEEYASK Hydropower Limited Partnership

Legend

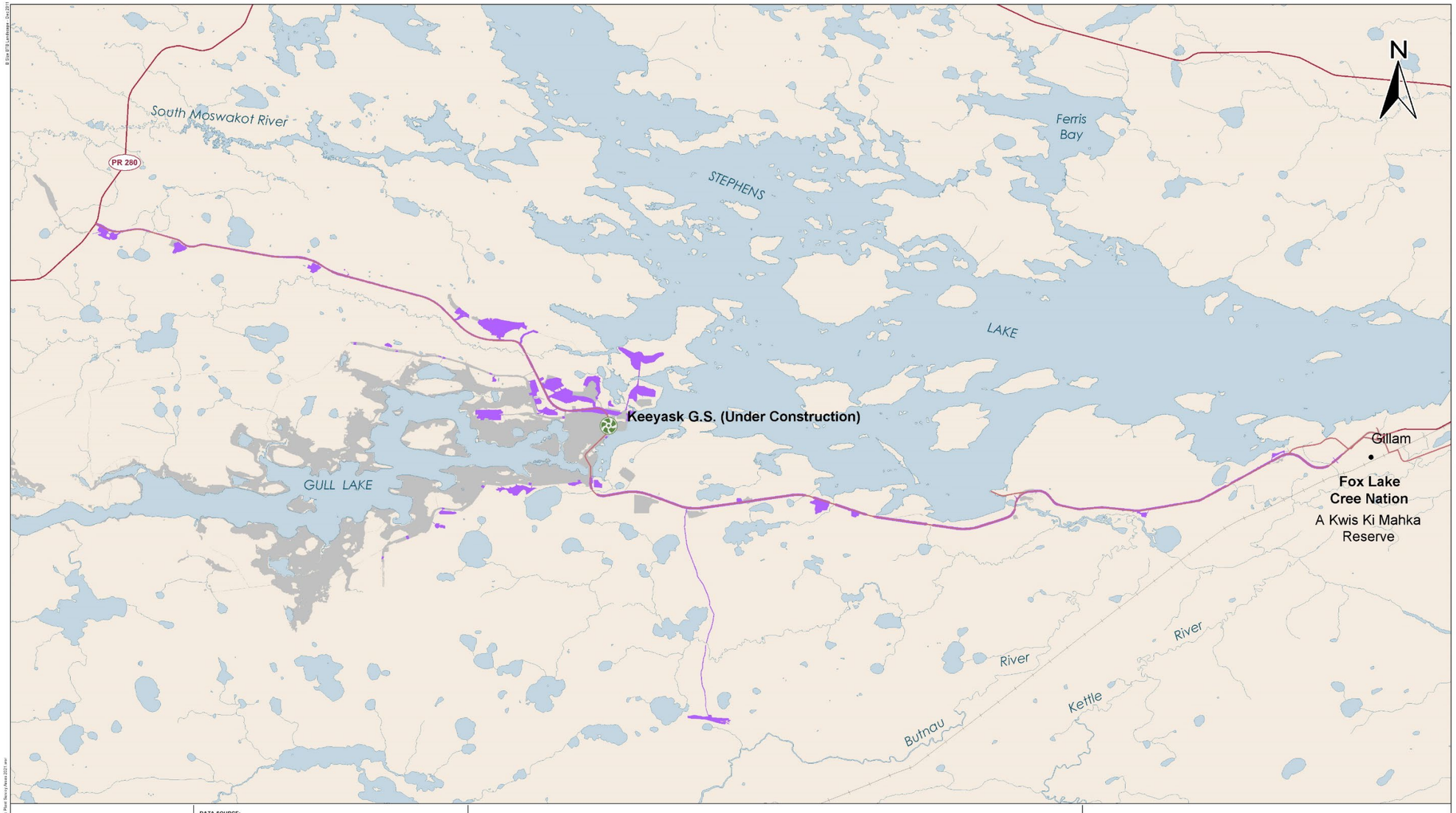
Project Components
- Borrow Area
- Camp
- Cemetery Site
- Cutlines
- EMPA
- Generating Station Area
- Access Roads
- Dykes
- Portage Route
- Possibly Disturbed Project Footprint
- Reservoir Clearing
- Work Area

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

Infrastructure
- Highway
- Secondary Road
- Rail

Project Components

Map 2-1: Project components



Map 2-2: Late summer non-native plant survey areas in 2021

3.0 RESULTS

3.1 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

Section 2.2 describes the metrics used to document changes in distribution and abundance.

As of late summer, 2021, overall non-native plant extent had increased to 145.5 ha, or 20.9% of the total area surveyed (Table 3-1; see Section 2.3 for comparison of areas surveyed). This was an increase of 72.2 ha, which was nearly double the extent in the previous year and the largest total increase in extent since the start of construction monitoring (previously, the largest total extent increase was by 35.0 ha between 2017 and 2018, which was also a doubling of the previous year's extent).

The degrees of increase should be interpreted with caution as the data prior to 2021 understate plant extent compared with subsequent years (see Sections 2.3 and 2.4 for the reasons and Section 5.1 for discussion of how they affect comparisons).

Non-native plant extent increases occurred in each of the surveyed Project components, with the largest being in the South Dyke followed by the North Access Road (NAR) and the camp and work areas, and were least widespread in the surveyed portion of the SAR (Map 3-1 to Map 3-5). For the Project components, plants were distributed over 10.4% to 43.7% of the surveyed areas.

Table 3-1: Total late summer non-native plant extent as a percentage of total area surveyed, by year[1] and Project component

Project Component	2014	2015	2016	2017	2018	2019	2020	2021	Change from 2020 to 2021[2]
North Access Road	0.3	0.9	3.5	4.4	7.6	4.9	4.6	20.7	16.1
South Access Road	-	-	0.2	2.8	7.9	7.7	7.9	10.4	2.5
Camp and Work Areas	3.2	4.7	4.0	5.9	12.8	13.1	13.9	26.3	12.4
Borrow Areas	0.3	3.1	2.1	5.1	8.9	8.0	11.5	15.2	3.7
North Dyke[3]	-	-	0.1	0.3	7.6	11.5	9.9	16.2	6.3
South Dyke[3]	-	-	0.0	0.1	0.2	0.2	10.7	43.7	33.0
Generating Station Area	-	-	0.5	0.2	-	-	1.0	-	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-	-
All Types	1.8	3.7	2.4	4.3	9.6	9.9	11.9	20.9	9.1
Total non-native plant extent (ha)	*4.9*	*9.3*	*14.8*	*28.9*	*64.0*	*69.4*	*73.2*	*145.5*	
Total area surveyed (ha)	*269*	*251*	*620*	*671*	*668*	*703*	*618*	*695*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Plant extent in some components are not directly comparable with other years because surveyed areas may change due to accessibility.

[2] Increase is inflated due to addition of "trace" cover class in 2021.

[3] Due to change in survey methods, data prior to 2020 understate extent years (see Section 2.2.1).

Total non-native plant cover increased to 9.8 ha by late summer, 2021, or 1.41% of the total surveyed area (Table 3-2). This was a 3.6 ha increase from 2020, and the total cover as a percentage of area surveyed increased by 0.41%. Non-native plant cover increased in all surveyed Project components except the SAR.

Table 3-2: Total late summer non-native plant cover as a percentage of total area surveyed, by year[1] and Project component

Project Component	2014	2015	2016	2017	2018	2019	2020	2021	Change from 2020 to 2021
North Access Road	0.01	0.07	0.25	0.38	0.62	0.45	0.50	3.53	3.03
South Access Road	-	-	0.01	0.36	1.21	2.17	3.96	3.62	-0.34
Camp and Work Areas	0.34	0.77	0.58	0.73	1.20	1.05	1.54	1.84	0.30
Borrow Areas	0.05	0.48	0.24	0.46	0.74	0.64	0.66	0.74	0.08
North Dyke[3]	-	-	0.00	0.01	0.79	1.10	0.43	0.69	0.27
South Dyke[3]	-	-	0.00	0.02	0.02	0.00	1.21	3.70	2.49
Generating Station Area	-	-	0.03	0.00	-	-	0.11	-	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-	-
All surveyed area	0.20	0.59	0.31	0.44	0.88	0.86	0.99	1.41	0.41
Total non-native plant cover (ha)	*0.53*	*1.49*	*1.89*	*2.98*	*5.85*	*6.02*	*6.13*	*9.77*	
Total area surveyed (ha)	*269*	*251*	*620*	*671*	*668*	*703*	*618*	*695*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Plant extent in some components are not directly comparable with other years because surveyed areas may change due to accessibility.
[2] A negative sign means that cover decreased.
[3] Due to change in survey methods, 2020 and 2021 values not directly comparable to previous years.

As a percentage of surveyed area, non-native plant cover was highest along the surveyed segments of the South Dyke (3.7%) and the SAR (3.6%), followed by the surveyed segments of the NAR (3.5%) and the camp and work areas (1.8%).

Non-native plants continued to spread in the more recently cleared areas. The majority of the non-native species found in each year since 2015 were in the components used either for the KIP only or minimally affected by the Project, and components used by both the KIP and the Project (e.g., Start-up Camp, Borrow Area G-1).

In 2021, non-native plant extent was highest (34.2%) in areas used either for the KIP only or areas minimally affected by the Project (e.g., Borrow Area KM-4; Appendix 4, Table 8-7). Non-native plant cover was also highest (2.0%) in areas utilized by KIP, followed by areas utilized by both KIP and the Project (1.6%) and areas utilized by the Project only (1.2%). Previously, in areas that had not been used since the KIP or minimally affected by the Project, there was a general decrease in cover of non-native plants each year from 2017 to 2020. The increase in 2021 cover of non-native plants in the KIP areas is likely partially inflated due to the introduction of the new trace category (see above), as well as a decrease in the size of area surveyed. In areas used by both the KIP and the Project and in areas used by the Project only, non-native plant extent and cover increased in 2021 (Appendix 4, Table 8-7 and Table 8-8). The increase in cover was much larger in areas utilized by the Project only. Extent and cover of non-native plants in these areas had remained relatively unchanged from 2018 to 2020, then increased to levels similar to the levels recorded in the other Project area categories in 2021.

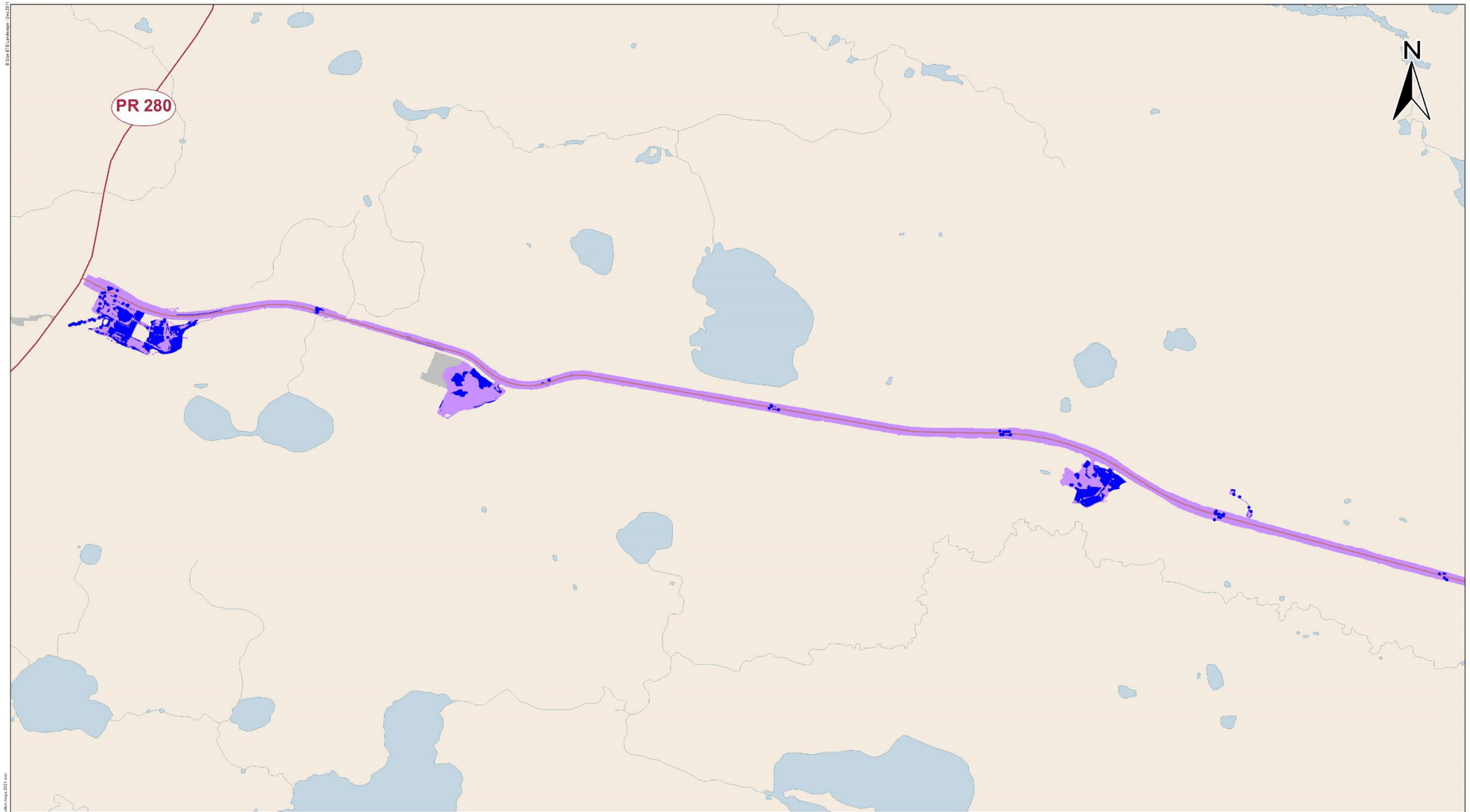
In 2021, the distribution of non-native plants in the Project footprint was broadly similar to that of 2020, albeit with higher plant cover. Some exceptions were EMPA D12 (2)-E and portions of EMPA D16 which had been entirely graded, removing most of the vegetation. There was also a slight decrease in cover along the SAR, however this was partially due to the inaccessibility of two of the regular survey stops closest to the Butnau marina at the time of the survey (see Section 5.1 for discussion of how this affects the comparisons). The largest increases were in components where construction activity had stopped or decreased since 2019, particularly along the NAR and the South Dyke and its associated EMPAs. Non-native plants were present in all surveyed Project components (Map 3-1 to Map 3-5).

The largest increase in non-native plant cover north of the Nelson River occurred along the NAR (Map 3-1 to Map 3-5). This increase was somewhat unexpected, as non-native plant cover had peaked in 2018 and then remained fairly level in 2019 and 2020, although the addition of the "trace" category may account for at least some of the increase. Non-native plant cover also increased in areas where construction activity was more recent, such as EMPA D12 and Work Area X. Borrow Area N-21, which was not surveyed in 2020 due to construction activity, observed a large increase in non-native plant cover between 2019 and 2021 surveys. Borrow Area Km9, one of the older Borrow Areas mainly utilized by the KIP, also experienced a fairly large increase in non-native plant cover. Non-native plant cover remained steady or decreased somewhat in many of the areas along the NAR and North Dyke that were older and had not experienced much change in usage in several years (such as Borrow Area G-1 at KM 15 and KM 17 and EMPA D9).

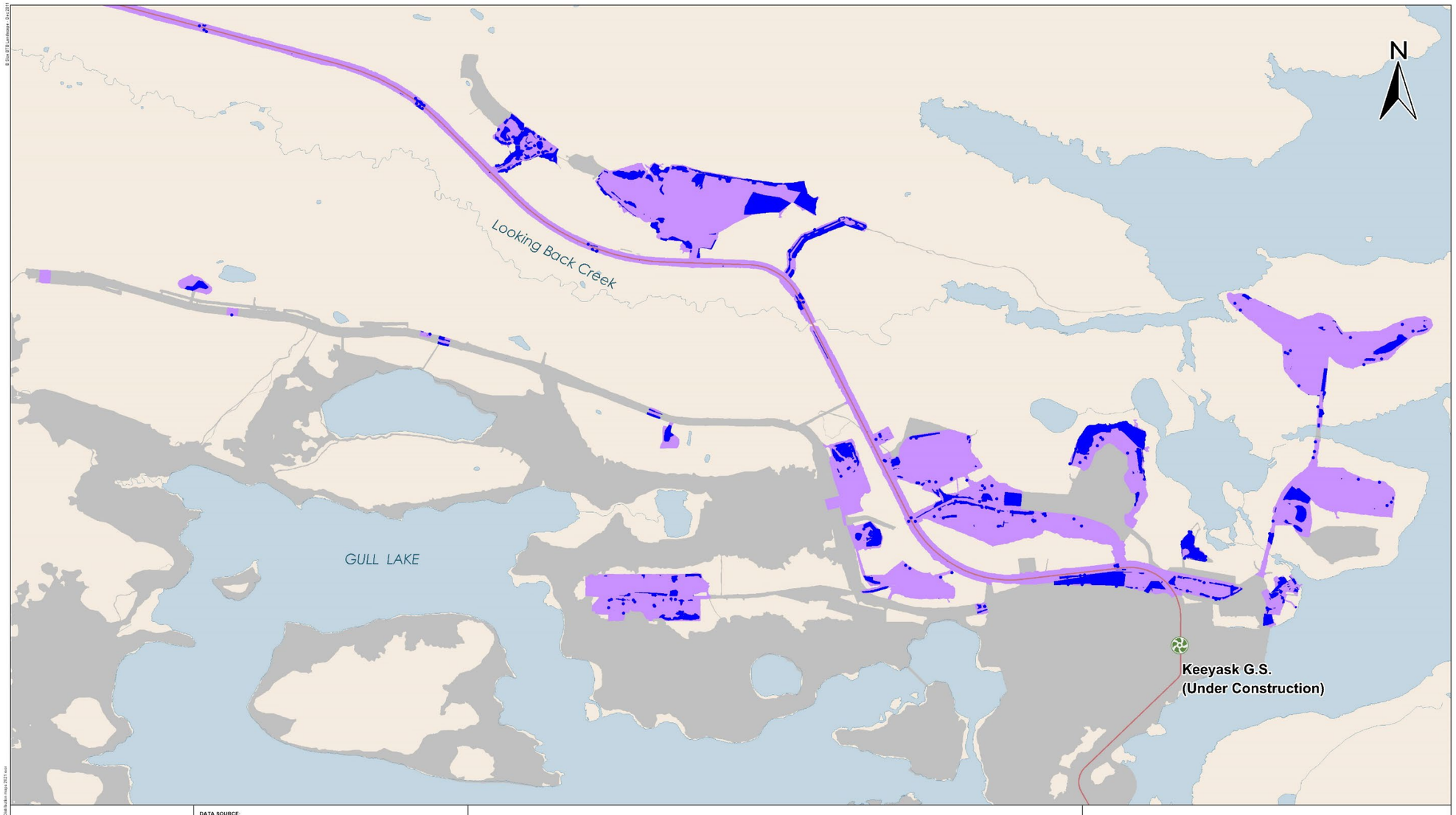
On the south side of the Nelson River, non-native plant cover continued to increase in areas along the South Dyke and SAR after construction was completed in 2019 (Map 3-1 to Map 3-5). In particular, EMPAs D27 and D28 experienced a large increase in cover. Non-native plant cover increased at survey locations along the South Dyke as well. Non-native plants were also

expanding in some of the Borrow Areas attached to the SAR (Borrow Areas B-3 and B-8), but remained steady, or decreased in others (Borrow Areas B-6 and B-2) and along the SAR itself. The decrease along the SAR may itself be explained by the inaccessibility of two of the regular survey locations. Construction activity was occurring in some of the areas near the Butnau marina along the SAR and in the corresponding Borrow Areas during the 2021 survey and were therefore inaccessible.

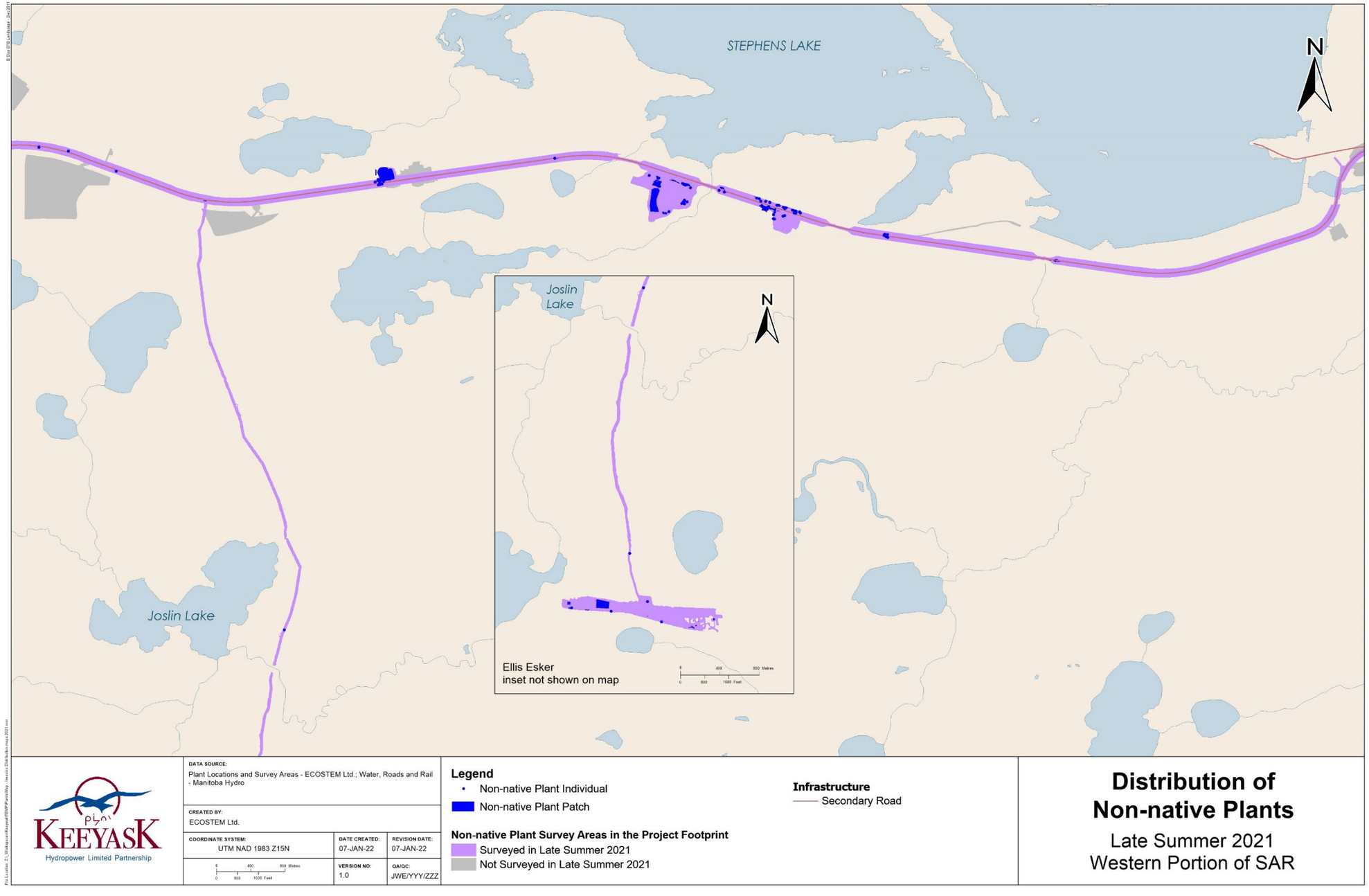
Clearing for the Ellis Esker borrow area (Borrow Area E-1) occurred during the winter of 2017/2018, was in use up to the winter of 2018/2019 after which excavation ceased there. Cleared areas included the winter access road corridor and the borrow area. By late summer 2021, non-native plant cover had increased primarily in the Borrow Area (Map 3-5), with only a few sites along the access corridor.



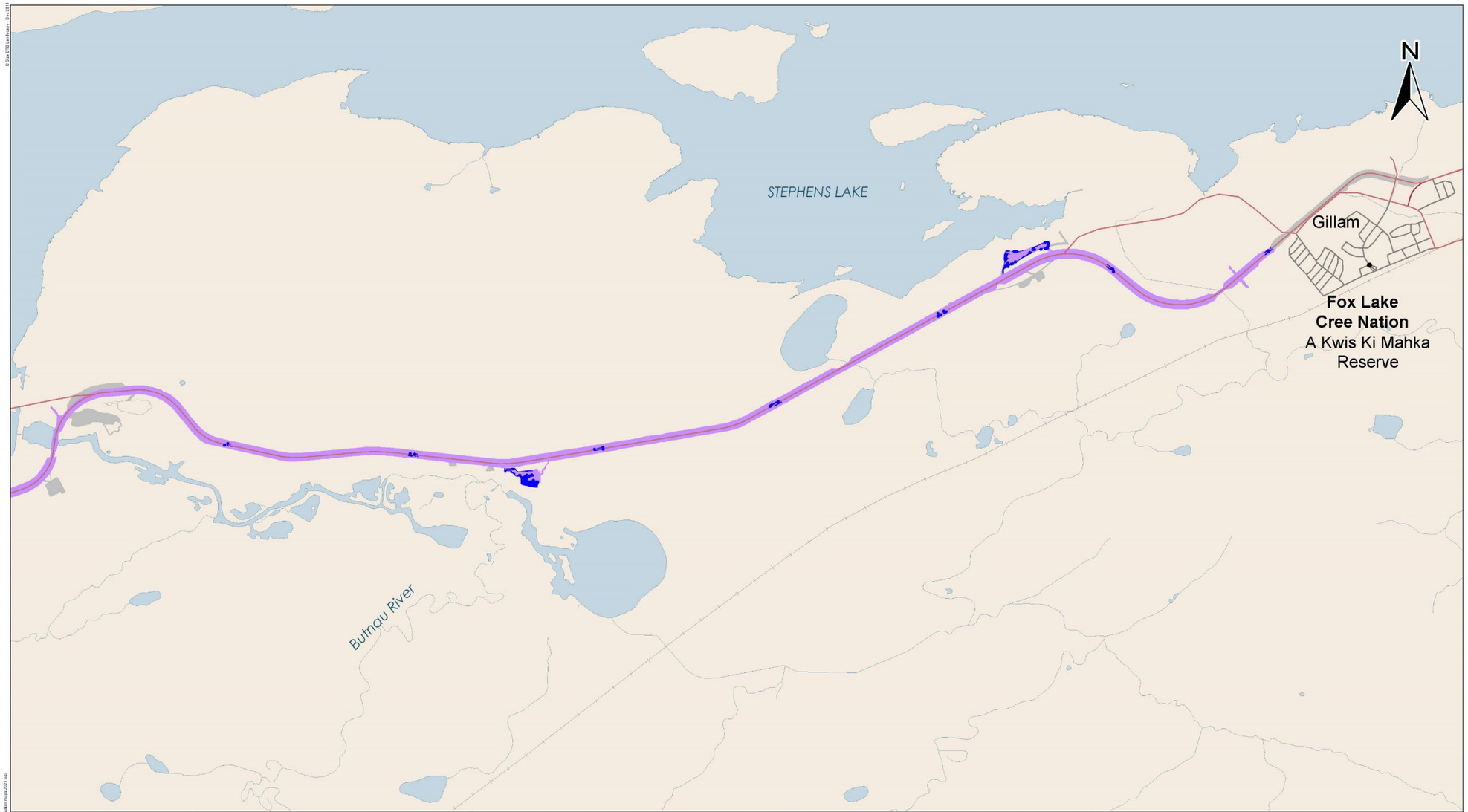
Map 3-1: Distribution of non-native plants during late summer 2021, in the Project footprint along the western portion of the North Access Road



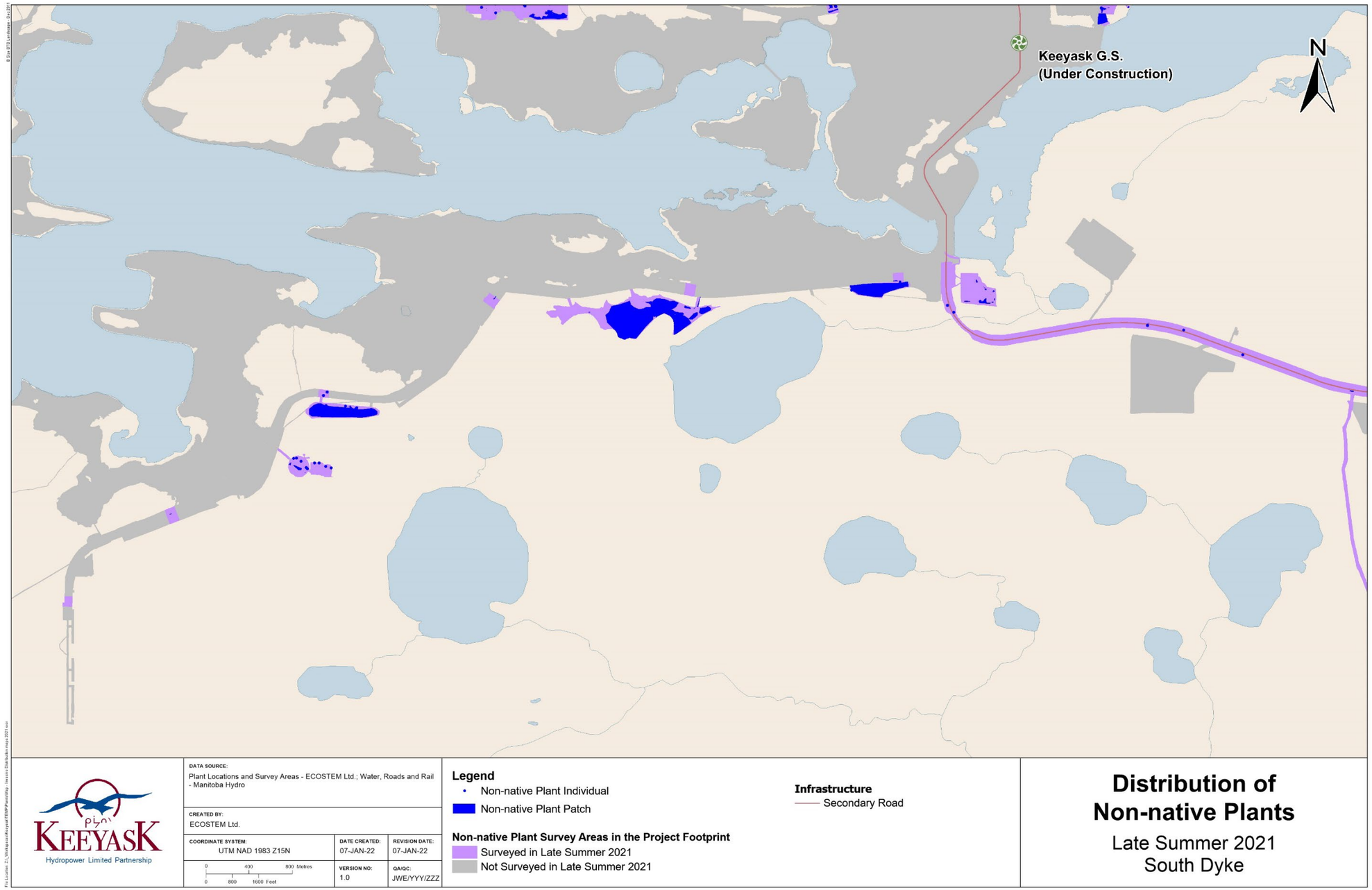
Map 3-2: Distribution of non-native plants during late summer 2021, in the Project footprint along the eastern portion of North Access Road



Map 3-3: Distribution of non-native plants during late summer 2021, in the Project footprint along the western portion of the South Access Road



Map 3-4: Distribution of non-native plants during late summer 2021, in the Project footprint along the eastern portion of the South Access Road



Map 3-5: Distribution of non-native plants during late summer 2021, in the Project footprint in the South Dyke area

3.2 CHANGES TO SPECIES DISTRIBUTION AND ABUNDANCE

A total of 25 non-native plant species were recorded in 2021 from the non-native plant monitoring and from incidental observations (Appendix 4, Table 8-3). No new species were recorded. Map 8-1 to Map 8-25 (Appendix 3) show the distribution and abundance of the five most abundant non-native species recorded in 2021 in the Project footprint.

The total number of species recorded in 2021 was two fewer than in 2020. This was the net effect of one species reappearing and three others not being recorded.

Ox-eye daisy (*Leucanthemum vulgare*) was recorded in 2021 for the first time since 2019, at one location in the decommissioned camp and work area on the north side of the SAR. The three species recorded in 2020 but absent in 2021 (Table 3-3) were canola (*Brassica napus*), flixweed (*Descurainia sophia*) and black medick (*Medicago lupulina*).

Canola and flixweed were recorded in the Project area for the first time in 2020. For canola, one individual was recorded in 2020, but no plants were found in 2021. The flixweed had been hand removed in 2020 because it was the first time that species was recorded. No flixweed individuals were observed in 2021. Although all known ox-eye daisy plants had been removed by the completion of the 2019 late summer survey during targeted control efforts and had not been recorded in the 2020 summer survey, one individual was recorded in a new location along the SAR. The ox-eye daisy was removed from this location at the time of the survey (see Section 4.0).

The five most abundant non-native species in 2021 (Table 3-3) accounted for 88% of all non-native plant cover (Table 3-4). These species were lamb's-quarters (*Chenopodium album*), white sweet clover, common dandelion (*Taraxacum officinale*), narrow-leaved hawks-beard (*Crepis tectorum*) and yellow sweet clover (*Melilotus officinalis*), each accounting for 33%, 19%, 19%, 13% and 4% of the total non-native cover in 2021, respectively (Table 3-4). The next most abundant species were field sow-thistle and spotted lady's-thumb (*Persicaria maculosa*) with 3% of the total non-native cover each, followed by five species at between one and two percent cover.

Five of the seven most abundant species increased in cover since 2020. As a percentage of the surveyed area, cover of lamb's-quarters and spotted lady's-thumb was about three times higher than in 2020, and white and yellow sweet clover cover increased by 88% and 29%, respectively. Common dandelion cover increased by 10%, while narrow-leaved hawks-beard and field sow-thistle cover decreased by approximately 19% and 14%, respectively, since late summer 2020.

Table 3-3: Total approximate late summer non-native species cover (m^2) in the Project footprint, by year

Common Name[1,2]	Species	2014	2015	2016	2017	2018	2019	2020	2021
Lamb's-quarters	*Chenopodium album*	2,903	8,844	6,342	15,229	19,812	25,817	11,113	32,493
White Sweet Clover	*Melilotus albus*	532	2,252	3,015	4,949	11,591	7,839	8,907	18,799
Common Dandelion	*Taraxacum officinale*	1,291	2,422	5,268	5,521	10,302	6,792	14,638	18,189
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	586	1,314	11,040	10,808	13,778	12,548
Yellow Sweet Clover	*Melilotus officinalis*	0	2	109	254	543	1,235	2,652	3,861
Field Sow-thistle	*Sonchus arvensis*	252	972	1,111	1,656	2,562	3,338	2,674	2,580
Spotted Lady's-thumb	*Persicaria maculosa*	-	-	-	-	-	77	752	2,529
Common Plantain	*Plantago major*	80	121	268	246	741	674	1,108	1,667
Unidentified Sweet Clover	*Melilotus spp.*	72	-	1,838	67	307	851	567	1,537
Smooth Catchfly	*Silene csereii*	-	5	26	32	294	338	855	1,048
Tufted Vetch	*Vicia cracca*	-	-	0	38	170	563	821	1,032
Alsike Clover	*Trifolium hybridum*	25	242	190	91	833	1,021	2,250	839
Alfalfa	*Medicago sativa*	124	11	14	40	98	102	139	319
Curled Dock	*Rumex crispus*	-	-	100	19	148	204	465	97
Pineappleweed	*Matricaria discoidea*	-	18	29	325	74	32	78	86
Wormseed Mustard	*Erysimum cheiranthoides*	-	-	-	-	-	495	470	81
Red Clover	*Trifolium pratense*	0	0	-	1	0	0	6	14
Common Timothy	*Phleum pratense*	-	-	0	0	0	0	13	12
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0	1	0	0	4
Common Tansy	*Tanacetum vulgare*	-	-	-	-	0	0	2	4
Canada Thistle	*Cirsium arvense*	-	0	0	1	2	1	5	4
Wormwood	*Artemisia absinthium*	-	0	1	1	1	-	1	3
White Clover	*Trifolium repens*	0	0	0	-	-	0	0	1
Shepherd's-Purse	*Capsella bursa-pastoris*	-	-	-	-	-	0	0	1
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0	-	0	2	1
Ox-eye Daisy	*Leucanthemum vulgare*	-	-	-	-	0	0	-	0
Common Burdock	*Arctium minus*	-	-	0	-	5	5	-	-
Canola	*Brassica napus*	-	-	-	-	-	-	0	-

Common Name[1,2]	Species	2014	2015	2016	2017	2018	2019	2020	2021
Flixweed	*Descurainia sophia*	-	-	-	-	-	-	0	-
Black Medick	*Medicago lupulina*	0	1	-	0	-	-	3	-
Rye	*Secale cereale*	0	-	-	-	-	-	-	-
Unidentified Clover	*Trifolium spp.*	-	-	-	-	-	0	0	-
Wheat	*Triticum aestivum*	-	-	30	21	-	-	-	-
All species		*5,280*	*14,890*	*18,927*	*29,805*	*58,524*	*60,191*	*61,300*	*97749*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-6). Italicized species are Level 2 invasive concern. Underlined species are Level 3 invasive concern. Remaining species are non-native species that may become problematic in some sites and/or condition. [2] Species difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

Table 3-4: Total approximate cover of non-native species as a percentage of total cover for all non-native species, by year

Common Name[1,2]	Species	2014	2015	2016	2017	2018	2019	2020	2021
Lamb's-quarters	*Chenopodium album*	55	59	34	51	34	43	18	33
White Sweet Clover	*Melilotus albus*	10	15	16	17	20	13	15	19
Common Dandelion	*Taraxacum officinale*	24	16	28	19	18	11	24	19
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	3	4	19	18	22	13
Yellow Sweet Clover	*Melilotus officinalis*	0	0	1	1	1	2	4	4
Field Sow-thistle	*Sonchus arvensis*	5	7	6	6	4	6	4	3
Spotted Lady's-thumb	*Persicaria maculosa*	-	-	-	-	-	0	1	3
Common Plantain	*Plantago major*	2	1	1	1	1	1	2	2
Unidentified Sweet Clover	*Melilotus spp.*	1	-	10	0	1	1	1	2
Smooth Catchfly	*Silene csereii*	-	0	0	0	1	1	1	1
Tufted Vetch	*Vicia cracca*	-	-	0	0	0	1	1	1
Alsike Clover	*Trifolium hybridum*	0	2	1	0	1	2	4	1
Alfalfa	*Medicago sativa*	2	0	0	0	0	0	0	0
Curled Dock	*Rumex crispus*	-	-	1	0	0	0	1	0
Pineappleweed	*Matricaria discoidea*	-	0	0	1	0	0	0	0
Wormseed Mustard	*Erysimum cheiranthoides*	-	-	-	-	-	1	1	0
Red Clover	*Trifolium pratense*	0	0	-	0	0	0	0	0

Common Name[1,2]	Species	2014	2015	2016	2017	2018	2019	2020	2021
Common Timothy	*Phleum pratense*	-	-	0	0	0	0	0	0
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0	0	0	0	0
Common Tansy	*Tanacetum vulgare*	-	-	-	-	0	0	0	0
Canada Thistle	*Cirsium arvense*	-	0	0	0	0	0	0	0
Wormwood	*Artemisia absinthium*	-	0	0	0	0	-	0	0
White Clover	*Trifolium repens*	0	0	0	-	-	0	0	0
Shepherd's-Purse	*Capsella bursa-pastoris*	-	-	-	-	-	0	0	0
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0	-	0	0	0
Ox-eye Daisy	*Leucanthemum vulgare*	-	-	-	-	0	0	-	0
Common Burdock	*Arctium minus*	-	-	0	-	0	0	-	-
Canola	*Brassica napus*	-	-	-	-	-	-	0	-
Flixweed	*Descurainia sophia*	-	-	-	-	-	-	0	-
Black Medick	*Medicago lupulina*	0	0	-	0	-	-	0	-
Rye	*Secale cereale*	0	-	-	-	-	-	-	-
Unidentified Clover	*Trifolium spp.*	-	-	-	-	-	0	0	-
Wheat	*Triticum aestivum*	-	-	0	0	-	-	-	-
All species		*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-6). Italicized species are Level 2 invasive concern. Underlined species are Level 3 invasive concern. Remaining species are non-native species that may become problematic in some sites and/or condition. [2] Similar species that are difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

4.0 EFFORTS TO MANAGE INVASIVE PLANTS

The non-native species that were considered for management measures included all of the Level 1 species (Section 2.6.2), which were the species of highest invasive concern for the Project footprint. Level 2 species were candidates for management measures if they were not already well-established in multiple locations. Level 3 and Level 4 species were opportunistically managed within locations where Level 1 or 2 species were treated.

Eight of the 25 non-native species recorded in 2021 (Appendix 4, Table 8-6) were classified as being Level 1 or 2 (Table 2-6). None of these were an ISCM Category 1 species, and none were a Tier 1 species in the *Noxious Weeds Act* of Manitoba.

The Level 1 species (Table 2-6) found in 2021 were ox-eye daisy, scentless chamomile (*Tripleurospermum inodorum*) and common tansy (*Tanacetum vulgare*). Level 2 species included Canada thistle (*Cirsium arvense*), field sow-thistle, tufted vetch (*Vicia cracca*), and white and yellow sweet clover.

Strategies employed to date to manage non-native plants include prevention, eradication and control. Several prevention measures are included in the Project Environmental Protection Plans (e.g., washing equipment before transporting to site). Examples of prevention measures implemented in the monitoring are: that staff conducting the surveys clean their footwear before they leave a surveyed area; and, providing site environmental staff with non-native plant identification training and resources.

The three primary eradication and control methods employed to date were rapid manual removal, herbicide treatments, and mowing at key sites. The following describes these measures.

4.1 RAPID MANUAL REMOVAL AND OTHER NON-CHEMICAL ACTIONS

The rapid manual removal (i.e., by hand) strategy was applied to Level 1 plants at sites with one to a few plants (see Section 2.6.3 for the removal methods). Such plants were immediately removed when they were found.

4.1.1 LEVEL 1 NON-NATIVE SPECIES

The three Level 1 non-native species recorded in 2021 were ox-eye daisy, scentless chamomile and common tansy. All three species are an ISCM Category 2 species or a Tier 2 species in the

provincial *Noxious Weeds Act* (Table 2-6). Scentless chamomile is also a weed seed plant in the federal Weed Seeds Order.

To date, the rapid manual removal appears to have been effective for the Level 1 species (Section 2.6.3). The following describes the situations for individual species.

Scentless Chamomile

Scentless chamomile (Photo 4-1) is an annual to short-lived perennial. It is a fast-growing prolific seed producer that can form dense monocultures (LSSG 2010).

Field surveys identified one scentless chamomile plant in the Start-up Camp footprint (on the path to the well in 2015), in EMPA D17 in 2016, and in EMPA D16 in 2017; several plants were found in the Start-up Camp, EMPA D16, Work Area B and the Main Camp in 2018 and 2019; and plants were found at two locations each along the SAR and the South Dyke in 2020 (Appendix 3, Map 8-26). Shortly after the 2015 and 2016 plants were found, it was recommended that Manitoba Hydro site staff remove and dispose of these plants using the preferred method. Manitoba Hydro site staff carried out the scentless chamomile plant removal shortly thereafter. ECOSTEM staff removed all the plants found since 2017.

The sites where scentless chamomile plants had been removed in prior years were revisited in 2021. These sites had no scentless chamomile plants.

In August 2021, scentless chamomile was found growing at ten new sites (Map 8-26): three in EMPA D16 (Photo 4-1), one on the north dyke, five in Borrow Area B-2, and one in EMPA D28(1)-E which is attached to the South Dyke. All of these plants were immediately removed and disposed of by ECOSTEM field staff, except for the plants growing in a large patch in EMPA D16, which were removed by Manitoba Hydro site staff on September 29, 2021 (Photo 4-2).

Photo 4-1: Scentless chamomile patch growing in EMPA D16 on August 27, 2021

Photo 4-2: Manitoba Hydro site staff removing scentless chamomile plants growing in EMPA D16 on September 29, 2021

Common Tansy

Common tansy (Photo 4-3) is a perennial that spreads through seeds and its extensive root system. Seeds from this plant can germinate after being in the ground for up to 25 years (ISCM 2022).

Common tansy was found growing at a single site along the North Dyke in late summer, 2018, at another site nearby in 2019 and at eight sites along the SAR, NAR, North Dyke and in Work Area A in 2020 (Photo 4-3; Appendix 3, Map 8-28). The plants were immediately removed by ECOSTEM field staff.

Common tansy was found growing at five sites in 2021. This included two sites in the ditch along the SAR, two in Borrow Area B-2 and one in Borrow Area B-3. Single plants were found at each site, except for one of the locations on the SAR, where several young plants were growing. The plant found in Borrow Area B-3 were close to (within approximately 10m) a site where a single plant was found in 2020. No other plants were found in 2021 growing at the sites where plants were removed in 2020. All plants were immediately removed by ECOSTEM staff.

Photo 4-3: Common tansy growing beside the South Access Road on August 30, 2021

Ox-eye Daisy

Ox-eye daisy (Photo 4-4) is an introduced ornamental perennial. It can quickly spread by both seed and rhizomes (ISCM 2022).

Single ox-eye daisy plants were found growing in Work Area B in 2017, in Borrow Area G-1 and the Sigfusson Northern/Voltage Camp in 2018, and in Borrow Area Q-9 in 2019. All plants were removed by ECOSTEM field staff. None were found in 2020.

One individual of ox-eye daisy was recorded at one location in Borrow Area B-2 in 2021 (Appendix 3, Map 8-27). Ox-eye daisy had not previously been recorded at this site. Sites that had ox-eye daisy plants that were removed were revisited in 2021, and no plants were found growing at those sites.

Photo 4-4: Ox-eye daisy growing in Borrow Area Q-9 on August 26, 2019

4.1.2 LEVEL 2 NON-NATIVE SPECIES

Five Level 2 non-native species were recorded in 2021. Of these, the ISCM "other" species included Canada thistle, field sow-thistle and tufted vetch. The first two of the preceding species are also Tier 3 species in the provincial *Noxious Weeds Act*. White *et al.* (1993) classify white sweet clover, yellow sweet clover and Canada thistle as moderately invasive in Canada. Canada thistle is also classified as a weed seed plant in the federal Weed Seeds Order (Table 2-6).

Manual removal has not been successful for Level 2 species in most cases. The following describes the situations for individual species.

Canada Thistle

Canada thistle is a perennial that has the capacity to proliferate from roots left in the ground after manual removal, and infestations can develop quickly (Saskatchewan Ministry of Agriculture 2008; Manitoba Agriculture 2019).

Canada thistle is the only Level 2 species that, in addition to meeting the criteria for inclusion in this level, is also a provincial Tier 3 noxious weed, a moderate invasive species in Canada, and a federal weed seed (Section 2.6.2).

Canada thistle was found at various sites around the Project footprint each year from 2015 to 2021 (Appendix 3, Map 8-29). The sites were located at the Start-up Camp, Borrow Area KM-4, beside the North Dyke and the NAR, in Borrow Area G-1 at KM 15, and in Borrow Area B-2.

For small patches or individual plants, it was recommended that the plants be removed where feasible (Hutchinson 1992; Alberta Invasive Plant Council 2014). The preferred disposal method was the same as the one described above for scentless chamomile, with particular attention to removing the main root to the extent feasible. Some sites were included in the areas treated with herbicides (see Section 4.2).

ECOSTEM field staff removed plants at most of the sites at the time they were found. Where larger patches were encountered, they were included in the areas targeted for herbicide application. The exception was one patch at the eastern corner of Borrow Area KM-4. These plants were removed in 2017, again in 2018 after re-establishing, and re-established again in 2019. As plants have reappeared in Borrow Area KM-4 after more than one removal, it is apparent that root systems have become established. This patch was not targeted for herbicide because it was interspersed with jack pine seedlings planted in 2016 as part of Project revegetation efforts.

The overall management strategy for Canada thistle was modified after 2018 because plants reappeared in the same site after several removals and manual removal can amplify vegetative spread. Canada thistle plants will no longer be removed at sites where the plants are mature or where they have reappeared after one removal of a plant. While manual removal will continue to include roots, there will be increased efforts to remove all of them at sites with one to a few plants.

Surveys in 2021 found two individuals of Canada thistle at the Start-up Camp, growing in a hole left from a previous removal. These individuals were removed (Photo 4-5). The patch in Borrow Area KM-4 was still present, but did not appear to have expanded in size since 2020. Canada thistle was also found at three sites in Borrow Area B-2 in 2021, near the site where plants were found in 2020. The plants in Borrow Area B-2 were not removed. Those sites will be targeted for treatment with herbicide in 2022 and re-visited during the late-summer surveys.

Photo 4-5: Canada thistle being removed by ECOSTEM staff from the Start-up Camp, August 22, 2021

Field Sow-Thistle

Field sow-thistle is a perennial that can spread both through seeds as well as through an extensive root system. It is capable of reducing the number of plant species in communities (ANHP 2011e; Manitoba Agriculture 2019).

The best form of control for field sow-thistle is removing or killing the plants before the extensive root system develops (Manitoba Agriculture 2019). Like Canada thistle, field sow-thistle infestations can develop quickly from roots left in the ground after manual removal. The overall management strategy for field sow-thistle is the same as described for Canada thistle.

Field sow-thistle was already present (sparsely but fairly widespread) in the Project footprint, and in disturbed areas throughout the Keeyask region, prior to the Project. By 2015, field sow-thistle was becoming well established in Project footprint components that were previously utilized by the KIP, particularly at the Start-up Camp, and in Borrow Area G-1 at KM-15. To limit further spread, ECOSTEM field staff implemented the rapid manual removal protocol at sites where only a small number of plants were present during the 2017 through 2021 surveys.

Of the sites containing field sow-thistle in 2019, portions of Borrow Area G-1 at KM-15, the Start-up Camp, the Main Camp, and the North Dyke were treated with herbicide in late July 2020. One area was also targeted for mowing. Several sites containing field sow-thistle in 2020 were selected for herbicide and/or mowing treatment in 2021 (see Section 4.2). The sites were located

in the start-up and main camp areas, portions of Borrow Area G-1 at KM-15 and KM-17, the North Dyke and several locations along the NAR and SAR.

Results from the 2021 late summer survey indicated that field sow-thistle cover persisted in all sites where it was already established (Appendix 3, Map 8-16 to Map 8-20). Total cover remained similar between 2020 and 2021, but increased in some components while decreasing in others. Total cover increased in Borrow Areas B-2, G-1 at KM 15 and KM-1, along the NAR, and EMPA D17. Total cover decreased in EMPAs D12 and D16, along the North Dyke, and in the Start-up Camp.

Tufted Vetch

Tufted vetch is a trailing perennial that can spread by seed as well as rhizomes, and can overgrow surrounding vegetation and alter soil chemistry (ANHP 2011a; ISCM 2022).

Tufted vetch plants were most widespread along the SAR east of the Butnau Marina in 2021 (Appendix 3, Map 8-30). Previous surveys indicated that tufted vetch was already well established in these sites and in nearby areas, particularly along the old Butnau Road and in the Town of Gillam. Plants were also present at two new sites in Borrow Area B-8 and the east portion of Borrow Area B-6, adjacent to the SAR and east of the marina (the portions of Borrow Area B-6 and the SAR ditch surveys closest to Butnau marina were not surveyed in 2021).

Some of the patches found in 2020 were targeted for herbicide and/or mowing treatment in 2021 (Section 4.2.1). These included sites in the northeast portion of the Main Camp, the east side of Borrow Area G-1 at KM 15 and the Cemetery.

Tufted vetch plants were found in three new areas west of the Butnau Marina during the 2021 surveys (Appendix 3, Map 8-30). These included scattered individuals in Borrow Area B-3, in the ditch of the SAR, near the south shore of the Nelson River and at one location along the South Dyke. Tufted vetch continued to grow in or around most of the sites where it had previously occurred.

Rapid manual removal was not employed (and not recommended) at the remaining tufted vetch sites along the SAR and in adjacent borrow areas east of the Butnau Marina. In these cases, the plants were well established at these sites and in areas adjacent to or near the Project footprint.

White and Yellow Sweet Clover

White and yellow sweet clover are biennial plants that spread prolifically by seed, and rapidly invade open areas, shading out other vegetation (ANHP 2011f). White and yellow sweet clover are commonly found in disturbed areas throughout the Province, particularly along roadsides, making it difficult to prevent them from spreading.

Yellow sweet clover plants have expanded in both extent and cover annually since construction monitoring began in 2014 (Table 3-3). This was generally also the case for white sweet clover, except between August 2018 and August 2019 when total cover decreased by approximately 32%. Total cover increased after 2019 and in 2021 cover had increased back to 2018 levels. The

year-to-year changes were not because the areas surveyed were somewhat different across the years (the areas surveyed in 2021 but not 2019 or 2020 had very low or no sweet clover cover).

Sweet clover (mainly white) was found at more sites along the NAR and total cover there increased by 25 times in 2021 (this increase is likely an overestimate because large patches were recorded between road stops in 2021, but not in 2020). Total sweet clover cover increased by nearly eleven times between 2020 and 2021 in Borrow Area B-3 (Map 8-12). Sweet clover cover also increased by large amounts in Work Area B and the Start-up Camp. Sweet clover was absent from Work Area B around the Hydro and BBE offices in 2019 following herbicide treatments, but had re-established in 2020 and increased again in 2021, but not to the same level that was present in 2018.

Sweet clover was recorded in both EMPA D12(1)-E and D23(2)-E for the first time in 2021. Both areas had been sampled in 2020 and sweet clover had not been recorded. Sweet clover was also recorded at six new sites in Borrow Area N-21, which was not sampled in 2020.

The rapid manual removal protocol was not applied for white and yellow sweet clover. White sweet clover was already fairly widespread in the Project footprint, and in disturbed areas throughout the Keeyask region, prior to the Project. This species had expanded considerably in extent and cover from 2014 to 2021, with a slight dip between 2018 and 2020. As of August 2021, the two species were collectively the second most abundant non-native species.

4.1.3 LEVEL 3 NON-NATIVE SPECIES

Six of the non-native species recorded in the Project footprint were Level 3 invasive concern. All are considered to be noxious weeds, weed seed species and/or minor invasives in Canada (Table 2-6). Level 3 species recorded in 2021 included wormwood (*Artemisia absinthium*), lamb's-quarters, narrow-leaved hawks-beard, common dandelion, curled dock (*Rumex crispus*), and alfalfa (*Medicago sativa*).

Lamb's-quarters

Lamb's-quarters is an annual that spreads by seeds. Its seeds can remain viable in the soil for up to 40 years (ANHP 2011c; Manitoba Agriculture 2019).

Lamb's-quarters has been the most abundant of the Level 3 species in every year of Project monitoring except in 2020 (Table 3-4). Total lamb's-quarters cover in 2021 was the highest to date, and made up 33% of all non-native plant cover. Results from the 2016 surveys suggested that lamb's-quarters cover was possibly beginning to decline (ECOSTEM 2017). However, by late summer 2017 lamb's-quarters extent and cover had increased substantially to its highest level since construction began (ECOSTEM 2018a). Plant cover continued to increase to late summer 2019 at a fairly consistent rate until decreasing sharply in 2020 and then recovering in 2021.

Lamb's-quarters continued to expand into new portions of the Project footprint in 2021. Large increases in lamb's-quarters cover occurred in most of the areas where it had previously been

recorded (Map 8-1 to Map 8-5). These Project components included EMPAs D16, D27 and D28, as well as some Borrow Areas. Decreases in lamb's-quarters cover occurred in some of the older Project components, such as the Start-up Camp, Borrow Area KM4 and at locations along the NAR.

Narrow-leaved Hawks-beard

Narrow-leaved hawks-beard is an annual that reproduces by seed, and can rapidly colonize areas delaying the establishment of other plants (ANHP 2011d; Manitoba Agriculture 2019).

In 2020, narrow-leaved hawks-beard was the second-most abundant non-native species in the Project footprint. By late summer 2021, narrow-leaved hawks-beard was the fourth-most abundant non-native species, making up 13% of the total non-native plant cover, with the total cover declining slightly from 2020. Part of the reason for the decrease may be due to alterations to areas where narrow-leaved hawks-beard had been widespread in 2020 (portions of EMPA D12 and Work Area B). The plant has generally continued to spread in Project components where it was previously recorded. The largest increases in cover were in areas such as Work Area X and EMPA D16 (Appendix 3, Map 8-21 to Map 8-25).

Common Dandelion

Common dandelion is a perennial that spreads prolifically by seed, as well as by shoots from root crowns (ANHP 2011b; Manitoba Agriculture 2019). Common dandelion is an early colonizer, and can also establish in existing vegetation and compete for resources and pollinators (ANHP 2011b).

By late summer 2021, common dandelion was among the three most abundant non-native species in the Project footprint (Map 8-6 to Map 8-10). Common dandelion cover has rapidly expanded since 2017, nearly doubling by late summer 2018. By 2019, total common dandelion cover had decreased by about 34%, but it increased again through 2020 and 2021 to its highest level to date. Increases occurred in all Project components. Cover remained very low or absent in the surveyed portions of the South Dyke and its attached EMPAs.

All Other Level 3 Species

Total cover for the remaining species at Level 3 invasive concern was relatively low in all survey years.

4.1.4 LEVEL 4 NON-NATIVE SPECIES

The remaining 13 non-native species recorded in the Project footprint were Level 4, or the lowest level of invasive concern, for the Project footprint.

While the Level 4 non-native species were fairly common in disturbed areas surrounding the Project, few of these species appeared to be spreading rapidly. Total cover of spotted lady's thumb, which was first recorded in in 2019, increased by three times in 2021; but wormseed

mustard (*Erysimum cheiranthoides*) and alsike clover (*Trifolium hybridum*) decreased in overall cover. The Level 4 non-native species with the highest cover overall were spotted lady's-thumb, common plantain (*Plantago major*) and smooth catchfly (*Silene csereii*), all of which increased in cover between 2020 and 2021. These three species each made up less than 3% of the total non-native plant cover. These species will continue to be monitored.

4.2 HERBICIDE TREATMENTS AND MOWING AT KEY SITES

4.2.1 TREATMENTS

Herbicide application at key sites, with follow-up mowing where required, was the second management strategy employed to date to control invasive plants. The key sites were selected based on a combination of which invasive species were present, where these species were most prolific, accessibility, and which sites had the highest potential for providing seed that could be spread to other Project areas (i.e., due to vehicles or footwear picking up seeds and carrying them elsewhere).

Herbicide treatment programs were carried out in 2016, 2018, 2019 and 2020 in selected areas. In 2016 and 2018, the herbicide applicators were provided with generalized areas that contained the plants targeted for herbicide control. For the subsequent years, the herbicide applicators were provided with more specific locations that were patches of plants that included the target species, based on the previous year's mapping. The species targeted for treatment included common burdock (*Arctium minus*), Canada thistle, ox-eye daisy, field sow-thistle, common tansy, scentless chamomile and tufted vetch. In 2020, Manitoba Hydro staff familiar with the target species visited the recommended treatment sites and marked the patches with flagging tape and stakes. Follow-up mowing treatments were also carried out in early October 2019, on September 10, 2020 at sites that were missed, or where herbicide effectiveness was low.

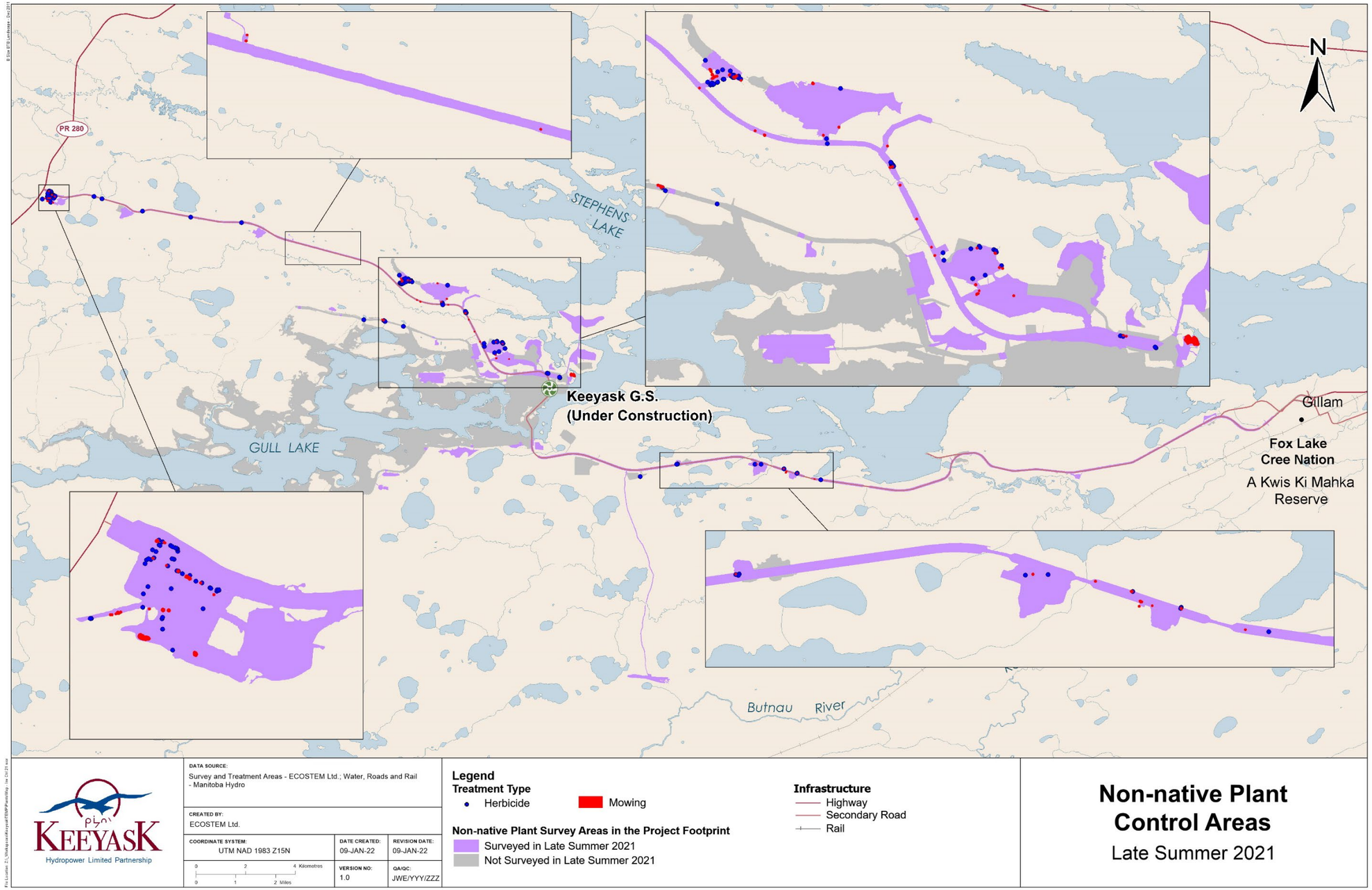
Herbicide treatment continued in 2021 in the areas shown in Map 4-1. Table 4-1 summarizes the dates, locations and herbicide mixture used for the treatments. ECOSTEM staff visited the recommended treatment sites as scheduled to mark the patches; however, the herbicide application had already occurred due to the contractor having to visit the site earlier than originally planned. Subsequently, the recommended patches were the patches marked to identify sites where follow-up mowing was required.

The downstream boat launch area was mowed during the last week of July 2021 (as the area was too close to water for herbicide application). Follow-up mowing treatments at most recommended sites were carried out during the week of August 16, 2021. Some touch-up mowing was also carried out at the downstream boat launch and Main Camp sites on September 10, 2021.

Table 4-1: Herbicide treatments carried out at key sites during Project construction to date

Treatment Dates	Areas Treated[1]	Herbicide Mixture[2]
August 25, 2016	Start-up Camp, Borrow Area KM-1, Borrow Area G-1 (KM 15), Work Area B	Vantage (5.0L)/ Milestone (0.5L)/ Esplanade (0.375L). Application rate = 700L/ha
Last week of July, 2018	Start-up Camp, Main Camp, Work Area B	Clearview (230g/ha)/ Esplanade (0.3L/ha)/ Roundup HC (5L/ha)
	Sigfusson Northern/Voltage Camp (SAR)	2,4-D Ester 700 (2L/ha)/ Blue Dye WSP40 (1 package/ha)/ Clearview (230g/ha)/ Esplanade (0.375L/ha)/ Roundup HC (5L/ha)
August 2 - 5, 2019	Start-up Camp, NAR gate staging area, Borrow Area G-1 (KM 15), Main Camp, Work Area B, Sigfusson Northern/Voltage Camp (SAR, decommissioned)	Navious (0.167g)/ VP480 (4L) treating 1.75ha; GalonXRT (8L)/ VP480 (8L) treating 4.5ha
July 23 - 24, 2020	Start-up Camp and NAR gate staging area, North Dyke, NAR, Borrow Area G-1 (KM 15), Main Camp, Work Area B, Borrow Area B-2, Borrow Area B-3	Navious (167g/ha)/ VP480 (2.5 L/ha)/ Arsenal (3 L/ha)/ Gateway (2.5 L/ha)
July 9, 2021	Start-up Camp and NAR gate staging area, North Dyke, NAR, Borrow Area G-1 (KM 15), Main Camp, Work Area B, Borrow Areas B-2, B-3, Sigfusson Northern/Voltage Camp (SAR, decommissioned)	Garlon 4 (6.0 L), Roundup Weatherpro (2.5 L), Milestone (0.5 L), Onsite (1 L). Application rate = 1000L/ha

Notes: [1] Herbicide was applied to target patches within the indicated areas. [2] "L/ha" = Litres per hectare; "g" = Grams; "g/ha" = Grams per hectare.



Map 4-1: Key areas selected for invasive plant herbicide control and mowing in 2021

4.2.2 EFFICACY OF TREATMENTS

The overall effectiveness of the herbicide treatments is uncertain at this stage. Despite promising initial results, the 2016 treatment was later found to be ineffective. This was likely due to the late timing of the application. While initial results were good for the 2018 treatment, surveys in 2019 found that plant cover for the target species had recovered or exceeded the pre-treatment cover. ECOSTEM (2019b) provides details for the 2016 and 2018 herbicide treatment results.

The herbicide treatment in 2019 reduced non-native plant cover by approximately 42% overall within the treated areas, but heavy rainfall shortly after the treatments may have reduced their efficacy (see ECOSTEM 2020 for details).

Herbicide treatment in 2020 was successful in reducing non-native plant cover by approximately 72% overall. This was thought to be an underestimate as several of the areas that were treated had no visible non-native foliage left at the time of the survey (see ECOSTEM 2021b for details).

For the 2021 treated sites, total non-native plant cover over all of the treated sites prior to treatment was approximately 175 m^2 in July, 2021 (Table 4-2; based on the total cover of live and deceased non-native plants). The herbicide treatment was most effective in the Start-up Camp, but this may only be due to the better accuracy of the herbicide application relative to the target areas in this area compared to other areas (Photo 4-6). As noted, herbicide was applied before a botanist could mark the target locations in the field, and many of the target areas were missed, or only partially treated (Photo 4-7). Another factor that may have reduced herbicide effectiveness was heavy rains that site staff noted later on the day of the herbicide application. Of the 76 locations marked for targeted treatment, 15 were at least partially treated.

Photo 4-6: Herbicide treatment within area marked for treatment in the Start-up Camp

Photo 4-7: Site with partial herbicide-treatment near the NAR gate

A total of four non-native species were identified within the sites that were actually treated with herbicide. White and yellow sweet clover was the most abundant species in the treatment areas, making up 46% of the total non-native plant cover, followed by field sow-thistle (39%) and common dandelion (13%). Species at Level 2 invasive concern included field sow-thistle and sweet clover. No species at Level 1 invasive concern were identified within the treated areas.

Combining all treated patches, individual species plant mortality ranged from 10% to 100%, with an overall average of 54% mortality. As indicated above, this number is likely an underestimate because some treated patches had no detectable non-native plant cover and several of the target areas were only partially treated. Living foliage among the treated patches was generally in poor condition regardless of the mortality rate for the entire patch. Based on patches where plants could be identified, the species with the highest mortality were white and yellow sweet clover (93%) and common dandelion (52%). Field sow-thistle was the target species confirmed to be present in the treated areas. Mortality for field sow-thistle was 28% overall.

When considering all identifiable non-native plant cover in the areas receiving herbicides, including foliage that survived treatment, overall live non-native plant cover in the treated sites was reduced by 63%, to 65 m^2 (Table 4-2). The largest overall cover reductions were in the treated patches of the Start-up Camp, where 84% of the non-native plant cover was killed (Table 4-3).

Due to the herbicide treatment occurring before target patches could be marked, all of the marked patches were designated for follow-up mowing in mid-August, just prior to the late summer survey.

During the late summer survey, it was noted that mowing was carried out in nearly all of the marked patches. On average, target plants were mowed down to a height of 5 to 10 cm. However, there was not yet evidence of mortality of the target species. The remaining portions of the basal leaves appeared to still be alive, although there was not yet signs of regrowth at the time of the surveys. The effectiveness of the mowing will be evaluated from the 2022 monitoring data given that the mowing happened late in the growing season.

Table 4-2: Non-native species cover in herbicide-treated sites[1] before and after treatment in 2021

Common Name	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change[2]
Common Dandelion	23	11	-52
Field Sow-thistle	68	49	-28
Narrow-leaved Hawks-beard	0	0	-100
White and Yellow Sweet Clover	85	6	-93
All non-native species	*175*	*65*	*-63*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".[1] Only sites with identifiable non-native plants are included. [2] A negative sign means that cover decreased.

Table 4-3: Non-native species cover in herbicide-treated sites[1] before and after treatment in 2021, by treatment area

Treatment Area[2]	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change[3]
Start-up Camp	94	15	-84
Borrow Area G-1	21	19	-10
Main Camp	31	16	-50
NAR	25	14	-47
North Dyke	0	0	-100
Helicopter pad	1	0	-100
EMPA D16	2	2	0
All treated patches	*175*	*65*	*-63*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".[1] Only sites with identifiable non-native plants are included. [2] An area may include multiple treated sites. [3] A negative sign means that cover decreased.

5.0 DISCUSSION

5.1 CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE DURING CONSTRUCTION

5.1.1 RECENT CHANGES

Total non-native plant cover as a percentage of the total area surveyed was only 1.4% in 2021. This percentage was quite low after seven years of construction, especially given that the total cover for the entire Project footprint was likely lower than for the area surveyed because the areas not surveyed generally had low non-native plant cover (see Section 2.3).

Even though total non-native plant cover in 2021 was still quite low, the existing patches of non-native plants could still be a concern because these species can quickly become broad infestations if not managed. Reinforcing this concern was the fact that non-native plants were present in almost 21% of the surveyed area (note that this is an overestimate of non-native plant distribution within the entire Project footprint for the reasons cited in the previous paragraph).

The degree of concern posed by the existing patches of plants is partly determined by the magnitude of recent increases in abundance. Year-to-year increases in total non-native plant cover as a percentage of area surveyed have ranged widely. From 2018 to 2021, year-to-year increases were approximately 97%, -2%, 16%, and 42%, respectively (as described in Section 2.3, there is a slight bias in these percentages, but that bias does affect the interpretation of the results).

The interpretation of these year-to-year increases is not straightforward due to changes in the nature, levels and locations of construction activity.

5.1.2 GENERALIZED PATHWAYS OF NON-NATIVE PLANT COVER

Overview

Changes in the nature, levels and locations of construction activity can have major impacts on non-native plant extent and cover. To illustrate the influence of these factors, generalized pathways of non-native plant cover progression during construction and early operation (i.e., cover pathways) were developed for the three largest major Project footprint components. These cover pathways were developed from analysis of the seven years of Project monitoring data and the results from eight years of Wuskwatim Generation Project monitoring (ECOSTEM and WRCS 2021).

The three major Project footprint components were defined based on similar types and temporal patterns of construction activity, and include: (1) borrow areas and EMPAs; (2) camp and work areas; and, (3) access roads and dykes. The reservoir area was omitted as it was inundated in 2020, which eliminated any existing non-native plants.

Figure 5-1 provides the generalized pathways of non-native plant cover progression for each of the three major components. This figure incorporates the existing status of several Project features (i.e., a specific borrow area, EMPA, camp area, work area, access road or dyke; e.g., Borrow Area G-1) to provide examples of states in these temporal pathways. As the figure does not capture all of the events that occur in the Project features, no specific Project feature will have a pathway whose shape is identical to the generalized form.

The generalized cover pathways illustrate that the amount of non-native plant cover depends on the type and level of activity as a function of time since the initial Project impacts. They also illustrate the effects of shifting the nature, levels and spatial distribution of construction activity over time. For example, non-native plant cover may increase for a period of years in a dormant portion of a Project feature, but then the cover can be removed if construction activity (e.g., excavation) resumes in that area, even if briefly. Examples of other factors that can create precipitous decreases or large ascents in the generalized pathway are herbicide treatments or rehabilitation efforts (e.g., slope regrading, site preparation, seeding/tree planting).

The following presents the generalized pathways of non-native plant cover progression for each of the three major Project footprint components.

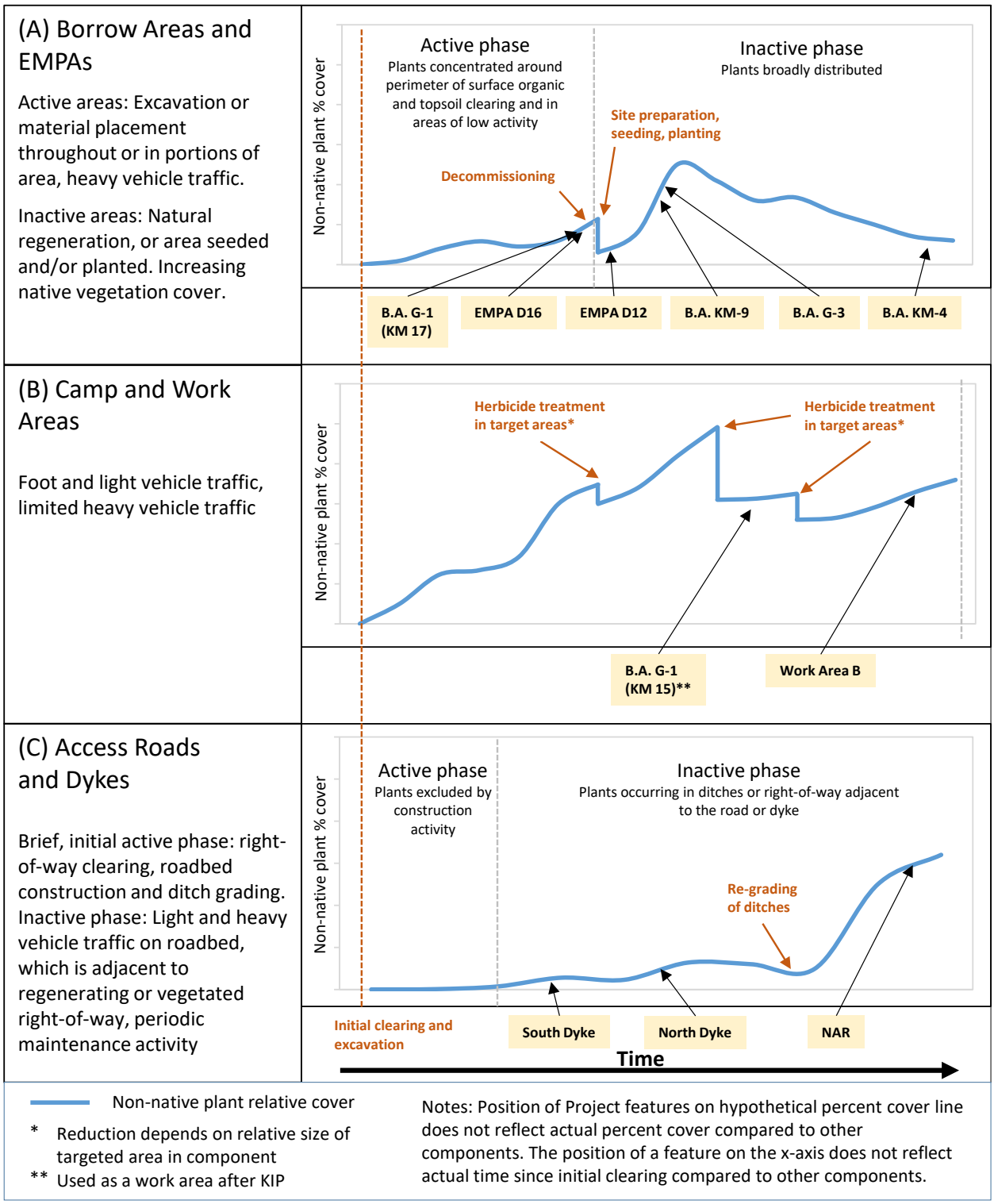


Figure 5-1: Generalized patterns of non-native plant cover progression for three major Project footprint components, factors that influence the patterns and example Project features

Borrow Areas and EMPAs

The stages in the typical pattern of construction activity in borrow areas and EMPAs are:

1. Vegetation clearing within the portion of the Project feature where excavation/material placement will likely occur based on construction plans at that time;
2. Stripping the surface organic layer and topsoil over the area where excavation/material placement will occur over the near-term;
3. Excavation or material placement starting in one location within the stripped area, and then expanding from it;
4. Expansion of the stripped area and excavation/material placement if construction plans are later revised;
5. Decommissioning the project feature; and,
6. Habitat rehabilitation.

Examples of exceptions to this generalization are: the area is dormant for one or more years during stage 3 or 4; or, the area is re-purposed for another use (e.g., Borrow Area G-1 at KM 15 became a work area).

As of late summer 2021, all of the borrow areas and EMPAs except for Borrow Areas S-2a and G1 (borrow sources for future wetland construction), Borrow area B-6 (materials were being placed from decommissioning of the SAR security gate area), EMPA D12-1 (ongoing decommissioning) and EMPA D23-2 (not yet decommissioned as a portion will remain for the future wetland area parking lot) had reached the end of their active phase, and/or had been decommissioned and were at varying stages of rehabilitation. At least one area (Borrow Area G-1 at KM 17) was re-purposed as a staging area.

The non-native plant cover pathway for borrow areas/EMPAs (Figure 5-1 (A)) has extended active and inactive phases during construction. During the active phase of the pathway, continual excavation/material placement prevents the cover for any non-native plants that might establish from expanding. Meanwhile, in the portion of the borrow area/EMPA where vegetation clearing was the only impact, the intact surface organic layer and ground vegetation virtually prevents non-native plant colonization. Viewing the entire Project feature, non-native plant cover tends to concentrate around the perimeter of the excavated portion of active areas, or in other locations where construction activity is low for sufficient time periods for plants to establish.

The active phase ends once the Project feature is no longer needed and is decommissioned to facilitate habitat rehabilitation. Habitat rehabilitation often creates a precipitous drop in total non-native plant cover, which is followed by a relatively large increase over several years, and then by a gradual decline over many years. The inferred causes for the shape of this pathway after decommissioning is that site preparation immediately removes most plant cover while simultaneously introducing plant seeds that take time to germinate and become cover. Although the plant seeds quickly become expanding plant cover in localized areas, successful rehabilitation efforts and natural regeneration eventually create sufficient competition to maintain or reduce overall non-native plant cover.

The borrow areas utilized by the KIP (Borrow Areas KM-4 and KM-9) illustrate virtually all of the borrow area/EMPA cover pathway as these features have been minimally impacted by the Project. KM-4 is positioned near the temporal end of the generalized cover pathway because it has remained virtually inactive throughout Project construction (with the only exceptions being a small area at the entrance where a temporary sweat lodge was constructed, and the placement of woody debris piles for amphibian habitat replacement). KM-9 is closer to the beginning of the inactive phase due to the introduction of additional Project impacts that pushed it backwards in time along the generalized pathway compared with KM-4 (see below).

Non-native plant monitoring foot survey data was first collected for Borrow Areas KM-4 and KM-9 in 2013 (total cover was very low for this year), and fully mapped cover data was available from 2014. Both borrow areas were inactive during the first year of Project construction monitoring in 2015 (except for small portions). Between 2014 and 2015, total cover in both areas increased. In 2016, KM-4 was entirely rehabilitated, and most of KM-9 was rehabilitated (with the exception of an area that was used to store explosives material). Following the 2016 rehabilitation efforts there was a sharp rise in non-native plant cover in 2017, presumably because non-native plant seeds were spread into the area within the materials used and by vehicle and foot traffic. However, from 2018 to 2020, total non-native plant cover declined annually in both borrow areas. These cover reductions coincided with tree and other plant regeneration having become advanced by 2020. The trend of decreasing plant cover continued for Borrow Area KM-4 in 2021. During the same period, there had been no additional construction activity in this borrow area.

The cover pathway for Borrow Area KM-9 deviated from the generalized borrow area/EMPA pathway in 2020. Between the 2020 and 2021 surveys, the area used to store explosives material was decommissioned and rehabilitated (site preparation and tree planting). This activity pushed this portion of KM-9 backwards on the generalized pathway. Over the same period, there was a relatively large increase in non-native plant cover from 2020 to 2021 (0.8% to 2.0%), with the presumed cause being a combination of the cessation of construction activity, and rehabilitation activity spreading non-native plant seeds into the area.

Rehabilitation in KM-9 illustrates how an additional Project impact can push a Project feature backwards in time on the cover pathway. KM-9 and KM-4 were at a similar position along the pathway until the rehabilitation occurred in KM-9. If KM-9 follows the generalized cover pathway in the future, there will be a return to a downward trend due to a combination of reduced dispersal from less foot and vehicle traffic and increasing competition from regenerating native plants.

For the remaining borrow/EMPA areas, relatively large increases in non-native plant cover were observed where rehabilitation activities were carried out in 2019 and 2020. These included Borrow Area G-3, several EMPAs along the South Dyke, and Borrow Are KM-9 (discussed above). As an example, in Borrow Area G-3 total non-native plant cover increased from 24 to 555 m^2 between 2020 and 2021, and much of the new non-native plant cover was concentrated in areas that were planted with trees. Spreading of stockpiled material and tree planting activity likely spread non-native plant seeds throughout these areas. More recent rehabilitation activity reduced non-native plant cover in other areas, which was observed in EMPA D12. This component had remained inactive since 2017, and non-native plant cover increased annually until the EMPA was

decommissioned and re-graded between the 2020 and 2021 surveys, removing almost all the non-native plant cover. These areas illustrate the sharp decline, followed by a steep rise in non-native plant cover show in Figure 5-1 (A).

Camp and Work Areas

The stages in the typical pattern of construction activity in camp and work areas are:

1. Vegetation clearing within the portion of the Project feature that will likely be used based on construction plans at that time;
2. Stripping the surface organic layer and topsoil over the area planned for use as a camp or work area (which may be less than the cleared vegetation area);
3. Levelling and grading of the area; and,
4. Constructing or moving in structures, as needed;
5. Decommissioning of selected Project features; and,
6. Habitat rehabilitation in decommissioned Project features.

As of late summer 2021, construction activity had been decreasing in many of the camp/work areas because the Project construction was nearing completion. A portion of these camp or work areas will remain as permanent infrastructure or be re-purposed for operation, while most will be decommissioned and rehabilitated.

The cover pathway for camp/work areas (Figure 5-1 (B)) has a relatively long active phase and a short inactive phase. The active phase lasts throughout construction, and into early operation for many Project features (which is why the inactive phase not included in the figure). This cover pathway is more variable than those for the other two major Project components.

There is substantial continuous activity in camp and work areas throughout most if not all of the active phase. These areas are characterized by high amounts of foot and vehicle traffic, including some heavy equipment. As higher traffic has a greater potential to spread non-native plant seed, patches of non-native plants often develop in these Project features. Consequently, management control (e.g., herbicide treatment, mowing) often occurs in these areas.

Total non-native plant cover in all camp and work areas has steadily risen throughout Project construction. Periodic decreases within specific Project features were typically due to control efforts. For example, decreases in overall non-native plant cover were observed in Work Area B following herbicide treatments in 2016 and 2019. In Borrow Area G-1 at KM 15, a substantial cover decrease was observed following the 2019 herbicide treatment. However, non-native plant cover began increasing in these areas in the years following the treatments. Herbicide treatments do not necessarily result in an overall reduction in total non-native plant cover because the treatments are targeted to specific patches of plants (see Section 4.2). If only the treated areas were considered, non-native plant cover would remain low for a longer period of time than illustrated in the cover pathway.

The camp/work area cover pathway does not include the post-construction or decommissioning stage. Once camp and work areas are decommissioned, the generalized pathway is expected to resemble the inactive phase of Figure 5-1 (A). Work Area X is an example demonstrating this.

Non-native plant cover in this area increased at a steady rate between 2016 and 2020, then there was a sharp rise in cover (250%) by 2021, after the work area had been decommissioned.

Access Roads and Dykes

The stages in the typical pattern of construction activity in access roads and dykes are:

1. Clearing vegetation in the right-of-way;
2. Stripping and stockpiling the surface organic layer and topsoil over the area where required;
3. Construction of the road or dyke and grading of the side slopes for drainage;
4. Revegetation (seeding) where needed along portions of the rights-of-way; and,
5. Periodic maintenance and re-grading of side slopes in localized areas when required.

These areas are characterized by light and heavy vehicle traffic on the roadbed during construction. Traffic volumes are high on the access roads.

As of late summer 2021, construction activity except for traffic had generally ceased for the access roads and dykes. The exception was some maintenance along portions of the SAR.

The non-native plant cover pathway for access roads/dykes (Figure 5-1 (C)) excludes roadbed areas because plants cannot establish on them. This cover pathway typically has a short active phase during construction, which reflects the relatively short time required for clearing, roadbed construction and right-of-way grading. The actual length of the relatively long inactive phases can be quite variable since some features can be decommissioned well before construction completion while others will become permanent features.

Non-native plants typically establish on mineral substrates within the roadbed shoulders and side slopes. The remaining portion of the cleared right-of-way has an intact surface organic layer, which usually excludes non-native plant establishment (ECOSTEM 2017, 2018b). the relatively high traffic volumes have greater potential to spread non-native plant seed, including along the entire extent of the linear feature.

The NAR and SAR illustrate virtually all of the access road/dyke pathway. The NAR was already completed when Project construction started (i.e. NAR was constructed during the KIP). The SAR was completed in 2017.

For the active phase, non-native plant cover was virtually absent in 2013 (the first year when data were collected under the KIP). Total non-native plant cover generally increased steadily after their initial construction activity ceased (i.e., after end of the initial active phase), particularly in portions of the right-of-way where there was less competition from native vegetation.

During the inactive phase, non-native plant cover increased more rapidly along the SAR than the NAR, particularly east of the Butnau Marina. This was attributed to regular vehicle traffic from and to the Town of Gillam, and close proximity to the decommissioned Butnau Road, where non-native plants were well-established prior to the Project. Until native vegetation expands, it is expected that non-native plant cover will continue to increase and expand westward along the SAR side slopes.

For the NAR, extensive re-grading along portions of the side slopes in 2019 removed non-native plant cover. This was followed by a large increase in non-native plant cover along the road in 2021. This is represented by the slight decline, and sharp rise in non-native plant cover late in the time sequence of the access road/dyke cover pathway. It is possible that this increase in cover was caused by equipment spreading non-native seed to new areas.

The active phases of the North and South Dykes were completed more recently. The length of the active phase for the dykes, particularly the South Dyke, was somewhat longer than what is illustrated in Figure 5-1 (C). The rights-of-way for both dykes were initially cleared of vegetation, and there was some initial excavation and construction, followed by a period of little to no construction activity before the dykes were completed. During the period of low activity, non-native plant cover remained very low or absent in the cleared areas.

The North Dyke, which was completed earlier than the South Dyke, appears near the middle of the pathway. Total non-native cover increased along the North Dyke starting in 2017, then peaked in 2019, declined in 2020, then rose to its highest level in 2021. Non-native plant cover remained steadily low along the South Dyke, then increased by over 300% between 2020 and 2021. This Project feature had experienced heavy construction activity in recent years, which slowed or ended prior to the 2020 growing season. Because this is a more recently completed footprint component, and overall cover still remains low, it is positioned toward the left of the pathway in Figure 5-1 (C).

The Ellis Esker winter access road is an exception to the access road/dyke cover pathway. This road consisted of a right-of-way where only the vegetation was cleared during the winter of 2018/2019, leaving most of the organic surface substrate intact. The road was only used in the winter. As of 2021, non-native plant cover in this component has remained virtually absent. This was attributed to the organic surface substrate being left undisturbed, and construction activity being limited to winter months.

Evidence of non-Project related use of the Ellis Esker access corridor was observed in 2020. While the number of non-native plant locations decreased along the corridor in 2021, it is possible that in the future, use by local recreational vehicles along the corridor may continue being a seed source. However, because of regenerating native vegetation, and an intact surface organic layer along most of the corridor's length, it is likely that non-native plant cover will remain relatively low.

5.1.3 NON-NATIVE PLANT COVER INCREASES

As a demonstration that most footprint components have reached the end of their active phases (just left of the sharp decline in Figure 5-1 (A)), total non-native plant cover in the newer footprint components used only by the Project doubled between 2020 and 2021 (Appendix 4, Table 8-8). This includes several components where construction activity has declined or stopped, but no decommissioning has yet been carried out. In addition, there were fewer areas in the Project footprint where rehabilitation activities such as site preparation could temporarily reduce non-native plant cover in areas where non-native plants had been growing, such as was seen 2020

(see ECOSTEM 2021b). The reduction of disturbance in many of the Project areas may have resulted in a surge of non-native plant growth in 2021.

For the areas used by KIP, the overall increase in non-native plant cover was predominantly due to the large increase in non-native plant cover in Borrow Area KM-9 (Appendix 4, Table 8-8). A smaller proportion of the increase is explained by a slight reduction of total sampled area, due to the elimination of a small area from Borrow Area KM-4 where regeneration is advanced and non-native plants are generally not present (note: this area was only ever cleared, and not excavated or disturbed in another way). However, even if this area were to be included, total percent non-native plant cover in KIP areas would only decline to 1.7%, which is still more than double the cover in 2020.

5.2 CHANGES IN SPECIES DISTRIBUTION AND ABUNDANCE

There were some notable changes in the relative abundances of some species. Lamb's-quarters nearly tripled in cover between 2020 and 2021, remaining the most abundant species in 2021, as it had been until 2020. White sweet clover and spotted Lady's-thumb also more than doubled in abundance in 2021.

Lamb's-quarters, the most abundant species, accounted for less than 20% of total non-native plant cover in 2020, but has accounted for no less than 33% of total cover in any other year, including 2021. The overall year-to-year variability of total non-native plant cover in the Project areas is largely driven by this species. Lamb's-quarters has been declining in cover in areas used for the KIP only (the oldest areas) since 2017 and was all but absent from these areas in 2021. In all other areas, Lamb's-quarters cover had increased up until 2019 and then began to decline in 2020. In 2021, the downward trend continued in areas affected by both the KIP and the Project (middle aged areas), where it had decreased by 94% between 2019 and 2021. In areas utilized by the Project only (newest areas), there was a slight decline (27%) in Lamb's-quarters cover in 2020, but a nearly 500% increase between 2020 and 2021.

The largest increases were observed in the EMPAs, particularly D27, D28 and D12, all of which had been recently decommissioned. Lamb's-quarters was also abundant in EMPA D23 (1)-E, which was surveyed for the first time in 2021 and Borrow Area N-21, which was not sampled in 2020. In the older areas of the Project (i.e., the areas utilized by the KIP only and by the KIP and the Project), lamb's-quarters expanded year to year before reaching a peak (2017 in the KIP only areas, and 2019 in areas used by the KIP and the Project), and then declining. It is possible that a similar pattern will occur in the recently decommissioned areas. Continued monitoring will help determine if this is the case.

In areas utilized by the KIP only, lamb's-quarters had nearly disappeared by late summer 2021. There was also a drastic decrease in lamb's-quarters cover in the areas utilized by both the KIP

and the Project, where it decreased by 82%. Total cover in these areas has been declining since peaking in 2019.

The increases in white sweet clover extent and cover were seen in all Project areas but were largest in areas used by both the KIP and the Project (more than doubled), particularly the Start-up Camp and the NAR. White sweet clover also doubled in cover in areas utilised by the KIP only, in both Borrow Areas KM-4 and KM-9. Increases in white sweet clover extent were seen in areas where there was also abundant regenerating native vegetation, and no apparent additional construction disturbance. This observation did not support the expectation that increased competition from native vegetation will generally reduce non-native plant cover. The exception to this is the NAR, where recent re-grading was completed by 2020. It is possible that large increases in sweet clover along the NAR were the result of seed being spread by the grading equipment.

Possible explanations for the increase in white sweet clover cover includes individual species tolerance to competition, detectability bias between survey years, and/or construction activity. Sweet clover is a biennial plant. It is possible that the extent and cover of the plants were underestimated in areas with denser regenerating vegetation in 2020. Plant development and/or different conditions (e.g. lower moisture availability for competing vegetation, and/or a coincidence with a particularly prolific period in the species life cycle) in 2021 may have resulted in the plants being more conspicuous, and were consequently given a higher cover estimate compared with the previous year that did not reflect an actual increase of that magnitude. Or it is possible that the periodic disturbance in these areas may have simply kept the biennial species under relative control prior to 2021, or conversely, may have spread seed. Annual variability may also have affected seed germination differently in 2021. Sweet clover is an abundant plant in the side slopes along Highway 280 (KLHP 2012b). Over time, it is expected that traffic along the NAR and SAR will continue to introduce sweet clover, as well as other non-native plants that occur along the highway. Monitoring in 2022 will help determine if these trends continue.

Spotted lady's thumb went from not being recorded in 2018 to being the seventh most abundant species recorded in 2021. The largest increases in that timeframe happened in areas utilised by the Project only, followed by areas utilized by the KIP and the Project. The increase in abundance in 2021 was primarily in EMPA D12(1)-E and Work Area X. As these areas are more recently utilised areas, and this species has not been recorded in the older areas utilized by the KIP (including low numbers or absence in the Start-up Camp, the NAR, the Main Camp and most of the Borrow Areas along the NAR), it is possible that this species was introduced by equipment used during the more recent construction activities. Another possibility is that the species was present, but not detected prior to 2019.

The total number of non-native plant species recorded during the 2021 surveys (25) was lower than in 2020. The three species not recorded in 2021 (canola, flixweed and black medick) had very low abundance in 2020. The Level 1 species that reappeared in 2021 (ox-eye daisy) was found at one new spot and was removed following non-native plant management methods.

In 2021, common tansy and scentless chamomile continued to be found in new locations. This is concerning because the species are of the highest level for invasive concern. Common tansy was

found at five new sites in 2021, while scentless chamomile was found at 10 new sites. All of these plants were removed, either by ECOSTEM or Manitoba Hydro site staff, including one site where a low-density patch of common tansy was found. The dispersal of sites suggest that the seed has been spread, possibly during roadwork or by vehicles from an unknown source. Continued monitoring will determine if the plant continues to appear at new locations in the Project footprint.

5.3 EFFORTS TO MANAGE INVASIVE PLANTS

To date, the rapid manual removal (i.e., by hand) control strategy for invasive plants appears to have been effective for Level 1 species but not for Level 2 species in most cases. The most plausible possible explanations for the difference in success were plant root systems being already well-established, seeds from the seed bank germinating, and/or some plants in the area had already produced seed. One Level 1 species targeted for rapid manual removal that had not been found in 2020, ox-eye daisy, was found at one new site in 2021. All new Level 1 species sites were manually removed in 2021.

While the overall effectiveness of the herbicide treatments varied by year, the years when effectiveness was low could largely be explained by application issues or weather. The 2016 treatment was completely ineffective likely because the herbicide applications occurred in late August, which was after the plants had already produced seed. While the 2018 herbicide applications considerably reduced total non-native plant cover over all of the treated areas (i.e., approximately 84%), the cover reduction for the target species was much lower (i.e., 1.6%) because the contractor missed treating the priority areas with largest amounts of the target species (in areas that were treated, it was possible that the roots of some of the herbicided plants were not killed). Herbicide treatments in 2019 addressed the areas that were missed in 2018, however, heavy rains shortly after the herbicide application likely reduced its effectiveness. The 2020 herbicide treatments were found to be generally accurate and effective, and a similar method was organized for treatment in 2021.

For the 2021 treatments, the herbicide contractor arrived earlier than initially planned and applied the herbicide before the botanist was scheduled to accurately mark the areas chosen for targeting. As a result, inspection of the targeted areas shortly after herbicide application showed that many of the areas had been missed, or only partially covered by herbicide. Heavy rains that occurred later on the day of herbicide application may also have been a factor that reduced effectiveness.

Due to the above noted scheduling issue, all of the locations were targeted for mowing later in the growing season. Inspection of the patches later in the season, during the non-native plant survey showed that the mortality rate of all herbicided vegetation was high (Photo 5-1), but it remains uncertain if the follow-up mowing treatment will be effective in controlling the target species because too little time had passed (Photo 5-2).

Photo 5-1: General vegetation mortality in an herbicide-treated patch in the Start-up Camp

Photo 5-2: Mowed area in Borrow Area Km15, showing remaining field sow-thistle

Comparison of total cover for the target invasive species in the treated Project footprint components provides a more informative assessment of the overall effectiveness of the herbicide treatments.

Total cover of field sow-thistle, which was the most abundant target species in the treated footprint components, increased by 400%, from 98 m^2 in 2020, to 414 m^2 in 2021, following targeted herbicide and mowing treatments in Borrow Area G-1 at KM 15 (Table 5-1). This was after there had been a decrease in 2020 following two consecutive years of effective herbicide treatments. Although ten areas had been targeted for treatments in this Borrow Area, it appeared that only one of the sites was partially treated with herbicide in 2021. Provided the heavy rains were not the reason for the lack of herbicide evidence, it is likely that herbicide treatment would have again been effective in this Project area if the patch marking had been carried out before the treatment.

Although there was a decrease in field sow-thistle in the Start-up Camp area, it is uncertain how much could be attributed to the herbicide treatment, since only trace amounts of the species were observed in the herbicided area immediately after treatment.

A single treatment in 2020 reduced target species cover by 63% since 2019 along the North Dyke. Herbicide treatments in 2021 may have further reduced cover, although there were no identifiable non-native plants in the treated areas when they were visited for marking.

Herbicide treatment of the single patch of common burdock in the Main Camp in 2019 appeared to be 100% effective (Table 5-1). No plants were found at that site, or elsewhere in the Project footprint in 2020 or 2021. Continued monitoring of the site in subsequent years will determine if the plant has been eradicated from the site, or if viable seed remains in the soil.

The long-term effectiveness of the herbicide program and follow-up mowing will be analyzed in more detail in the synthesis report.

Table 5-1: Total live cover[1] of species targeted by herbicide treatment[2] as of late August in Project components that were treated from 2018 to 2021

Common Name	Year	KM15 Borrow Area	KM17 Borrow Area	Start-up Camp & NAR Gate Staging	Main Camp	NAR	North Dyke	Work Area B	Sigfusson Northern/ Voltage Camp & Borrow Areas B-2 & B-3
Canada Thistle	2018	-		0	-	0	0	-	-
	2019	-		0	-	-	-	-	-
	2020	**0**		**0**	-	-	-	-	0
	2021	**-**		0	-	-	-	-	1
Common Tansy	2018	-		-	-	-	0	-	-
	2019	-		-	-	-	0	-	-
	2020	-		-	-	1	0	-	0
	2021	-		-	-	-	-	-	0
Field Sow-thistle	2018	1,265	7	**481**	**11**	172	-	**1**	**3**
	2019	**722**	43	**449**	**5**	104	95	**0**	**7**
	2020	**98**	84	**257**	**28**	**68**	**35**	**2**	**53**
	2021	414	**41**	113	**54**	**187**	31	-	208
Common Burdock	2018	-		-	7	-	-	-	-
	2019	-		-	**-**	-	-	-	-
	2020	-		-	-	-	-	-	-
	2021	-		-	-	-	-	-	-
Ox-eye Daisy	2018	0		-	-	-	-	-	0
	2019	-		-	-	-	-	-	0
	2020	-		-	-	-	-	-	0
	2021	-		-	-	-	-	-	-
Scentless chamomile	2018	-		1	-	-	-	0	-
	2019	-		-	0	-	-	-	-
	2020	-		-	-	-	-	-	0
	2021	-		-	-	-	0	-	0
Tufted Vetch	2018	3		0	-	-	-	-	-
	2019	0		-	-	-	-	-	5
	2020	1		-	0	-	-	-	**0**
	2021	0		-	-	1	-	-	**2**

Notes: [1] Live cover following herbicide treatment in that year. Not all patches of plants in the Project component were necessarily treated. [2] Bold-face font indicates that plants were treated with herbicide that year. Underlined font indicates plants were hand-pulled.

5.3.1 PREVENTION

The following provides some general considerations for future efforts to control invasive plants in the Project footprint. Specific control recommendations will be developed for the 2022 growing season based on the monitoring results to date.

It is difficult to prevent vehicles and people from inadvertently spreading non-native plant species into the Project footprint (Section 2.6.1). This becomes more difficult as portions of the Project footprint (i.e. the SAR and attached borrow areas, Ellis Esker access corridor) become open to the public. Therefore, recommendations in addition to the standard measures included in the Project's EIS and EnvPPs focus on the plant species of highest invasive concern and on the situations where there are practical ways to eradicate these species or to prevent them from spreading further.

Of the non-native plant species recorded during monitoring, several categorized as Levels 1 and 2 invasive concern were known to be present prior to the Project (KHLP 2009; KHLP 2012b). At least two such species (white sweet clover, ox-eye daisy) were likely already established in the Start-up Camp and Main Camp areas even before the KIP construction began (ECOSTEM 2014). Additionally, some Level 2 species (i.e., white and yellow sweet clover, Canada thistle, field sow-thistle) were found along PR 280 prior to development of the KIP (KHLP 2009; KHLP 2012b).

One strategy to prevent or reduce the spread of invasive plants beyond their current locations is for equipment, machinery, vehicles and people to avoid or minimize travel through infested areas. This naturally occurs to a large degree once an area is decommissioned. A related strategy is to restrict travel to those periods when the spreading of seed or propagules is least likely (e.g., prior to seed development). Possible implementation of these strategies has become more feasible because the number of new construction areas have declined as the Project is approaching completion, and substantial additional Project clearing is not anticipated (Manitoba Hydro pers. comm. 2020).

Promoting native plant regeneration is another strategy to control and eradicate invasive plants. This can be accomplished in two ways: by implementing the already planned site regeneration as soon as is feasible after a construction area will no longer be used; and, by limiting traffic and other activity on sites where desired vegetation has established or is establishing. This strategy has already been implemented and will continue into the future. In many of the decommissioned areas, seeding of native plant species and tree planting are currently underway. A separate report (ECOSTEM 2022b) describes the ongoing rehabilitation activities in the Project footprint.

5.3.2 ERADICATION AND CONTROL

The only situation for which an eradication strategy for Level 1 and 2 plant species is both feasible and likely to succeed is within those footprint components where these species occur as small patches in one to a few sites.

For sites with only one to a few plants, rapid manual removal has been effective to date for the Level 1 species (Section 4.1.1). Monitoring surveys in 2022 will determine if rapid manual removal continues to be effective for controlling these species.

Rapid manual removal has only been partially effective where it was applied to small patches of Level 2 species in 2016 (efficacy of the 2021 manual removals to be determined after 2022

surveys). As described in Section 4.1.2, the manual removal method will only be implemented in certain situations.

Rapid manual removal by staff conducting the monitoring surveys will continue to be employed for newly found sites with Level 1 and 2 species. For previously recorded sites, rapid manual removal will not be implemented for species that reproduce prolifically by rhizomes and where either the plants are mature or it appears the plants have already developed a root system (see Section 4.1.2). Herbicide application is being considered for these sites.

Additional herbicide applications and/or mowing are recommended to control or eradicate invasive plants at key sites. Key sites will be identified for treatment in summer 2022 using the same criteria as in previous years.

A general strategy to eradicate or control invasive plants involves promoting native plant regeneration. This can be accomplished in the same ways as described for prevention (Section 5.3.1).

Continued high vigilance is needed for Level 1 species because they are difficult to control (ISCM 2022). In addition, continued introductions by Project vehicles entering from outside of the Project footprint are quite possible. ISCM (2022) states that scentless chamomile, ox-eye daisy and common tansy are common along fence lines, roadways and fields in Manitoba, so vehicles and equipment coming to the Project site could easily transport them there. It is recommended that Manitoba Hydro site staff continue to look for the species of highest invasive concern (i.e., scentless chamomile, common tansy, ox-eye daisy) and manually remove plants from these species if and when they encounter them in the Project footprint. It is also recommended that Manitoba Hydro site staff receive an invasive plant identification training session each spring.

6.0 COMPARISON WITH PREDICTED EFFECTS

The *Keeyask Generation Project Response to EIS Guidelines* (EIS) predictions for effects on invasive plants included the following mitigation measures during the construction period KHLP 2012b):

- Temporarily cleared areas will be revegetated or treated with a non-invasive ground cover as soon as practicable during construction;
- Contractors utilizing equipment and machinery that was recently used more than 150 km from the Project area will wash that equipment and machinery prior to transport to the Project area;
- Where seeding is used as a rehabilitation or erosion control measure, the seed mixture will only contain native species and/or non-invasive introduced plant species;
- Containment, eradication, and/or control programs will be implemented if monitoring identifies problems with invasive plants;
- Contractors will be educated about the importance of cleaning their vehicles, equipment and footwear before travelling to the area; and,
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of invasive plant, accidental fire and other access-related effects.

As documented in other TEMP construction monitoring reports (ECOSTEM 2022a,b), the above mitigation was implemented, with the exception of trail blocking at all sites. While some form of blocking was created on two trails, dense regeneration following the 2013 wildfire effectively blocked most of the remaining trails and made many of them nearly indistinguishable from the surrounding area (ECOSTEM 2018a).

After considering mitigation, the EIS predictions (KHLP 2012b) for residual Project effects on invasive and other non-native plants were that:

1. Temporarily cleared areas could become non-native plant colonization centres as exposed mineral substrates provide ideal sites for plant establishment;
2. A severe accidental Project-related fire could create ideal conditions for some invasive species by killing off a high proportion of the plant propagules and/or burning off the surface organic layer to expose the mineral soil; and,
3. Project construction was not expected to substantially increase the rate at which non-native plants are introduced to or spread in the Local Study Area (Study Zone 2; Map 2-1) provided

mitigation measures are implemented, and that non-native plants would generally be confined to human footprints.

A moderately low level of uncertainty was associated with these predictions.

During Project construction, monitoring has shown that effects on invasive plants are consistent with those predicted in the EIS:

1. In terms of non-native plant establishment in temporarily cleared areas, the Project includes several areas where tall vegetation was cleared but the site was not excavated or otherwise used (portions of Borrow Areas KM-4, G-1 and N-5). Monitoring found that the Project did not spread non-native plants into these areas. The few non-native plants found in these areas were very likely there prior to the Project as they occurred within or near old cutlines (ECOSTEM 2017). As of 2021, native plant regeneration was advanced in these cleared areas.

   In temporary Project areas that included vegetation clearing and material excavation, monitoring found that non-native plant cover tended to establish shortly after disturbance, but only increased in the areas where construction and excavation activity were low. As an example, the areas developed by the KIP were disturbed prior to Project construction and then decommissioned and/or rehabilitated in the early years of Project construction. In these areas, non-native plant cover increased for a few years, peaked, and then declined as native vegetation developed (see Section 5.1.2).

2. There have been no Project-related fire effects. However, the 2013 natural wildfire provided an area to indirectly test the EIS prediction. The 2013 wildfire burned undisturbed areas and portions of the existing Project footprint. The natural wildfire burned off the surface organic layer and exposed mineral substrates in localized areas, and thereby created the conditions that facilitate the colonization of non-native plants. As such, exposed mineral substrates appeared in both non-Project and Project areas. Monitoring conducted in the burned areas found non-native plants. However, the non-native plant cover was almost entirely confined to the Project footprint and had not spread into surrounding natural areas.

3. Mitigation measures appear to have been effective in controlling non-native plants. Total non-native plant cover within the entire Project footprint was less than 1.5% of the surveyed area, and this percentage is expected to overestimate non-native plant cover within the entire Project footprint. Additionally, the species of the highest invasive concern have been effectively controlled.

   To date, there has been no evidence that the Project has spread non-native plants into the portion of the Local Study Area that is outside of the Project footprint (with exceptions indicated above). Looking forward, if the patterns observed in the previously developed KIP portions of the Project footprint and at the Wuskwatim Generation Project site repeat in other Project areas that are decommissioned, and foot or vehicle traffic in these areas continues to be limited or excluded, it is expected that total non-native plant cover in decommissioned areas should begin to decline several years into Project operation.

7.0 SUMMARY AND CONCLUSIONS

7.1 CONDITIONS AND PATTERNS

In August 2021, non-native plants covered 1.4% of the surveyed portion of the Project footprint, which included 12% of the total footprint area. Previous monitoring found that the areas not surveyed had low non-native plant cover because they are active construction areas.

Up until the summer of 2020, most of the non-native plant cover was within Project areas that were either there before construction started (e.g., cutlines, borrow areas and ditches along the pre-existing Butnau Road portion of the South Access Road), or were created by the Keeyask Infrastructure Project (KIP) and have been subsequently used by the Project. By 2021, non-native plant cover was becoming more evenly distributed across all of the Project areas.

Starting in 2018 and continuing in 2019, it appeared non-native plant cover and extent were decreasing in the older Project components that have been minimally used since earlier in construction. From 2020 to 2021, non-native plant cover increased substantially (42%) compared with increases in the previous two years. The large increases may be partially explained by a decrease in construction activity and an increase in rehabilitation efforts. It is expected that as widespread rehabilitation is carried out, there will be sharp localized decreases in total non-native plant cover, followed by rapid increases. Over a couple of years, the increases in non-native cover are expected to peak, then level off or gradually decline as native vegetation cover increases.

A total of 25 non-native plant species were found during the 2021 surveys. No new species were recorded in 2021, but one species that had not been recorded in 2020 was observed again in 2021 (ox-eye daisy), and three previously recorded species (canola, flixweed and black medick) were not observed.

Plants from the species of highest invasive concern for the Project area were found during every year of construction monitoring. Immediate manual efforts to eradicate these species were implemented. For example, in 2021, these species were ox-eye daisy, scentless chamomile and common tansy. Ox-eye daisy was found at one location along the SAR, common tansy was found at five new sites along the SAR, and scentless chamomile was found at 10 sites along the SAR, the North Dyke and EMPA D16. ECOSTEM and Manitoba Hydro field staff removed all of these plants by hand after they were found and documented.

Monitoring to date has indicated that manual removal of invasive plants of highest concern was effective with one exception, as new plants have not returned to most of those sites. The exception was for species that have the ability to proliferate from roots left in the ground. Manual removal will be continued in 2022, except for select situations of plants from species that can proliferate from roots left in the ground. Other control measures, such has herbicide application, will be considered for plants that are not manually removed.

A number of sites were targeted for herbicide treatments in mid-July 2021. The majority of these sites were also mowed in early August 2021. Monitoring in August 2021 found that the herbicide applications reduced total non-native plant cover in the treated sites by approximately 63%, but only reduced the target species cover by 28%. The low effectiveness of this herbicide treatment was potentially due to the sites not being able to be marked in the field prior to the herbicide application, and possibly due to heavy rainfall at site following herbiciding. The effectiveness of the follow-up mowing will be evaluated from the 2022 monitoring data given that the mowing happened late in the growing season. Monitoring in 2022 will evaluate the effectiveness of both the 2021 herbicide and mowing treatments.

7.2 COMPARISON WITH PREDICTED EFFECTS

During the construction phase, monitoring up to 2021 found that Project effects on non-native plants were consistent with EIS predictions. In particular, there is no evidence that Project construction has spread non-native plants into areas outside of the Project footprint. Also, Project mitigation measures have been effective at controlling total non-native plant cover and confining the vast majority of the small area of non-native plant cover to the Project footprint.

7.3 RECOMMENDATIONS

It is recommended that Manitoba Hydro site staff continue to look for the species of highest invasive concern (i.e., scentless chamomile, common tansy, ox-eye daisy) and manually remove plants from these species if and when they encounter them in the Project areas. It is also recommended that Manitoba Hydro site staff receive an invasive plant identification training session each spring.

Additional invasive plant control recommendations are being developed for the 2022 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2022.

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APPENDIX 1:
NON-NATIVE PLANT INDIVIDUAL AREAS

Table 8-1: Estimated radius and derived area for individual non-native plant species in 2021

Species	Estimated Radius (cm)	Derived Area (m^2)
Arctium minus	25	0.196
Artemisia absinthium	25	0.196
Avena sativa	4	0.005
Brassica napus	10	0.031
Capsella bursa-pastoris	5	0.008
Chenopodium album	10	0.031
Leucanthemum vulgare	10	0.031
Cirsium arvense	10	0.031
Cirsium vulgare	15	0.071
Crepis tectorum	8	0.020
Descurainia sophia	15	0.071
Erysimum cheiranthoides	20	0.126
Helianthus annuus	20	0.126
Hordeum jubatum	4	0.005
Lotus corniculatus	25	0.196
Matricaria discoidea	7.5	0.018
Medicago lupulina	10	0.031
Medicago sativa	25	0.196
Melilotus albus	25	0.196
Melilotus officinalis	25	0.196
Oenothera biennis	20	0.126
Persicaria maculosa	15	0.071
Phalaris arundinacea	15	0.071
Phleum pratense	3	0.003
Plantago major	10	0.031
Secale cereale	4	0.005
Silene csereii	10	0.031
Sonchus arvensis	10	0.031
Tanacetum vulgare	25	0.196
Taraxacum officinale	10	0.031
Trifolium hybridum	20	0.126
Trifolium pratense	20	0.126
Trifolium repens	20	0.126
Tripleurospermum inodorum	5	0.008
Triticum aestivum	4	0.005
Verbascum thapsus	20	0.126
Vicia cracca	20	0.126

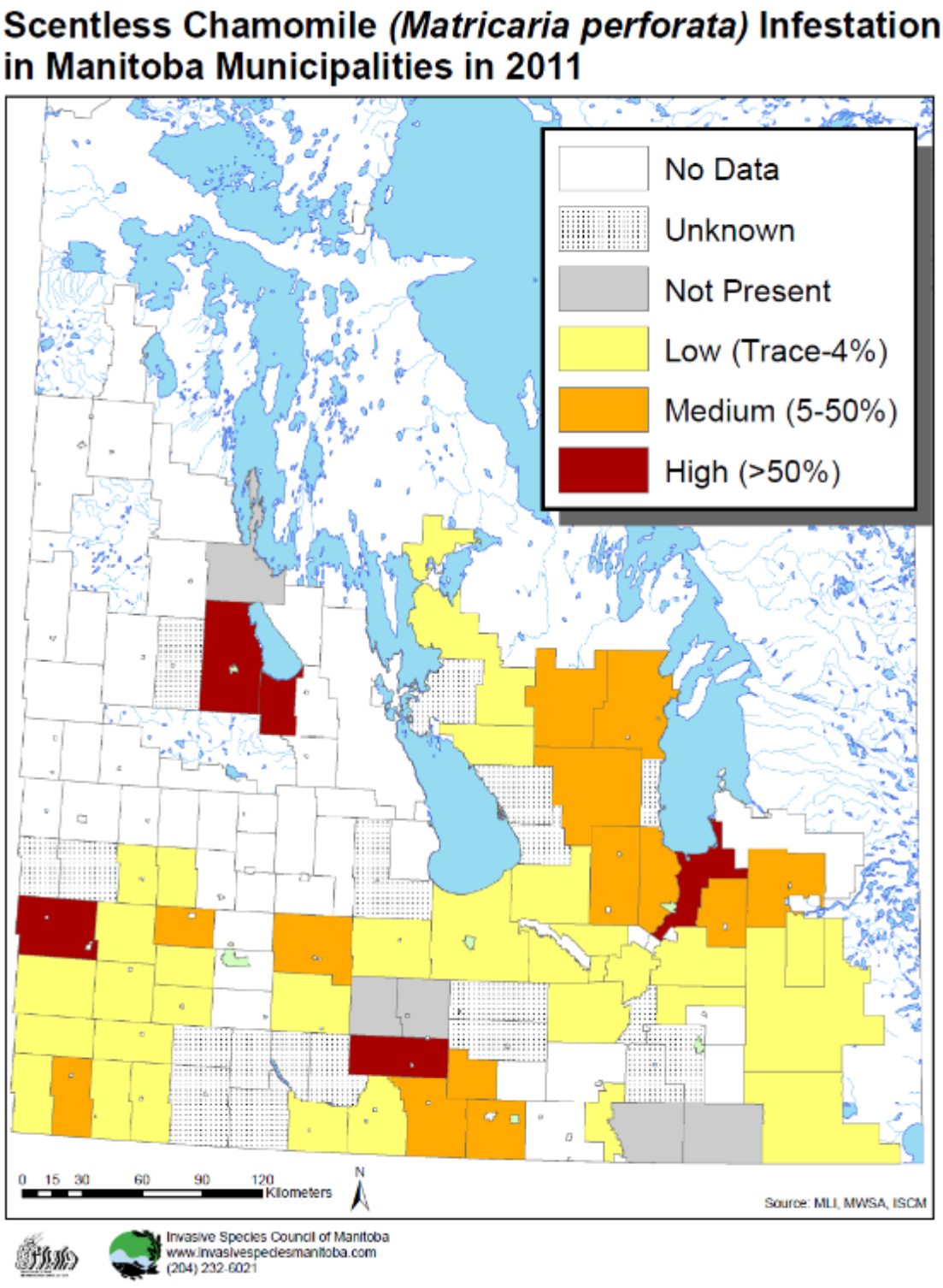
APPENDIX 2:
INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

8.1.1 BACKGROUND

This monitoring study provides additional control or eradication recommendations during construction monitoring. The following describes the approach taken to make recommendations regarding which non-native species to prioritize for management, and the types of locations that management efforts will focus on.

It is widely recognized that it is not practical to attempt to eradicate or even control all non-native plant species (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011). For example, some species are already too widespread and well-established to implement an approach that removes plants at a faster rate than they reappear in the same locations and establish in new locations.

Many of the non-native species recorded during Project monitoring are commonly found in disturbed areas throughout the Province (e.g., field sow-thistle, white sweet clover), particularly along roadsides, making it difficult to prevent them from being spread by human or natural sources. Maps produced by the Invasive Species Council of Manitoba (ISCM) demonstrate the widespread distribution of noxious weeds in southern Manitoba. For example, Figure 8-1 provides a general impression of how widespread scentless chamomile (a highly invasive species) was in southern Manitoba in 2011. However, this map considerably understates scentless chamomile distribution and abundance as data are missing for a high proportion of municipalities.



Source: ISCM 2022.

Figure 8-1. Scentless Chamomile infestation in Manitoba municipalities in 2011

As noted above, it is not practical to eradicate or even control all non-native plant species. For this reason, numerous ranking systems have been developed to prioritize which non-native plant species to target, which types of locations should be focused on and/or the preferred management strategies. Examples of publications that review some of these systems include Williams and Newfield (2002), Wikeem (2007) and Carlson *et al.* (2008).

Three themes which frequently appear in systems that prioritize and/or determine which non-native plant species to actively manage (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011) are:

1. The potential for the species to cause major harm to ecosystems, conservation values or human health;
2. The species' current and expected future distribution and abundance; and,
3. The likelihood that management efforts can achieve their objectives over the long-term.

This monitoring study uses the preceding three themes to prioritize and develop management recommendations for non-native plants in the Project area. Management recommendations focus on the plant species of highest invasive concern (first and second themes) and the situations where there are practical ways to reduce these species or prevent further spreading (third theme).

For this monitoring, the primary sources used to classify the potential for a non-native plant species to have substantial adverse effects on ecosystems or biodiversity in the Project area were the ISCM (2022), White *et al.* (1993), the Provincial *Noxious Weeds Act* (Government of Manitoba 2017a) and the Federal Weed Seeds Order (Government of Canada 2016). While the federal *Plant Protection Act* was also relevant from the regulatory perspective, few of the species currently on its list occur in Manitoba, and those that do are limited to a few locations in the southern portion of the province.

The primary additional sources of information that assisted with evaluating potential invasiveness in the Project area, and with developing management recommendations, included the Biology of Canadian Weeds Series (Canadian Weed Science Society. 2019a), the Biology of Invasive Alien Plants in Canada (Canadian Weed Science Society. 2019b), Manitoba Agriculture (2019) and results from EIS or monitoring studies for this and other projects in northern Manitoba. The last of these sources also provided some information regarding patterns of distribution and abundance in the Project region.

A limitation for some of the sources used to determine a plant's degree of invasiveness was that they did not include data from the Keeyask region. The observed degree of invasiveness for the species included in these sources was generally obtained in regions subject to much different climates than that occurring in the Project region. Local invasiveness can differ greatly from that observed in other regions (Carlson *et al.* 2008).

Of the sources used for ranking a species' degree of invasiveness listed above, ISCM (2022) and White *et al.* (1993) were considered the most relevant ones because their focus is on impacts to ecosystems and biodiversity. The Provincial *Noxious Weeds Act* and the Federal Weed Seeds Order were developed to address impacts on the agricultural economy or the viability of the agricultural operations. An upshot of this agricultural focus is that these regulations do not list

some species known to be of concern for impacts on native ecosystems and biodiversity (e.g., purple loosestrife). Conversely, these regulations also list some native boreal plant species (e.g., foxtail barley) as weeds since they can be problematic for agriculture. Native boreal species appearing on these lists were not considered to be invasive for the Project area.

An additional reason for including the *Noxious Weeds Act* of Manitoba is that it includes some management obligations for species encountered during construction activities. This Act creates a general duty to destroy species it identifies as noxious weeds because they are a significant threat to Manitoba's agricultural economy or to the viability of the agricultural operations. The Act states that: “Each occupant of land, or, if the land is unoccupied, the owner thereof, or the agent of the owner, and each person, firm, or corporation who or which is in control of, or in possession of, or in charge of, land, shall destroy all noxious weeds and noxious weed seeds growing or located on the land as often as may be necessary to prevent the growth, ripening and scattering of weeds or weed seeds.”

The degree of management response required by the Act depends on the species’ threat to agricultural crops. Species are categorized into one of three degrees of threat, which are Tier 1, 2 or 3. The Act requires that a landowner, occupier or contractor:

a) destroy all tier 1 noxious weeds that are on land that the person owns or occupies;
b) destroy all tier 2 noxious weeds that are on land that the person owns or occupies if the area colonized by the weeds is less than five acres [2.023 ha];
c) control all tier 2 noxious weeds that are on land that the person owns or occupies if the area colonized by the weeds is five acres [2.023 ha] or more; and
d) control a tier 3 noxious weed that is on land that the person owns or occupies if the weed's uncontrolled growth or spread is likely to negatively affect an aspect of Manitoba's economy or environment in the area of the land or the well-being of residents in proximity to the land.

The Act defines control as curtailing the weed’s growth and preventing its spread beyond its current location.

It is noted that, as there are no agriculture crops near the Project, weeds in the Project site do not pose a local threat to agricultural operations. Equipment or vehicles moving from the site to other regions could transport weed propagules into agricultural areas.

8.1.2 INVASIVE CONCERN CLASSIFICATION

As noted above, ISCM (2022) and White *et al.* (1993) were the primary sources for ranking a species’ degree of invasiveness. To provide background for this study’s invasive concern classification, the criteria used in the ISCM and White *et al.* (1993) classifications are first presented.

Table 8-2 provides the ISCM invasive plant categories, criteria for inclusion in a category and the minimum management criteria. Category 1 and 2 species are the species considered to pose the

greatest threats, and have a management response that includes eradication if feasible. The essential differences between these categories is that Category 1 includes species not yet known to be present in natural areas and species declared to be noxious weeds. Species that ISCM lists as "other" are not on the early detection and rapid response list.

White *et al.* (1993) classify alien plants in Canada as being either a principal, moderate or minor invasive. Principal Invasive Aliens are the species considered to pose the greatest threat to natural areas. Moderate Invasive Aliens are the species considered to pose an intermediate level of threat to natural areas. Minor Invasive Aliens are the species considered to be only minor problems.

Table 8-2. ISCM invasive plant categories, criteria for inclusion and minimum management criteria

Categories and Criteria for Inclusion	Minimum Management Criteria
Category 1 Species	
• These invasive plants are not present in Manitoba, but may be present in cultivation[1] but not yet known to have escaped, and/or • If listed as a Manitoba Noxious Weed, and/or • If on the List of Pests Regulated in Canada and • Capable of establishing in Manitoba based upon climate variables • A pathway of introduction exists • Easily identifiable with available resources.	• Eradication is first option if detected and if feasible. • A lead agency should be identified and a management committee formed to develop an eradication strategy. • An education and awareness program is required. • Provincial ban on sale and trade. • Species may be moved to next category if found in Manitoba.
Category 2 Species	
• These invasive plants are present in Manitoba and • Capable of further spread and • Pathways for spread are present and • Easily identifiable with available resources.	• Eradication is first option, when feasible. • Containment and control programs are second option. • Education and awareness programs to foster prevention. • A response plan is available or under development.
Other Species	
• Other terrestrial invasive plants	• Not specified in the ISCM website.

Source: ISCM (2022).

Notes: [1] Cultivated as a garden plant, for ornamental horticulture, water ponds or gardens, for lawns; and is outside its natural range.

The non-native plant species recorded during monitoring to date were classified into one of four levels of invasive concern for the Project area (Table 2-5). Level 1 was the highest level of invasive concern for the Project. Level 1 species included ISCM Category 1 and 2 species.

The second highest level of invasive concern for the Project (Level 2 species) included ISCM "other" species of concern and/or the non-native species that White *et al.* (1993) classify as being principal or moderate invasives in Canada. These species also have the potential to crowd out native species in many of the conditions where non-native plants are found.

The third highest level of invasive concern (Level 3 species) included non-native species that White *et al.* (1993) classify as minor invasives in Canada and/or the species that government sources classify as noxious weeds or weed seed species.

The fourth and lowest level of invasive concern (Level 4 species) included all of the non-native plant species not already included in another level. Species at the third and fourth levels may become problematic in some locations and/or conditions (*e.g.*, changed climate). They will also be a consideration when developing revegetation plans for areas being rehabilitated to native habitat types.

Table 2-6 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project footprint to date.

Table 8-3 classifies non-native species that have not been recorded to date but could potentially occur in the Project footprint. These included species that are known to be present in Manitoba, and are listed as Tier 2 or 3 noxious weeds in Manitoba (Government of Manitoba 2017b), or are listed as Category 2 or Other invasive plants by the ISCM (2022).

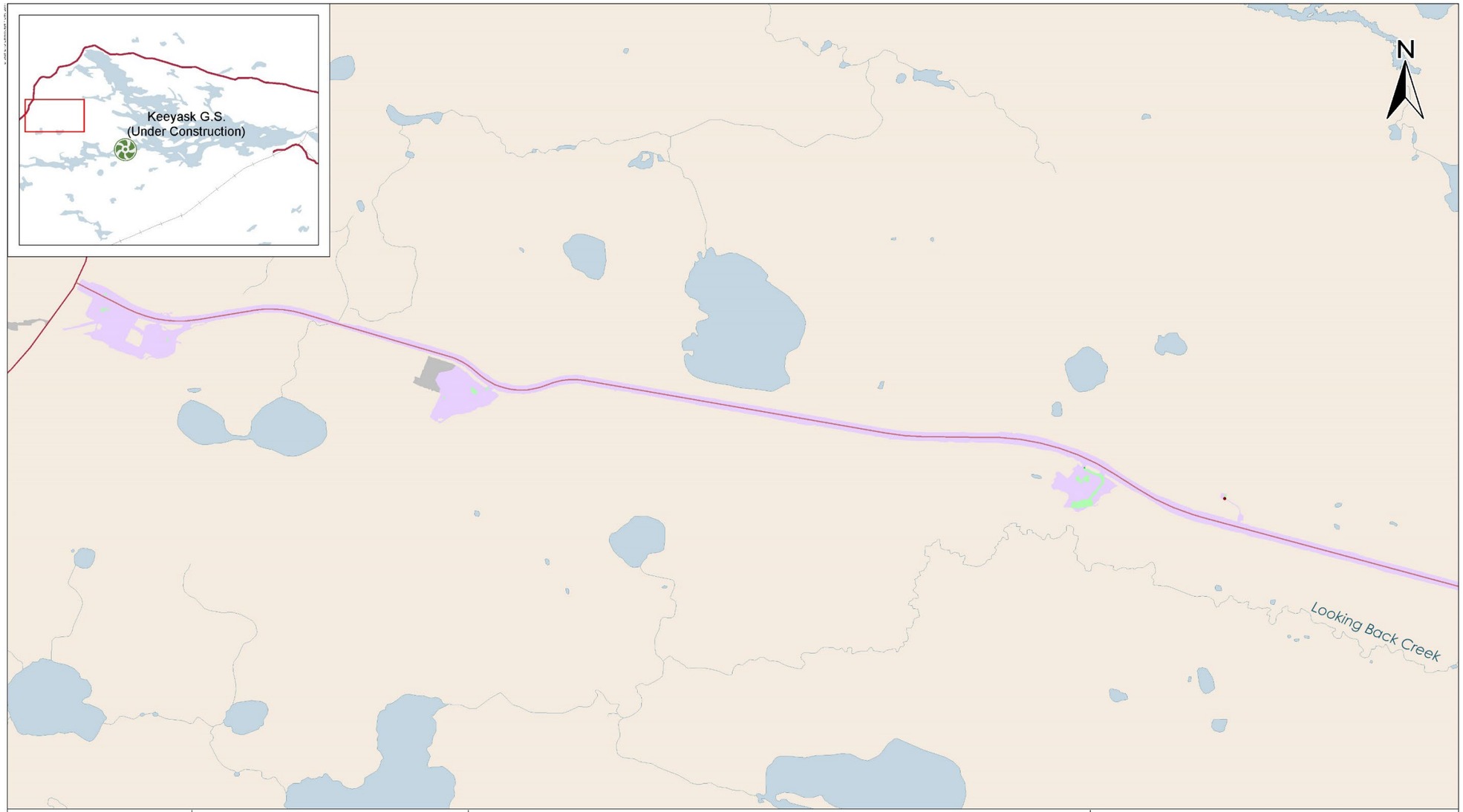
Table 8-3: Invasive concern classifications for non-native plant species that could potentially occur in the Project footprint

Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White *et al.* Category[4]	Noxious weed[5]	Weed Seed[6]
Level 1	Hoary alyssum	*Berteroa incana*	Other		Tier 2	
	Japanese brome	*Bromus japonicus*	Category 2		Tier 2	
	Downy brome	*Bromus tectorum*	Category 2		Tier 2	
	Flowering Rush	*Butomus umbellatus*	Category 2	Principal		
	Thistle, nodding	*Carduus nutans*	Category 2	Minor	Tier 2	Prohibited
	Blueweed	*Echium vulgare*	Category 2			
	Spurge, leafy	*Euphorbia virgata*	Category 2	Principal	Tier 2	Prohibited
	Baby's-breath	*Gypsophila paniculata*	Other		Tier 2	
	St. John's-wort	*Hypericum perforatum*	Category 2	Moderate	Tier 2	
	Large Touch-me-not	*Impatiens glandulifera*	Category 2			
	Scabious, field	*Knautia arvensis*	Category 2		Tier 2	
	Toadflax, Dalmatian	*Linaria dalmatica*	Category 2		Tier 2	Primary
	Toadflax, yellow	*Linaria vulgaris*	Category 2		Tier 3	Primary
	Purple Loosestrife	*Lythrum salicaria*	Category 2	Principal		Primary
	Bartsia, red	*Odontites vulgaris*	Category 2		Tier 2	Prohibited
	Common reed, invasive	*Phragmites australis* ssp. *australis*	Category 2		Tier 2	
	Buckthorn, European	*Rhamnus cathartica*	Category 2	Principal	Tier 3	
	Bouncingbet	*Saponaria officinalis*	Category 2		Tier 2	
Level 2	Garlic Mustard	*Alliaria petiolata*	Other	Principal		
	Bellflower, creeping	*Campanula rapunculoides*	Other		Tier 3	
	Thistle, bull	*Cirsium vulgare*	Other		Tier 3	
	Field Bindweed	*Convolvulus arvensis*	Other			Primary
	Common Hound's Tongue	*Cynoglossum officinale*	Other			

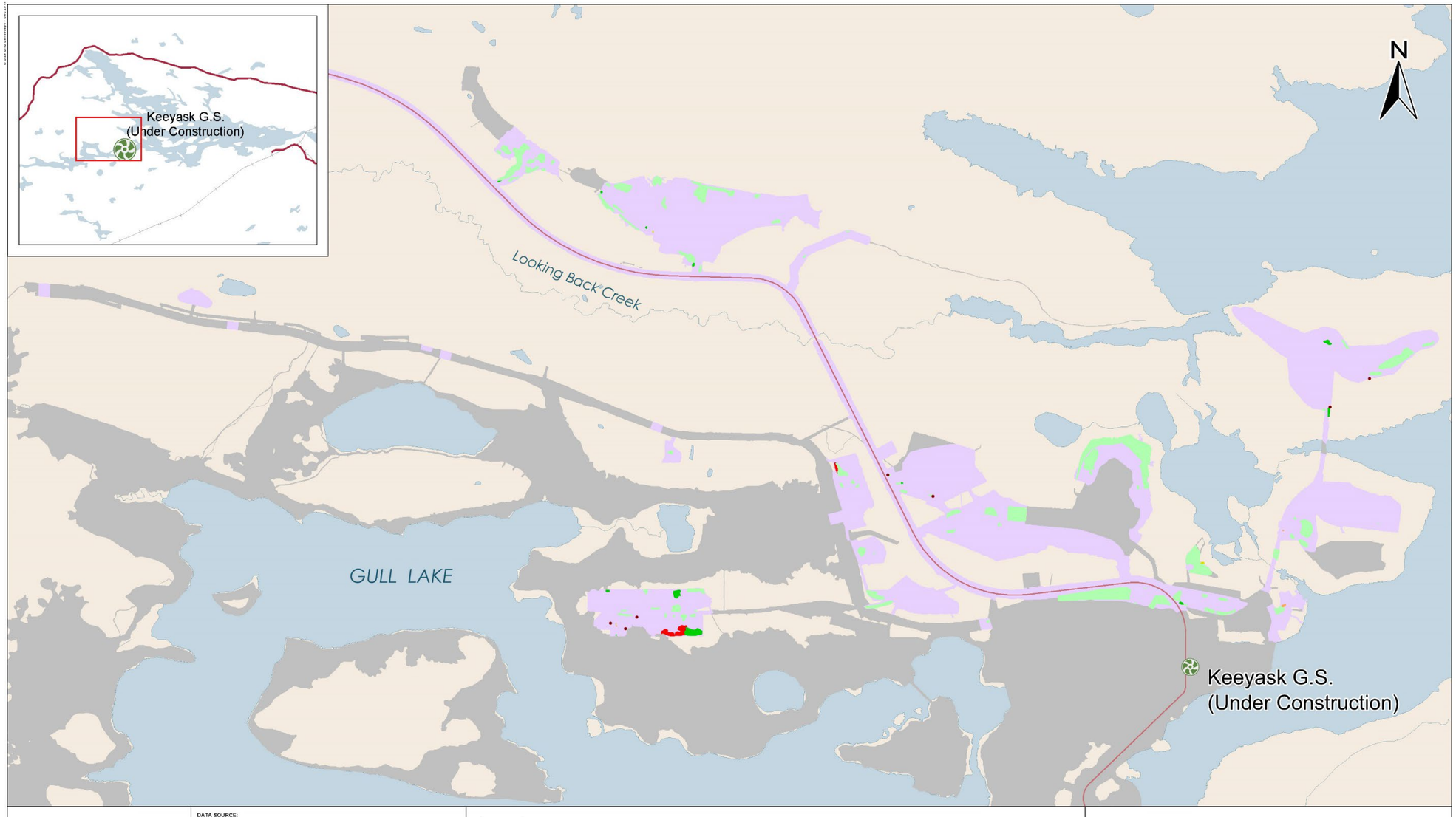
Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White *et al.* Category[4]	Noxious weed[5]	Weed Seed[6]
	Japanese Knotweed	*Fallopia japonica*	Other			
	Giant hogweed	*Heracleum mantegazzianam*	Other			
	Dame's-rocket	*Hesperis matronalis*	Other	Minor		
	Tansy Ragwort	*Jacobaea vulgaris*	Other			Primary
	Scotch Thistle	*Onopordum acanthium*	Other			
	Orange Hawkweed	*Pilosella aurantiaca*	Other			
	Common Buttercup	*Ranunculus acris*	Other			
	Cockle, white	*Silene latifolia*	Other		Tier 3	Primary
	Puncture Vine	*Tribulus terrestris*	Other			
	Cow-cockle	*Vaccaria hispanica*	Other			Secondary

Notes: [1] See Table 2-5 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2022). [4] White *et al.* (1993). [5] Government of Manitoba (2017b). Number in column is the Tier in the Act (see text). [6] Government of Canada (2016).

APPENDIX 3:
NON-NATIVE PLANT DISTRIBUTION MAPS



Map 8-1: The distribution and abundance (cover class) of lamb's-quarters in the Project footprint along the western portion of the North Access Road in late summer, 2021



KEEYASK Hydropower Limited Partnership

DATA SOURCE: Species Cover and Survey Areas - ECOSTEM Ltd.; Water, Roads and Rail - Manitoba Hydro

CREATED BY: ECOSTEM Ltd.

COORDINATE SYSTEM: UTM NAD 1983 Z15N

DATE CREATED: 10-JAN-22

REVISION DATE: 10-JAN-22

0 400 800 Metres
0 800 1600 Feet

VERSION NO: 1.0

QA/QC: JWE/YYY/ZZZ

Legend

Cover Class
- Trace to Very Sparse (Less Than 3%)
- Sparse (3 to 10%)
- Low (11 to 25%)
- Moderate (26 to 50%)
- High (51 to 75%)
- Very High (Greater Than 75%)

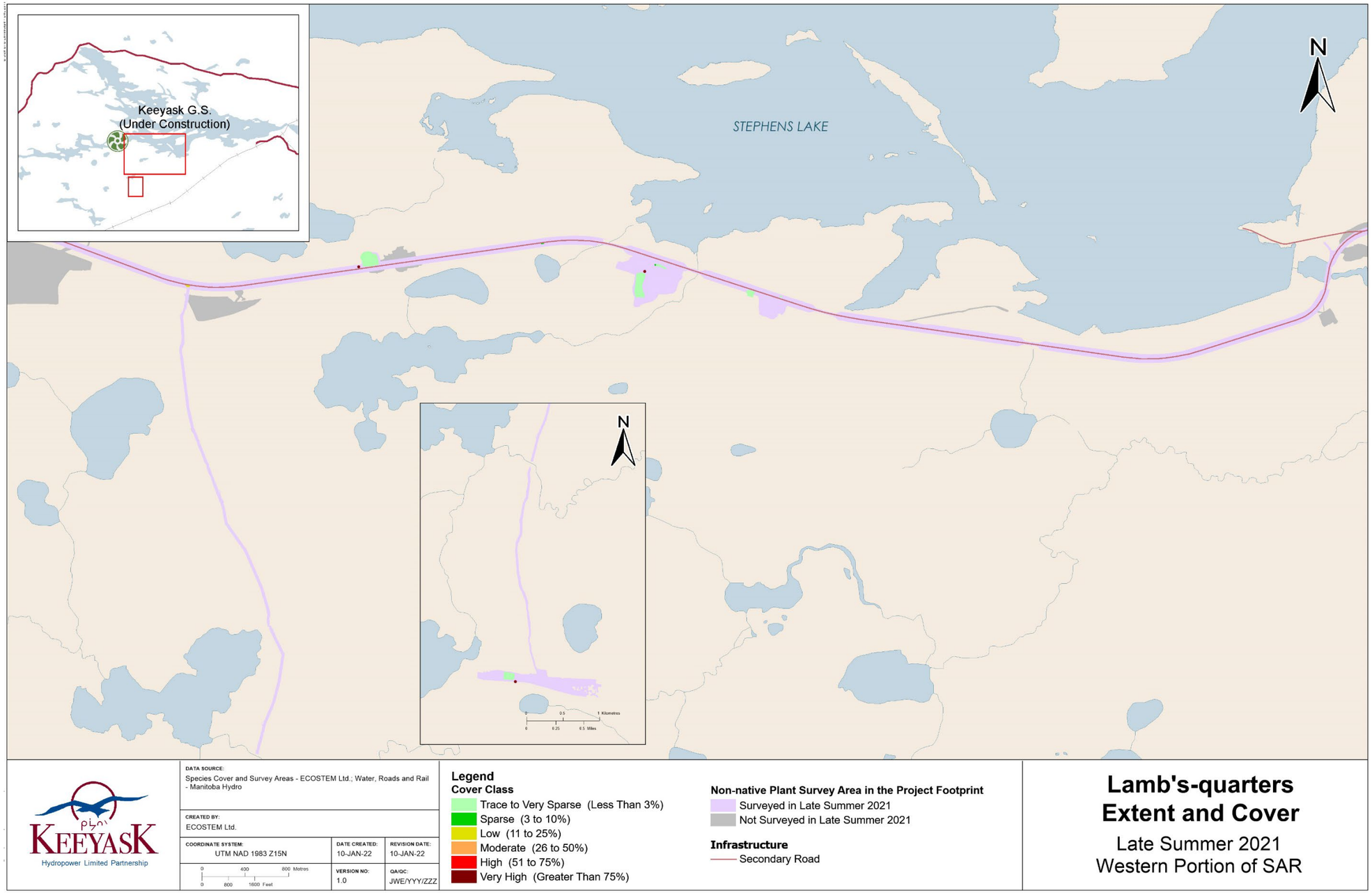
Non-native Plant Survey Area in the Project Footprint
- Surveyed in Late Summer 2021
- Not Surveyed in Late Summer 2021

Infrastructure
- Secondary Road

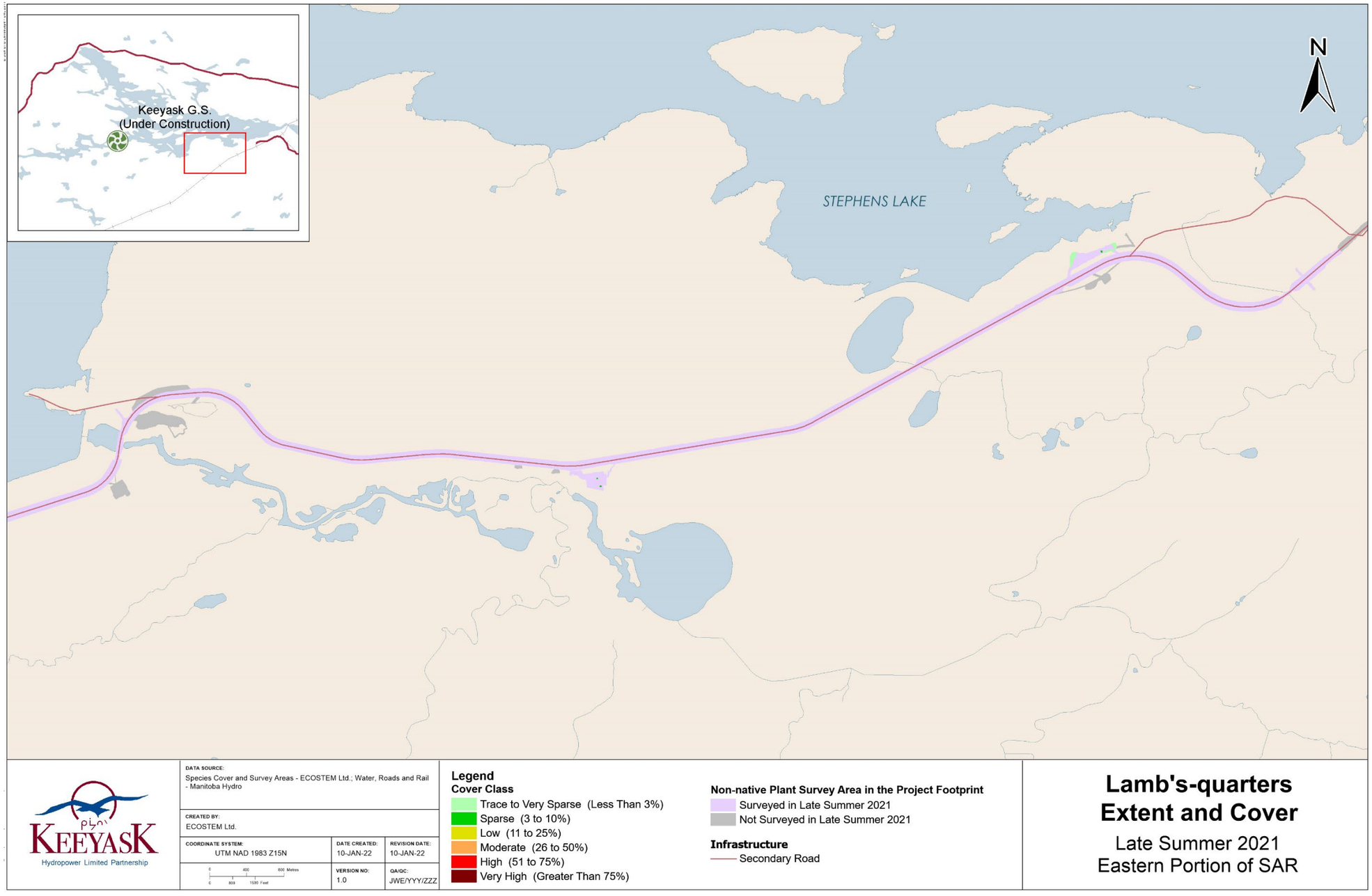
Lamb's-quarters Extent and Cover

Late Summer 2021
Eastern Portion of NAR

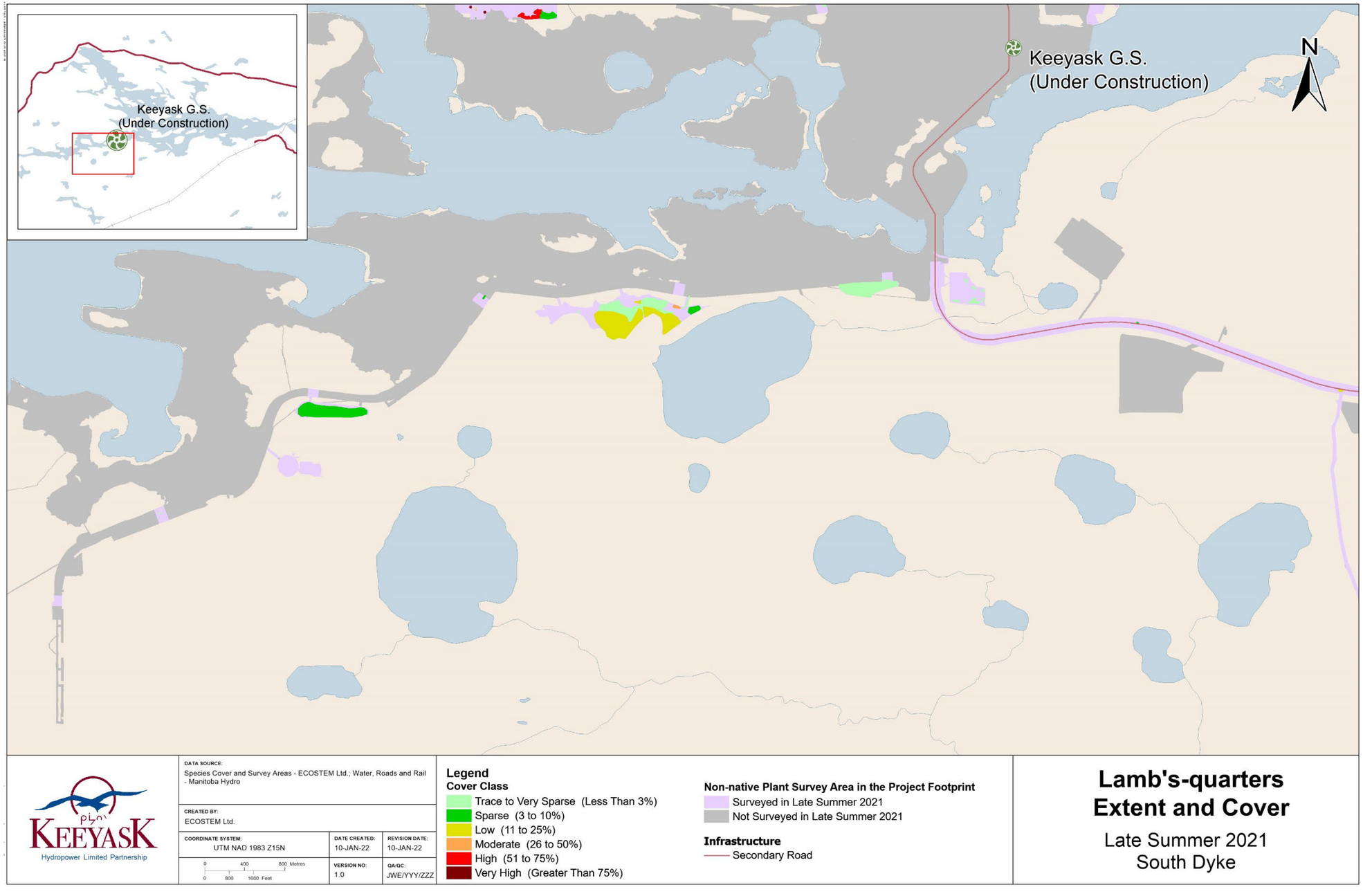
Map 8-2: The distribution and abundance (cover class) of lamb's-quarters in the Project footprint along the eastern portion of the North Access Road in late summer, 2021



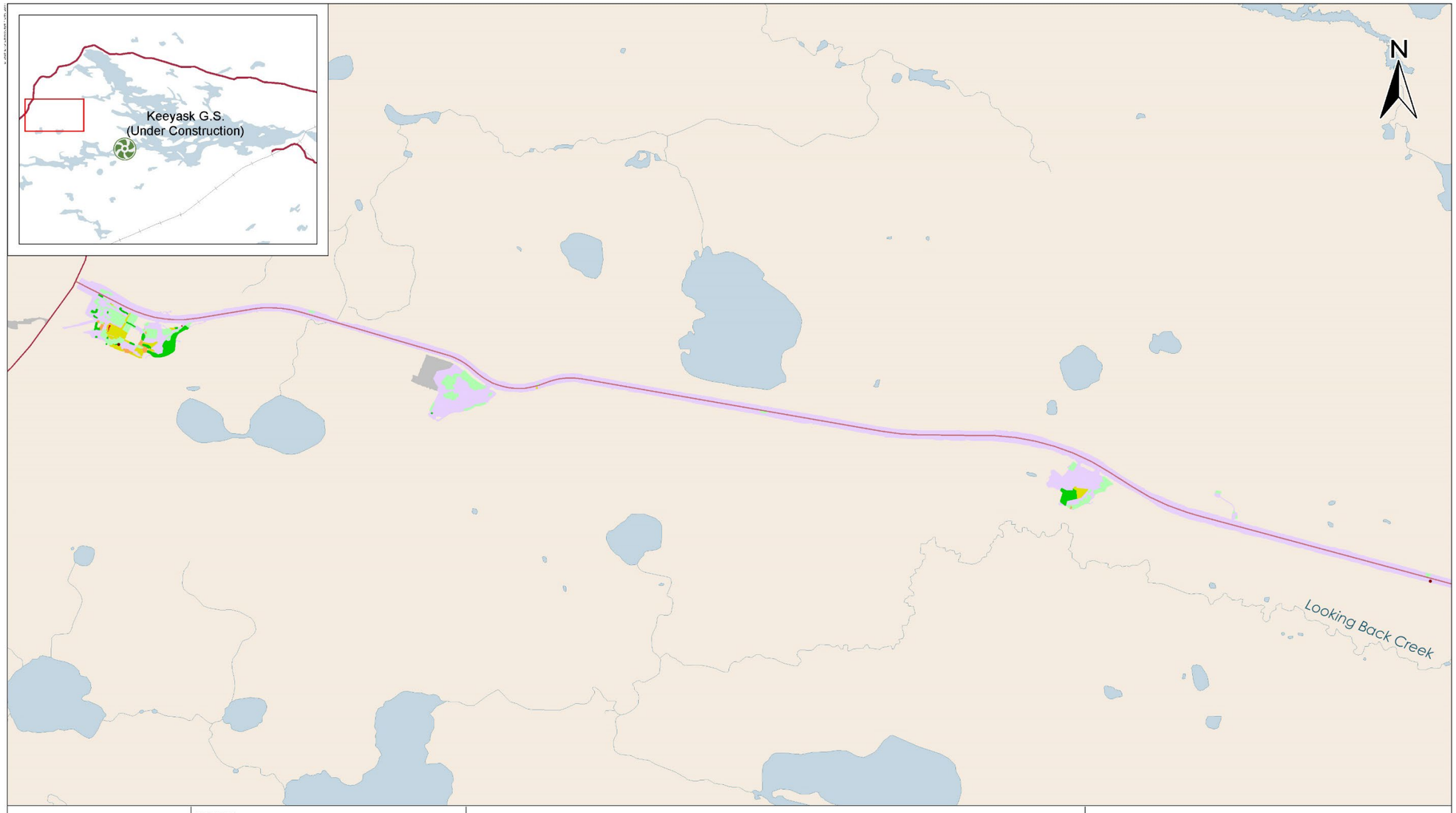
Map 8-3: The distribution and abundance (cover class) of lamb's-quarters in the Project footprint along the western portion of the South Access Road in late summer, 2021



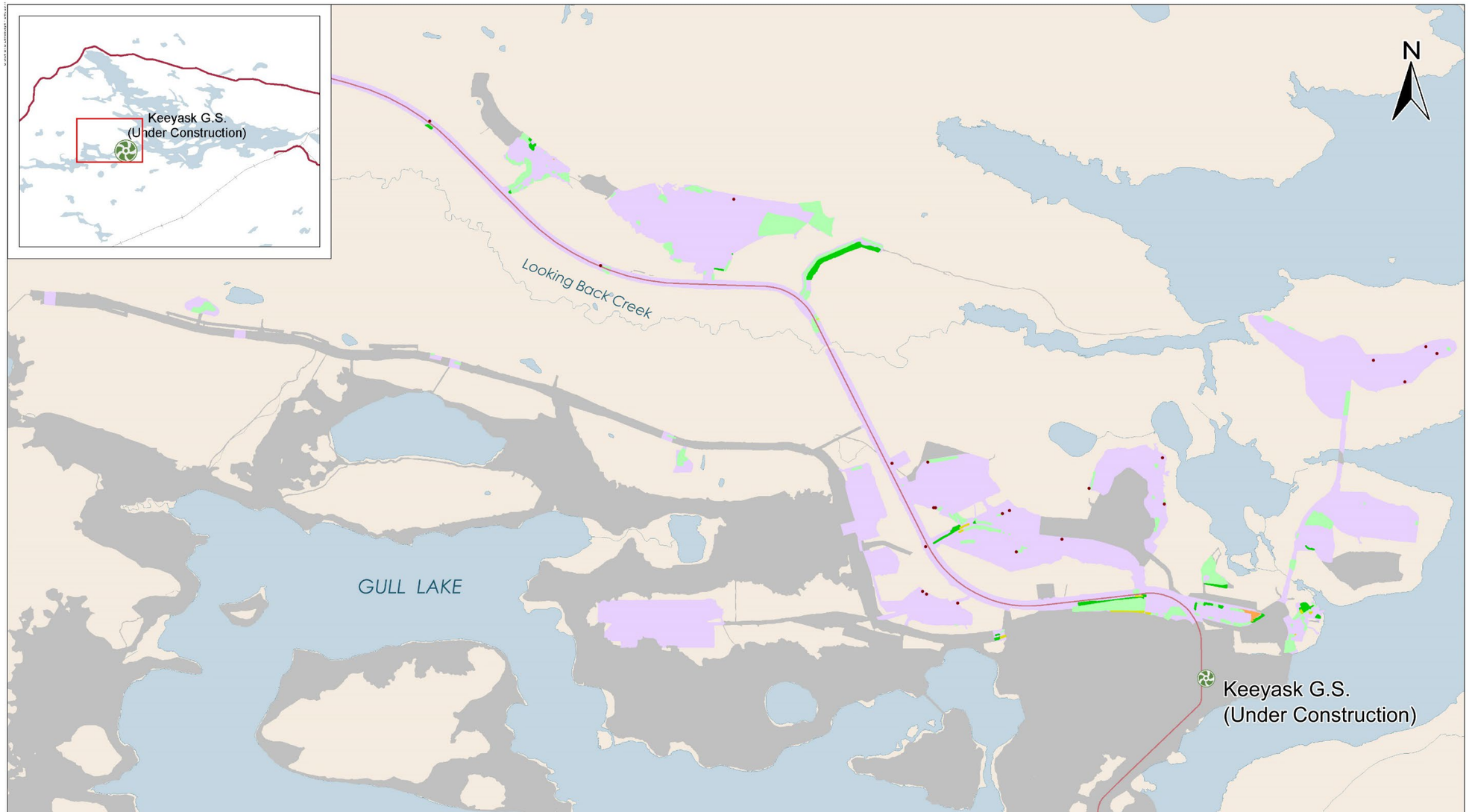
Map 8-4: The distribution and abundance (cover class) of lamb's-quarters in the Project footprint along the eastern portion of the South Access Road in late summer, 2021



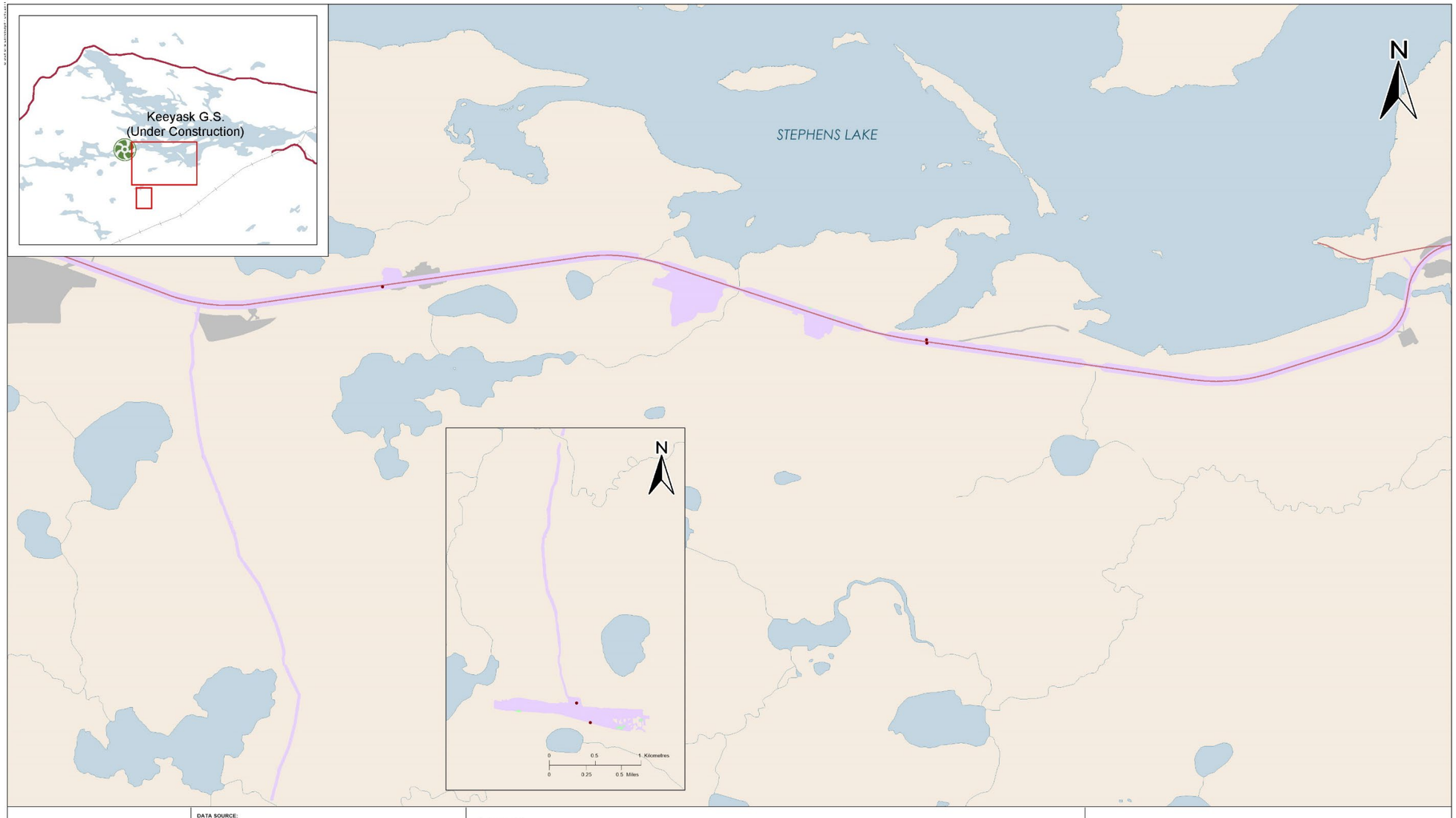
Map 8-5: The distribution and abundance (cover class) of lamb's-quarters in the Project footprint along the South Dyke in late summer, 2021



Map 8-6: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the North Access Road in late summer, 2021



Map 8-7: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the North Access Road in late summer, 2021



DATA SOURCE:
Species Cover and Survey Areas - ECOSTEM Ltd.; Water, Roads and Rail - Manitoba Hydro

CREATED BY:
ECOSTEM Ltd.

COORDINATE SYSTEM: UTM NAD 1983 Z15N

DATE CREATED: 10-JAN-22

REVISION DATE: 10-JAN-22

0 400 800 Metres
0 800 1600 Feet

VERSION NO: 1.0

QA/QC: JWE/YYY/ZZZ

KEEYASK Hydropower Limited Partnership

Legend

Cover Class
- Trace to Very Sparse (Less Than 3%)
- Sparse (3 to 10%)
- Low (11 to 25%)
- Moderate (26 to 50%)
- High (51 to 75%)
- Very High (Greater Than 75%)

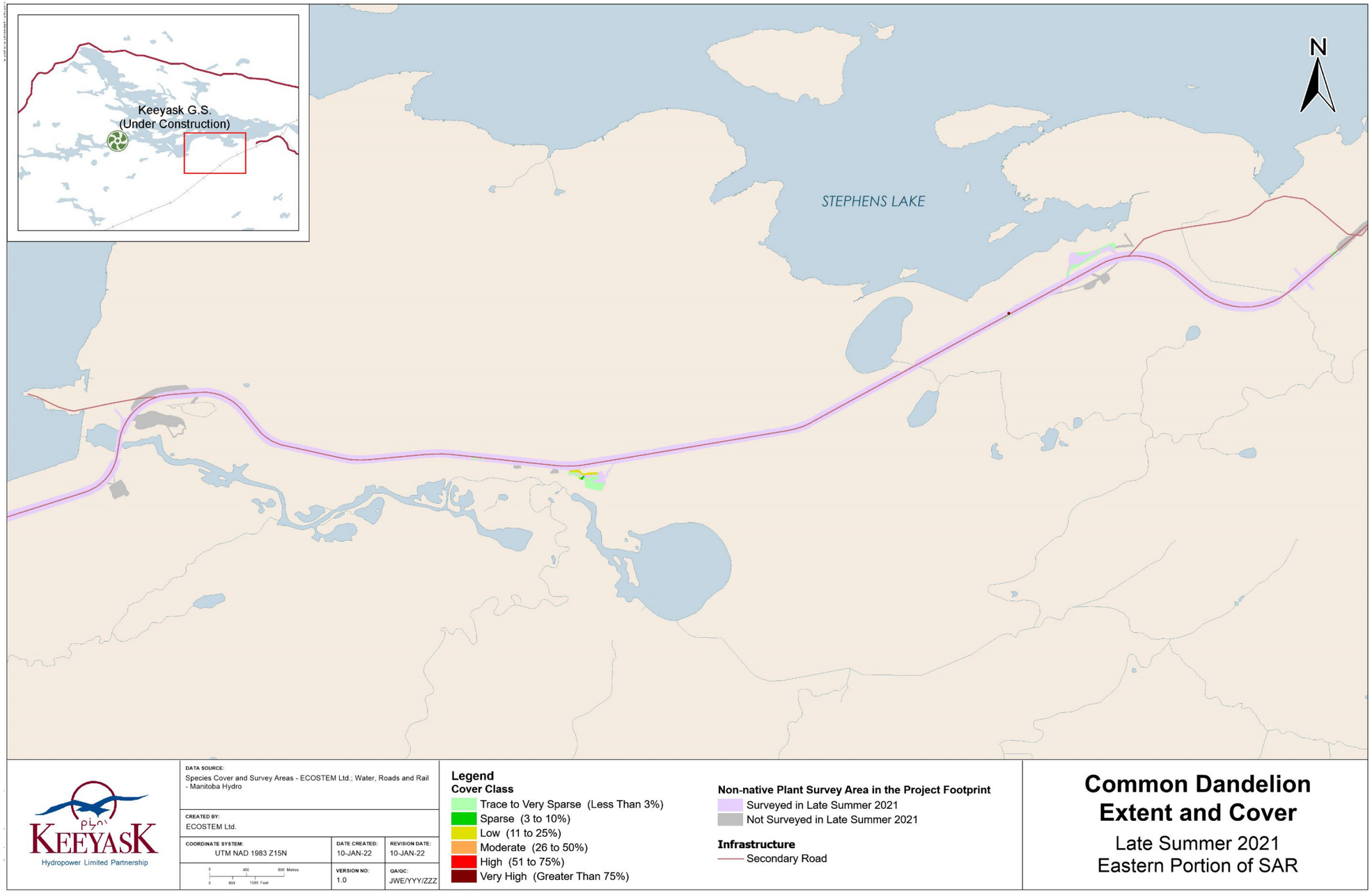
Non-native Plant Survey Area in the Project Footprint
- Surveyed in Late Summer 2021
- Not Surveyed in Late Summer 2021

Infrastructure
- Secondary Road

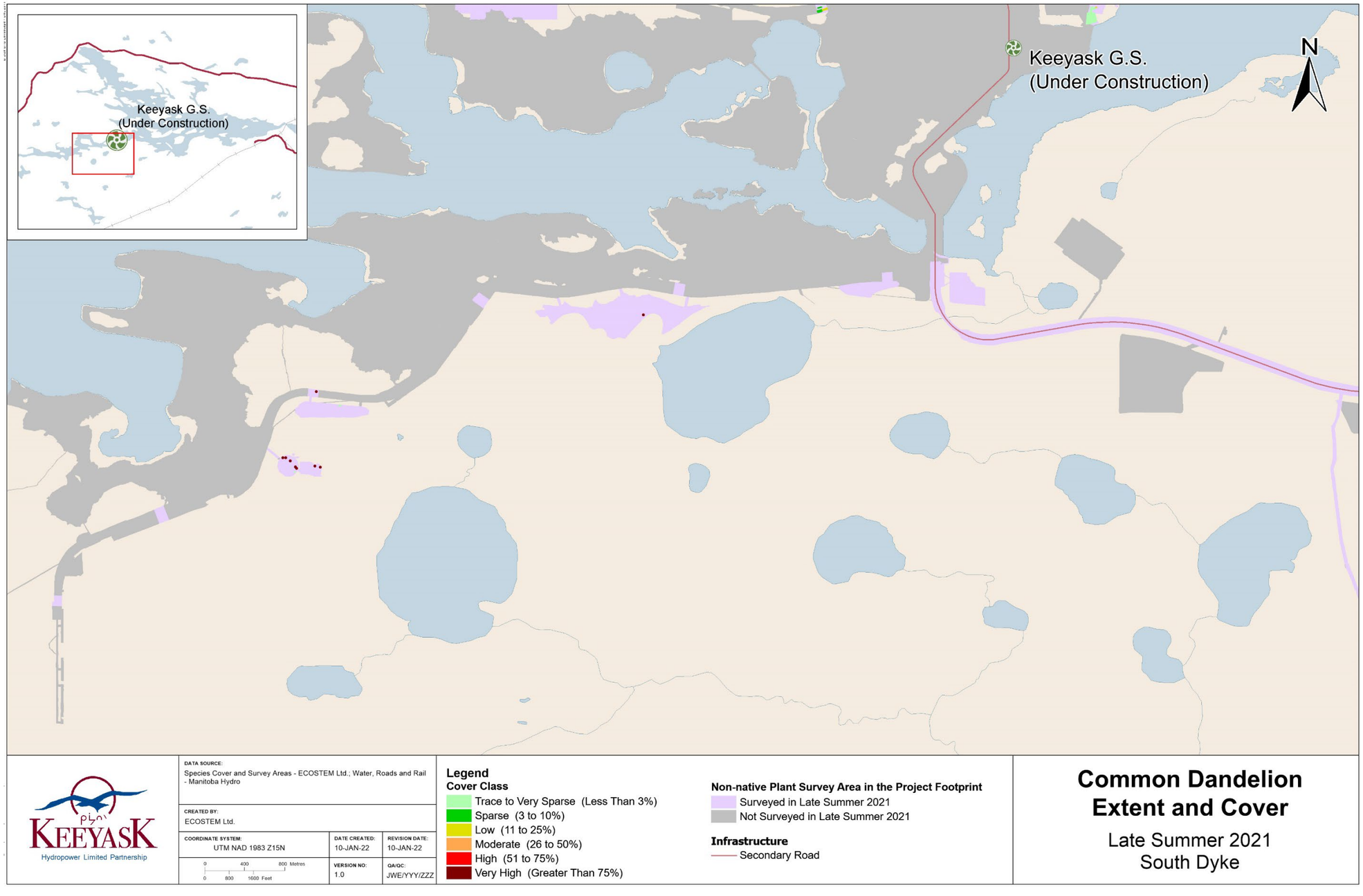
Common Dandelion Extent and Cover

Late Summer 2021
Western Portion of SAR

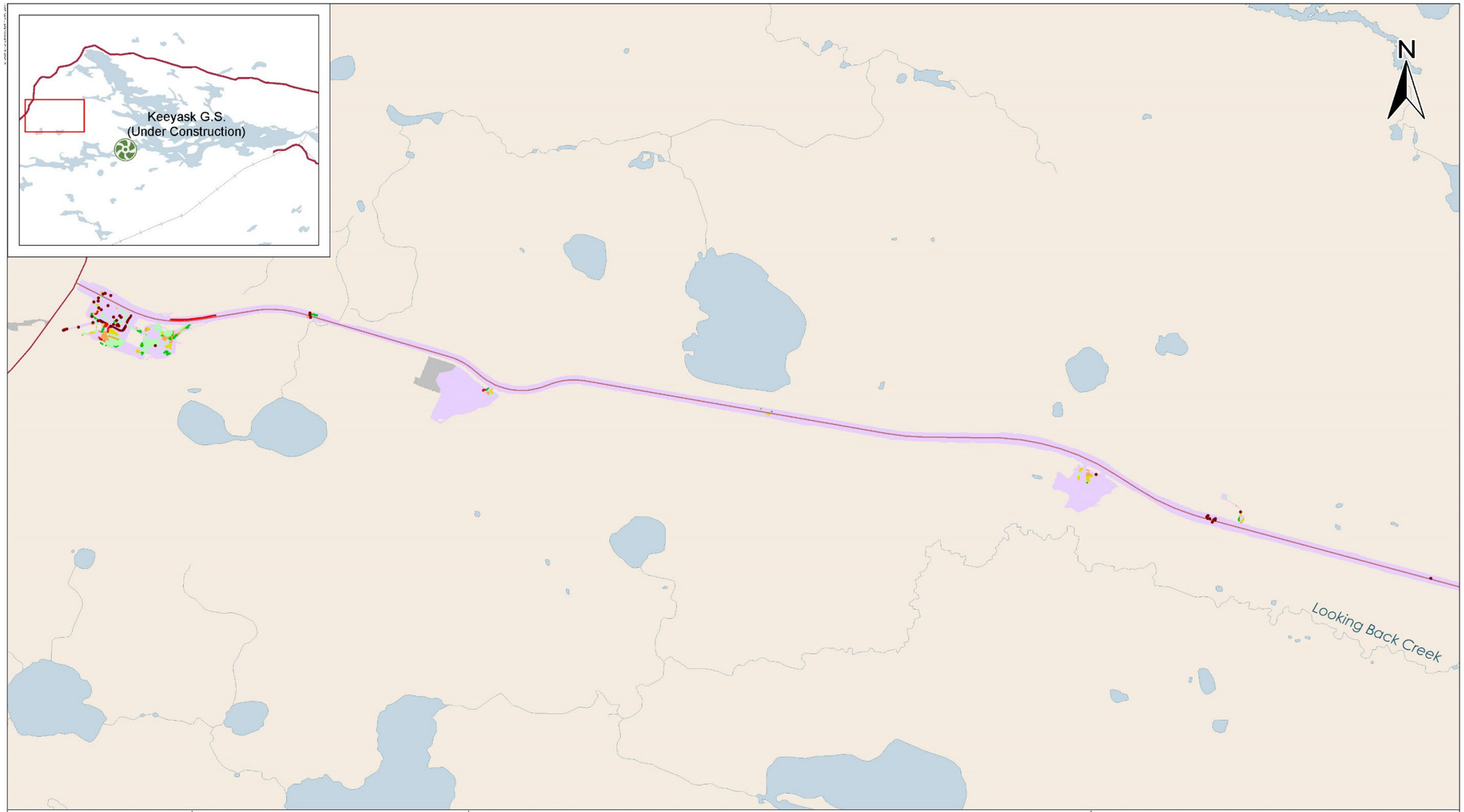
Map 8-8: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the South Access Road in late summer, 2021



Map 8-9: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the South Access Road in late summer, 2021

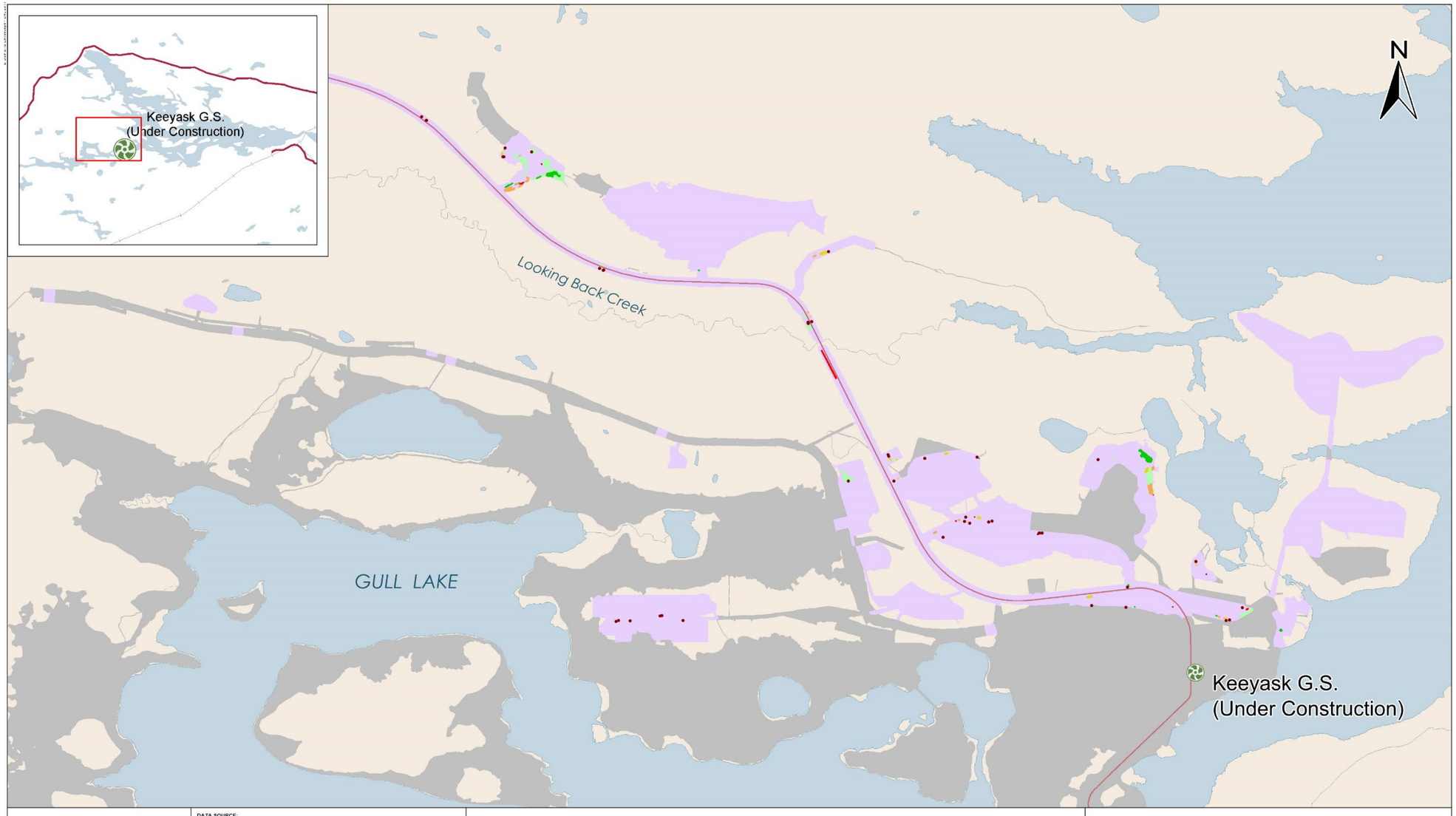


Map 8-10: The distribution and abundance (cover class) of common dandelion in the Project footprint along the South Dyke in late summer, 2021



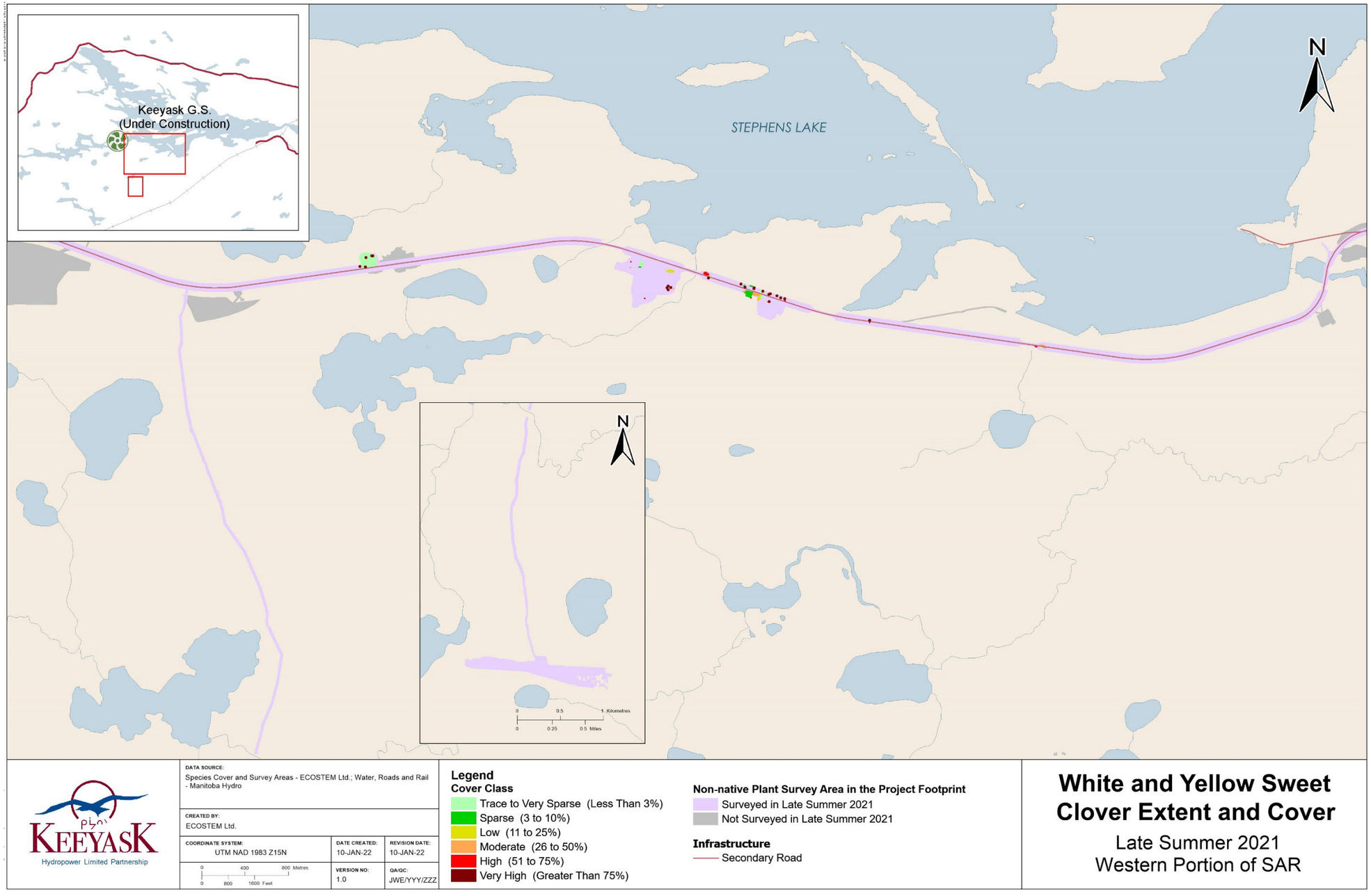
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 8-11: The distribution and abundance (cover class) of sweet clover[1] in the Project footprint along the western portion of the North Access Road in late summer, 2021



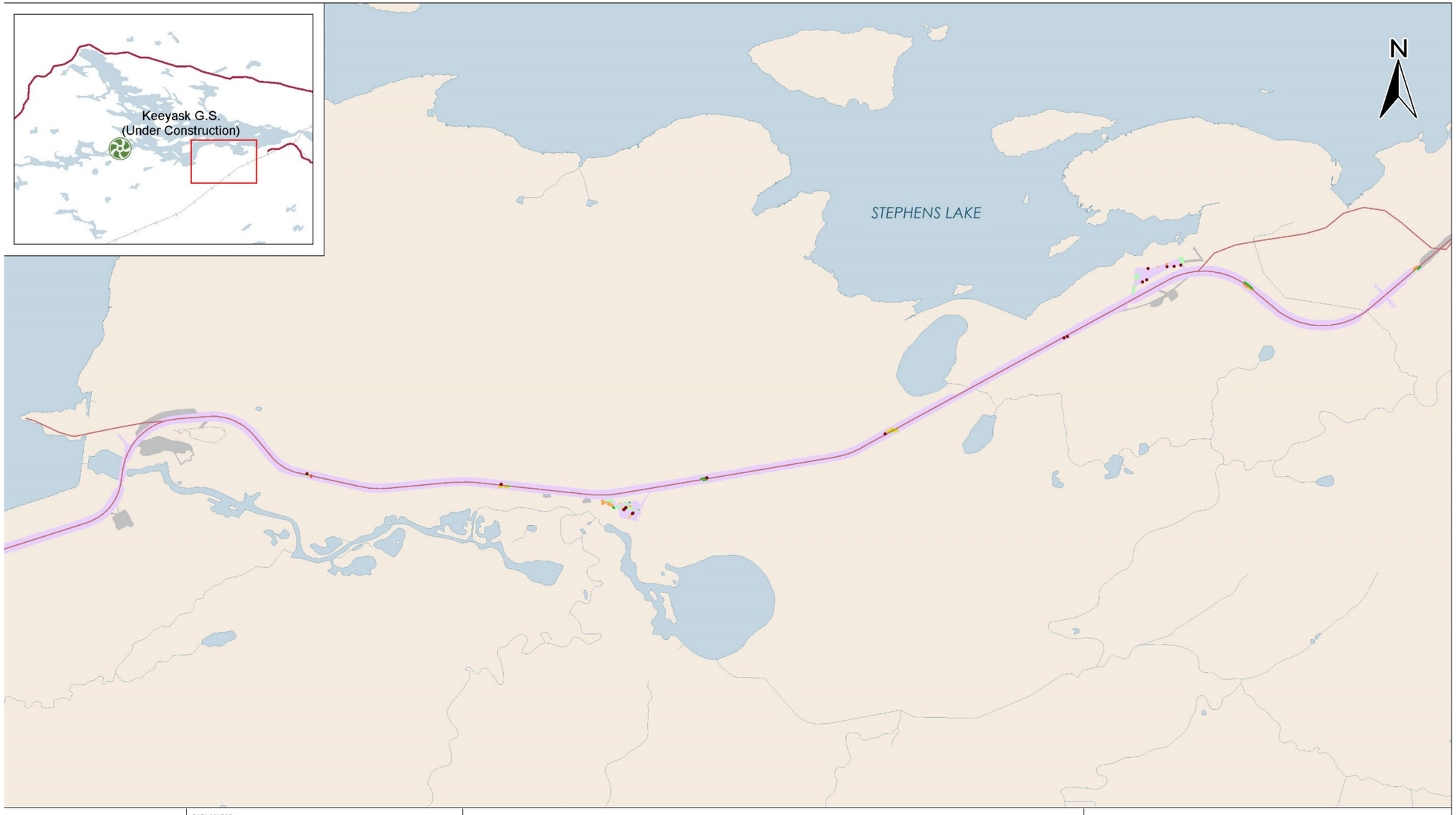
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 8-12: The distribution and abundance (cover class) of sweet clover[1] in the Project footprint along the eastern portion of the North Access Road in late summer, 2021



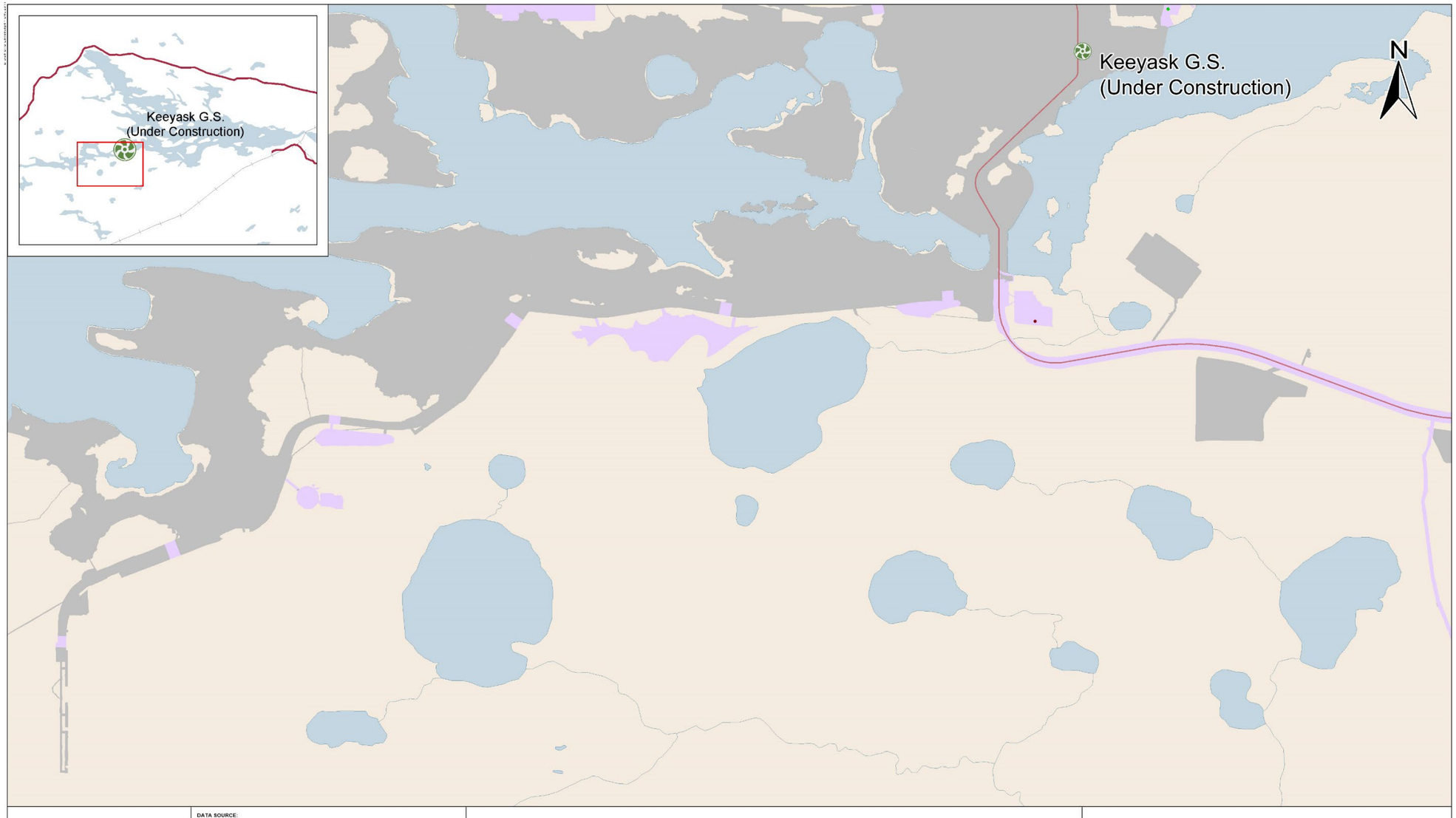
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 8-13: The distribution and abundance (cover class) of sweet clover[1] in the Project footprint along the western portion of the South Access Road in late summer, 2021



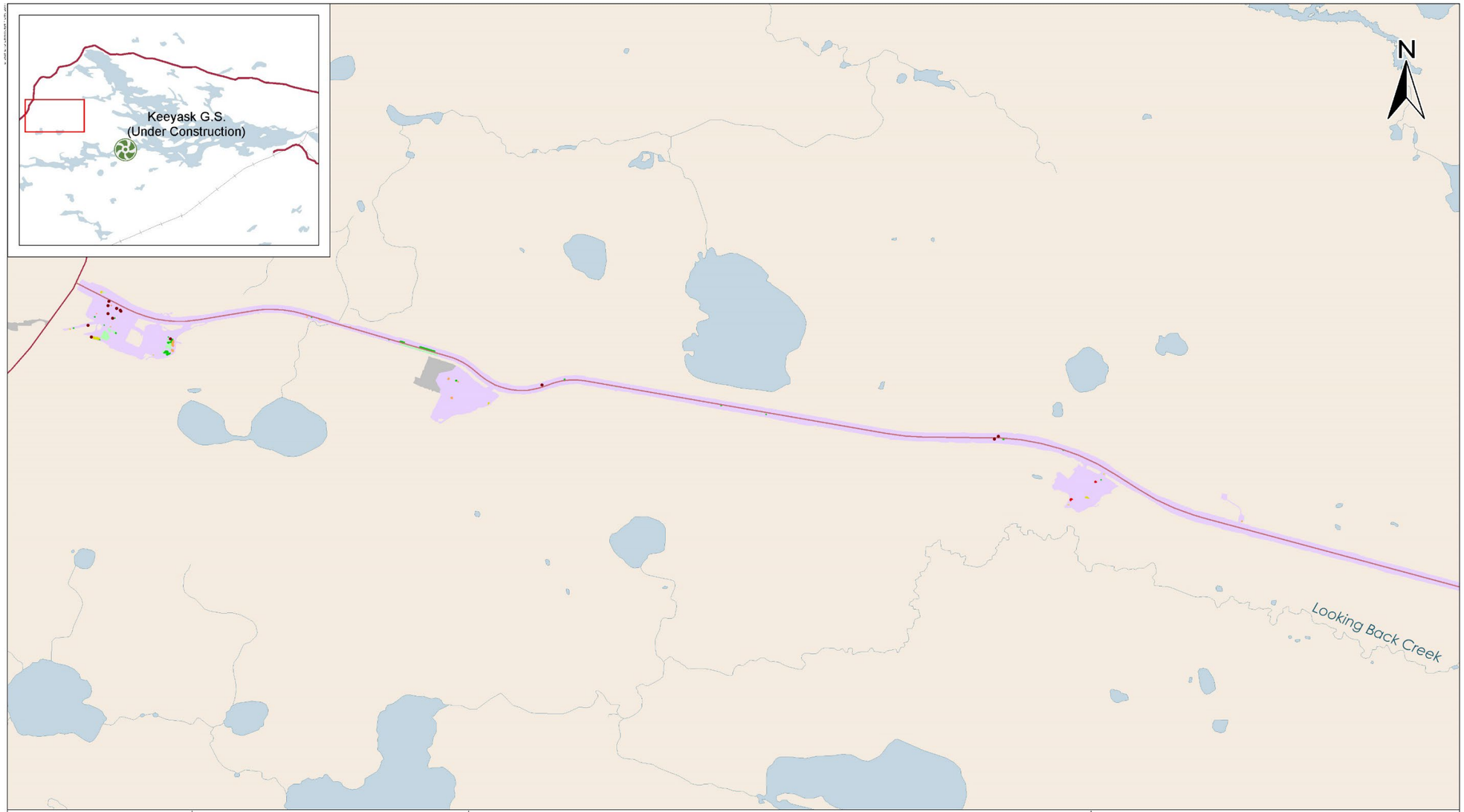
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 8-14: The distribution and abundance (cover class) of sweet clover[1] in the Project footprint along the eastern portion of the South Access Road in late summer, 2021

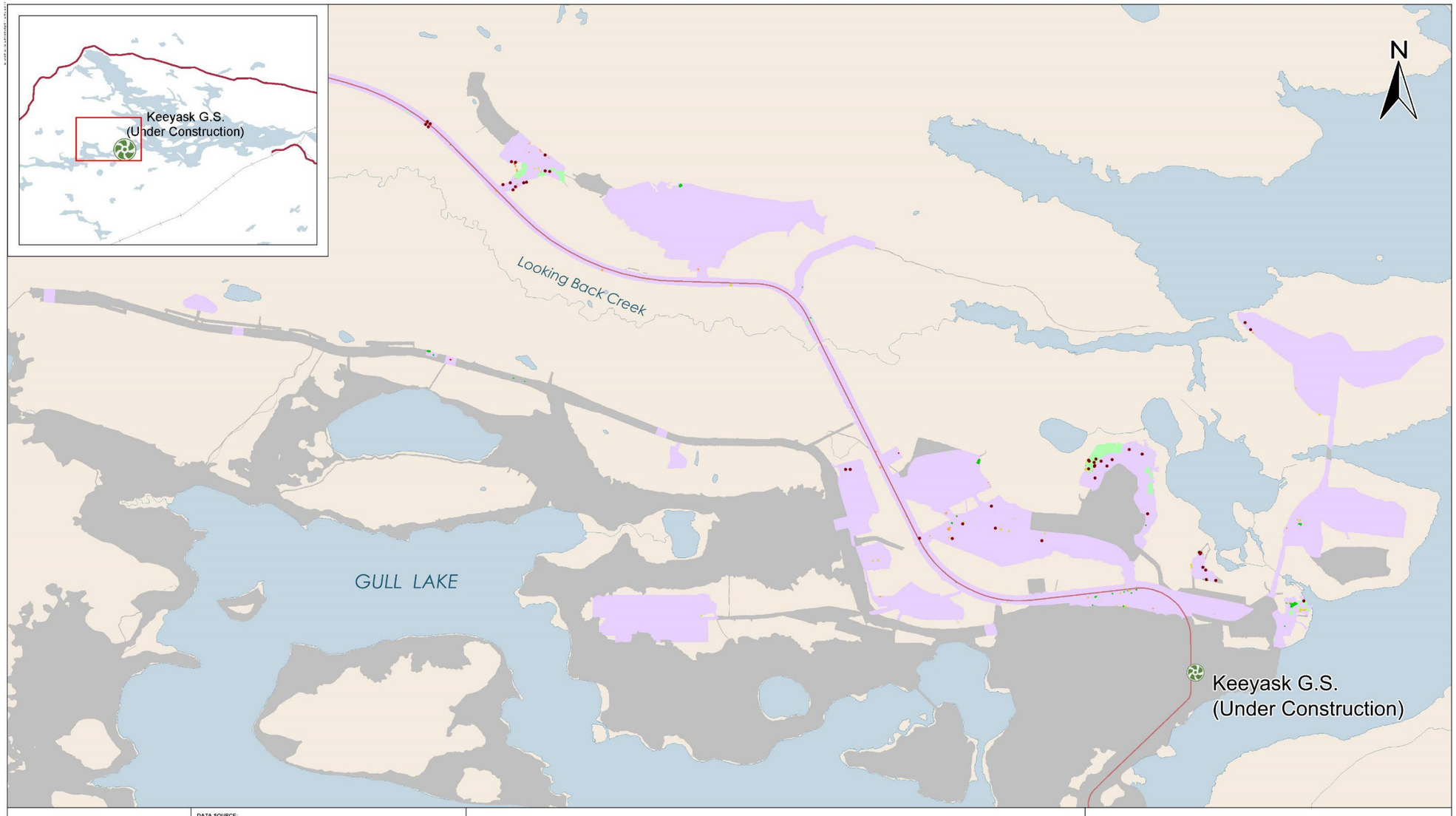


[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

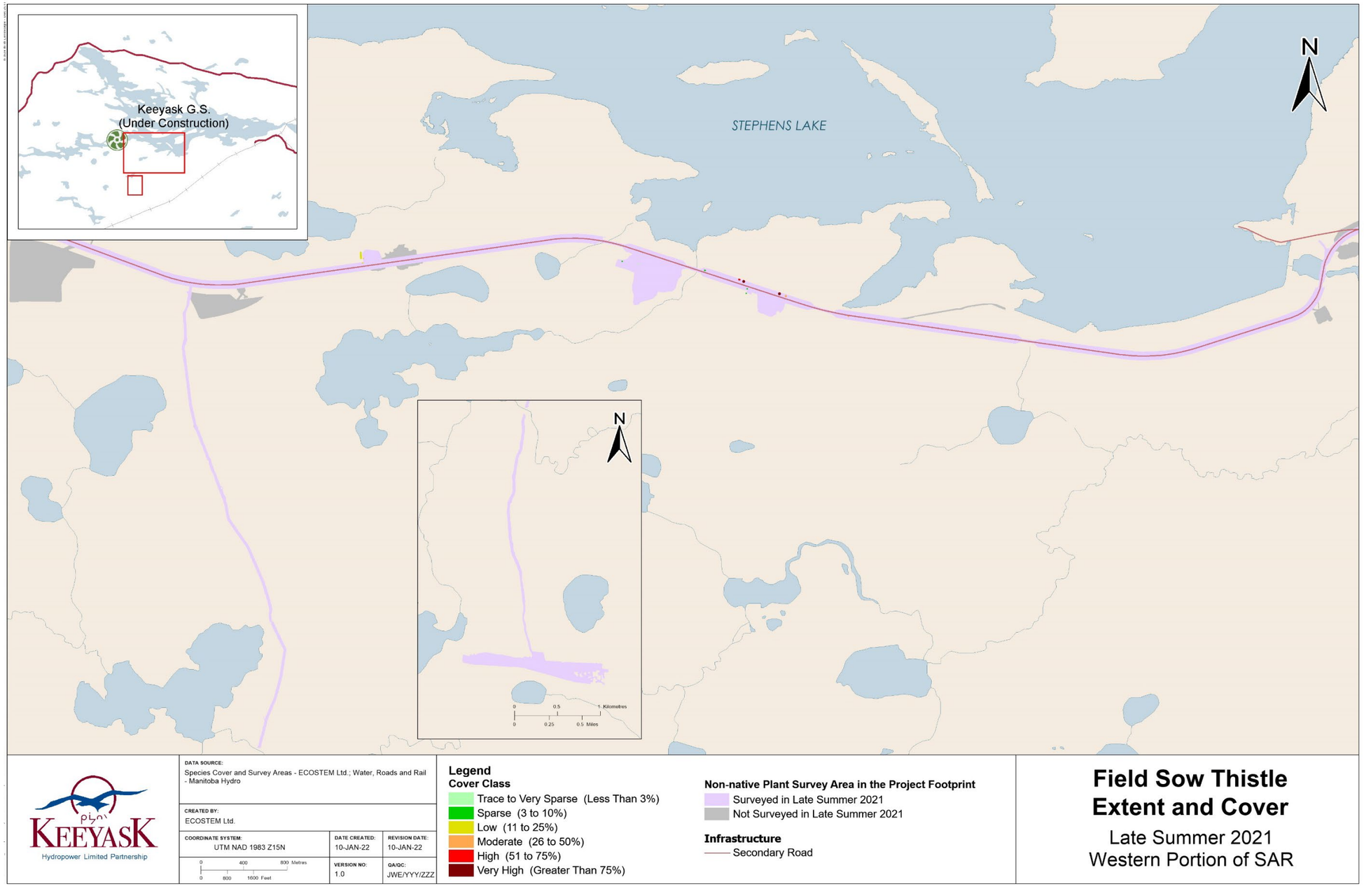
Map 8-15: The distribution and abundance (cover class) of sweet clover[1] in the Project footprint along the South Dyke in late summer, 2021



Map 8-16: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the North Access Road in late summer, 2021

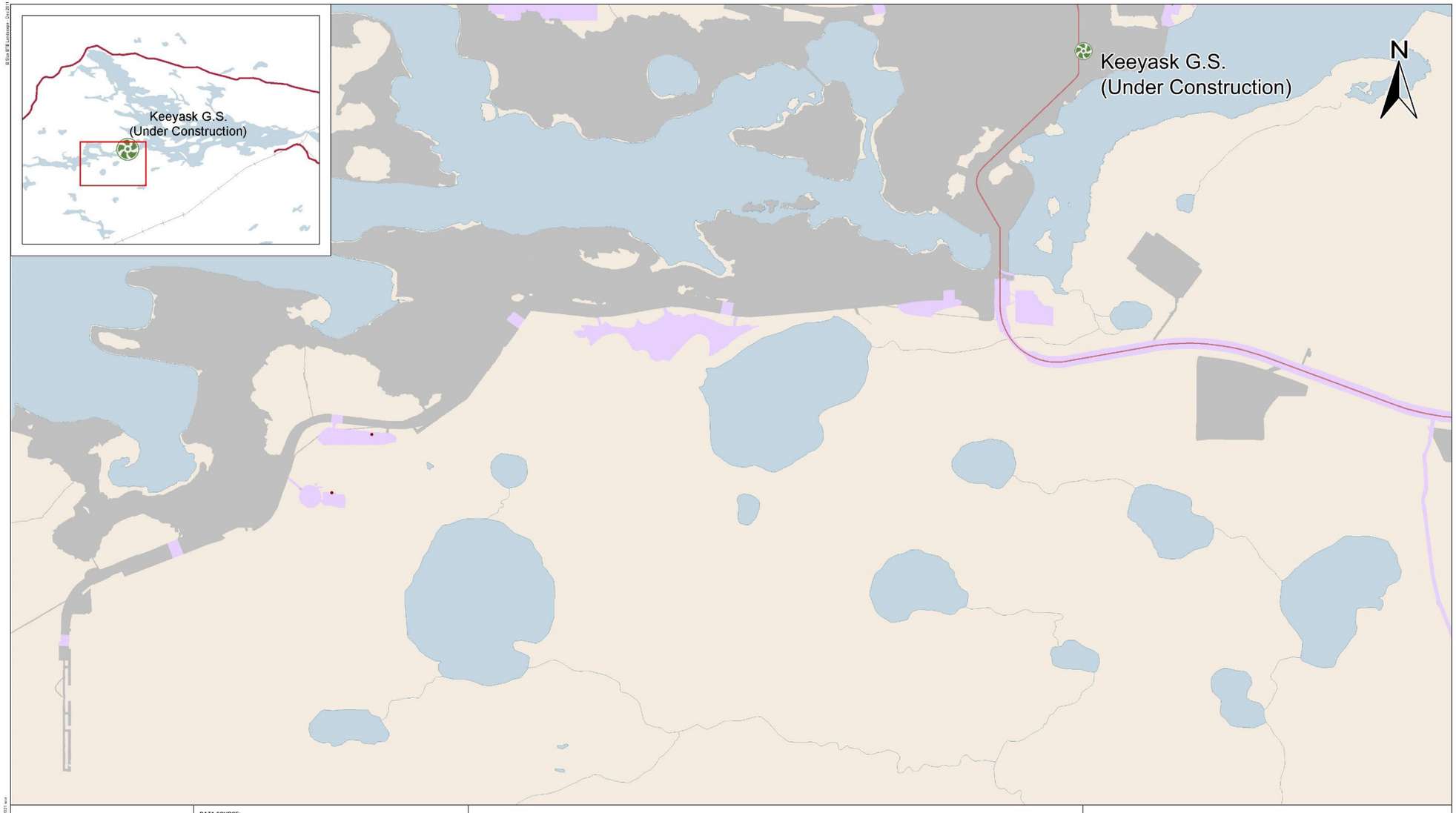


Map 8-17: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the North Access Road in late summer, 2021

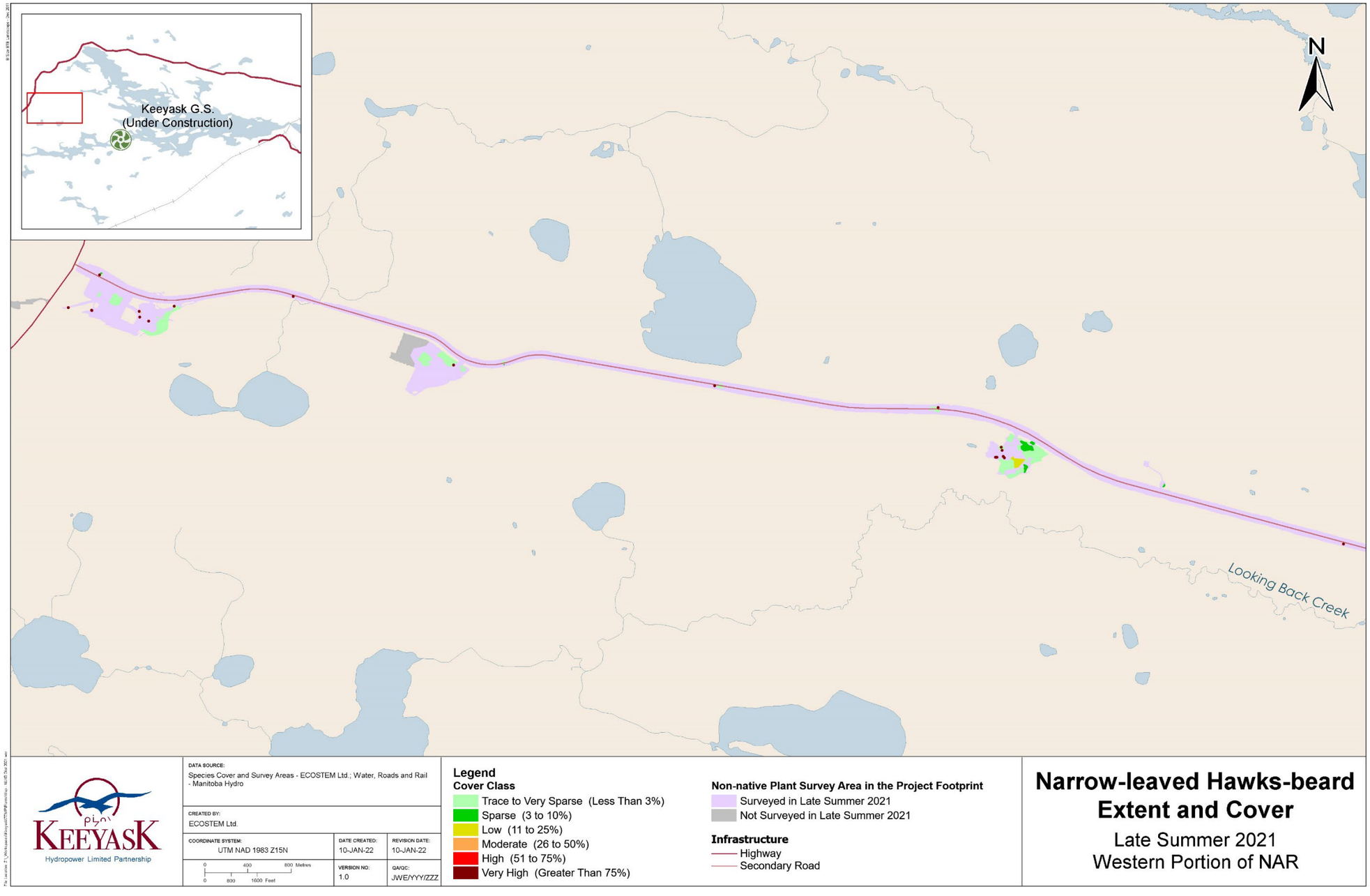


Map 8-18: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the South Access Road in late summer, 2021

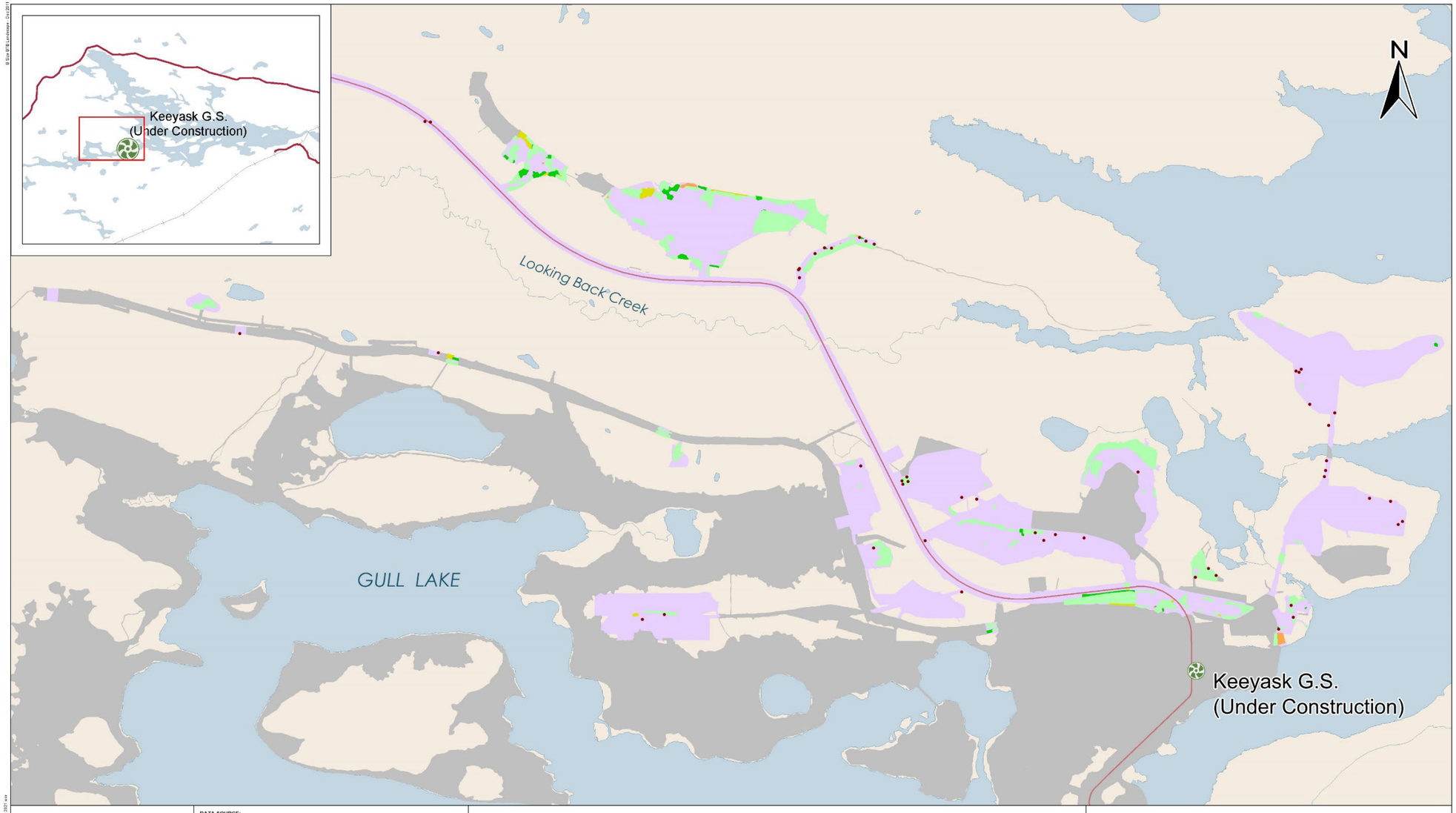
Map 8-19: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the South Access Road in late summer, 2021



Map 8-20: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the South Dyke in late summer, 2021

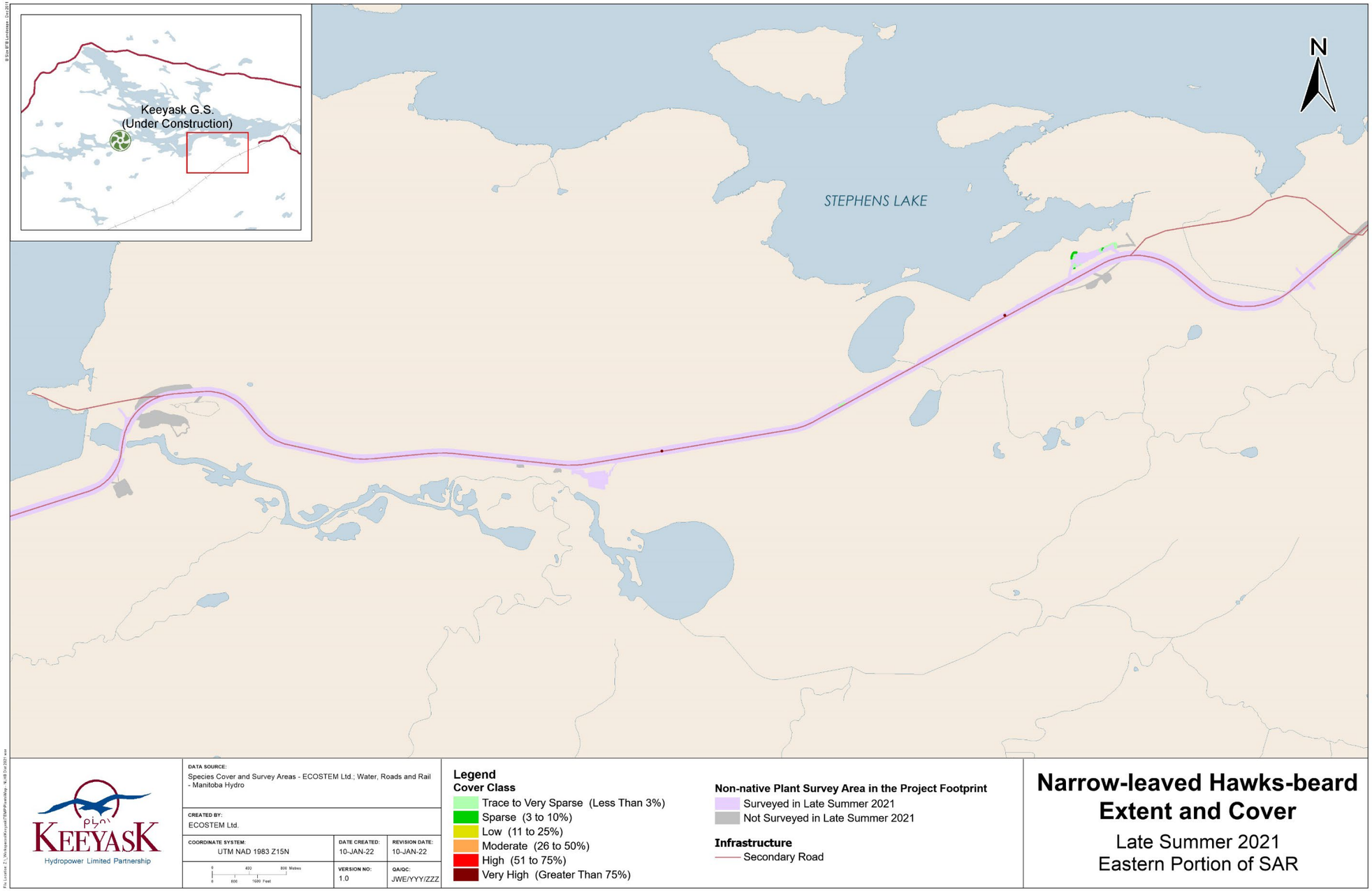


Map 8-21: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the North Access Road in late summer, 2021

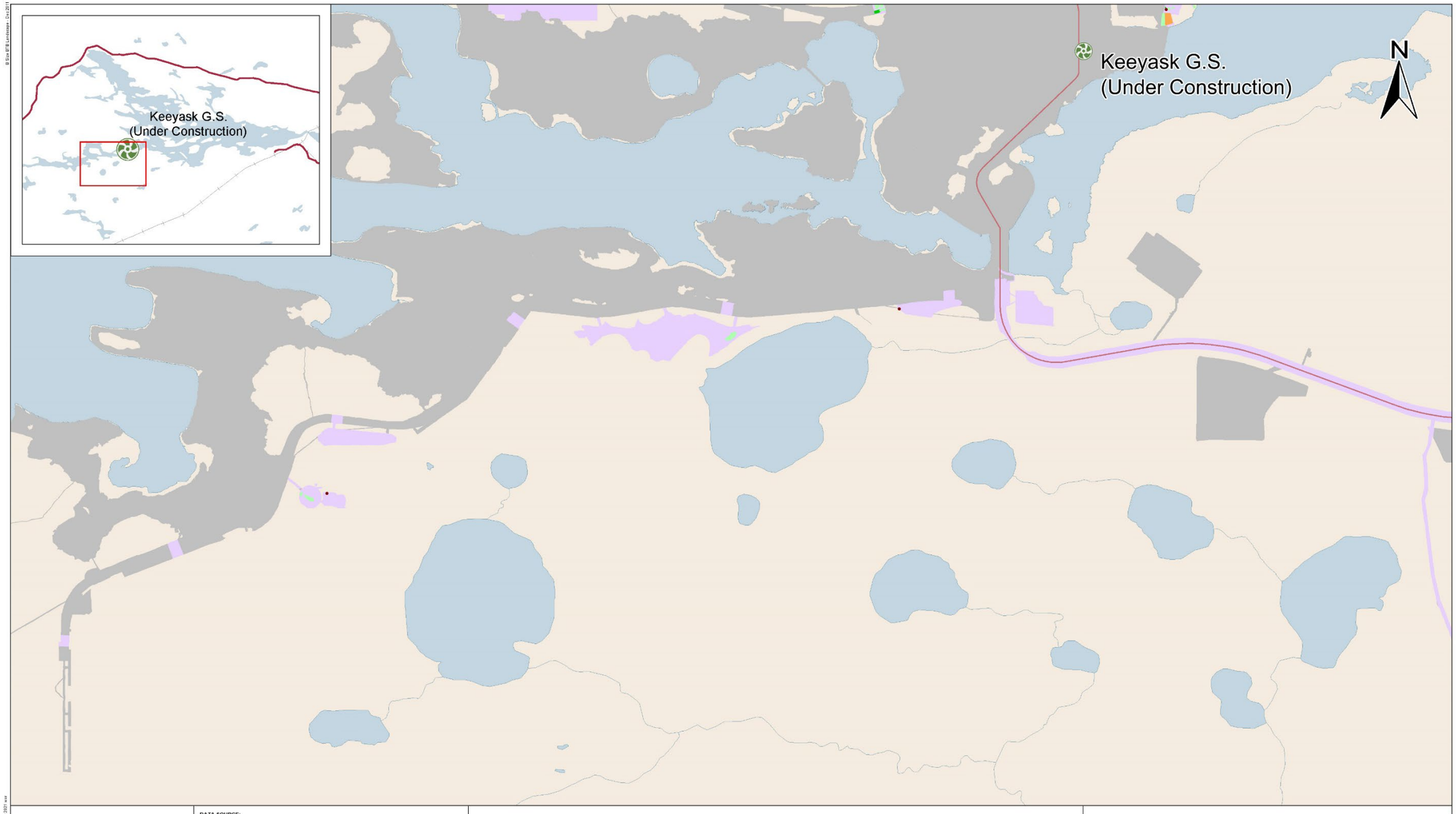


Map 8-22: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the North Access Road in late summer, 2021

Map 8-23: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the South Access Road in late summer, 2021



Map 8-24: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the South Access Road in late summer, 2021



KEEYASK Hydropower Limited Partnership

DATA SOURCE:
Species Cover and Survey Areas - ECOSTEM Ltd.; Water, Roads and Rail - Manitoba Hydro

CREATED BY:
ECOSTEM Ltd.

COORDINATE SYSTEM: UTM NAD 1983 Z15N
DATE CREATED: 10-JAN-22
REVISION DATE: 10-JAN-22
0 400 800 Metres
0 800 1600 Feet
VERSION NO: 1.0
QA/QC: JWE/YYY/ZZZ

Legend

Cover Class
- Trace to Very Sparse (Less Than 3%)
- Sparse (3 to 10%)
- Low (11 to 25%)
- Moderate (26 to 50%)
- High (51 to 75%)
- Very High (Greater Than 75%)

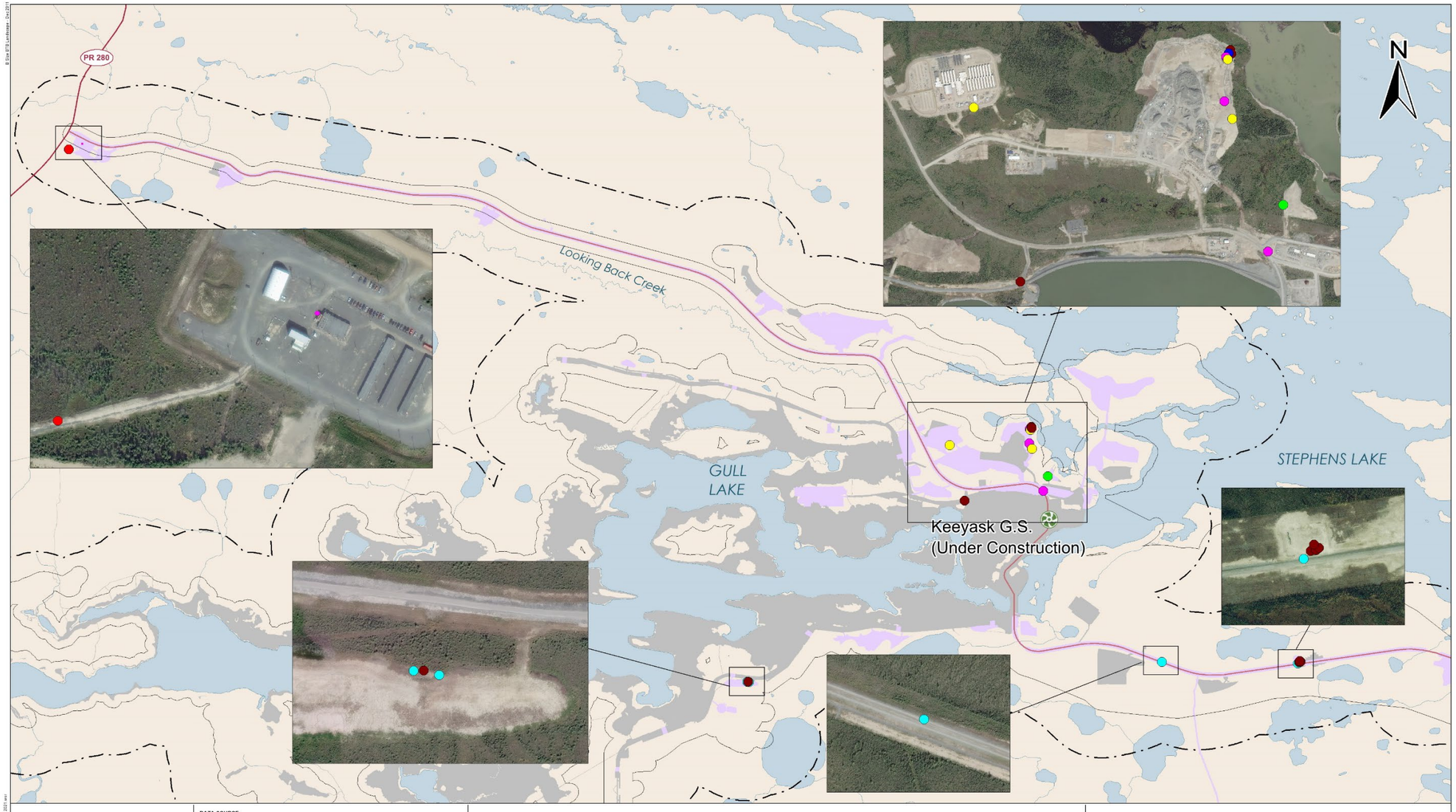
Non-native Plant Survey Area in the Project Footprint
- Surveyed in Late Summer 2021
- Not Surveyed in Late Summer 2021

Infrastructure
- Secondary Road

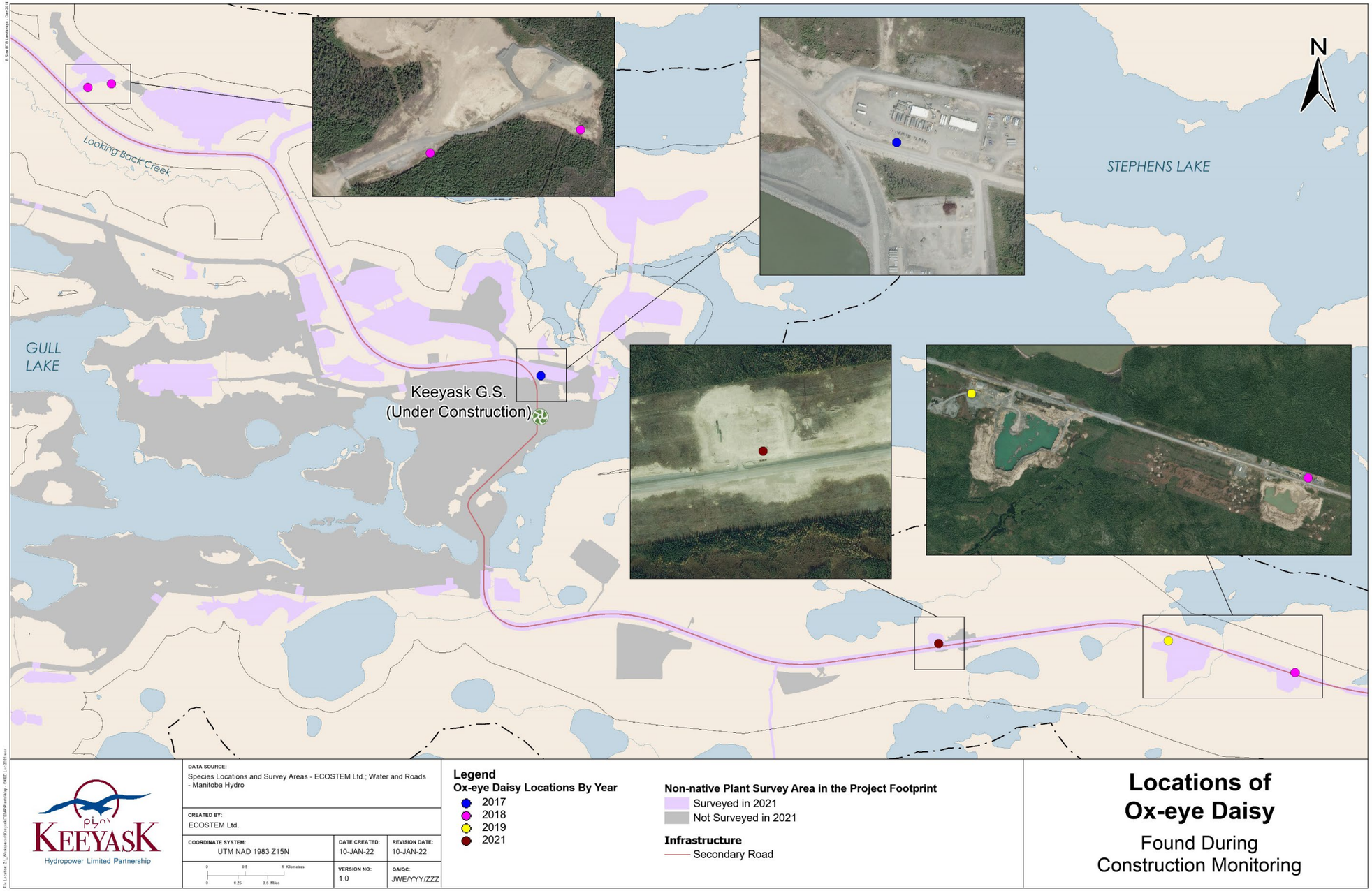
Narrow-leaved Hawks-beard Extent and Cover

Late Summer 2021
South Dyke

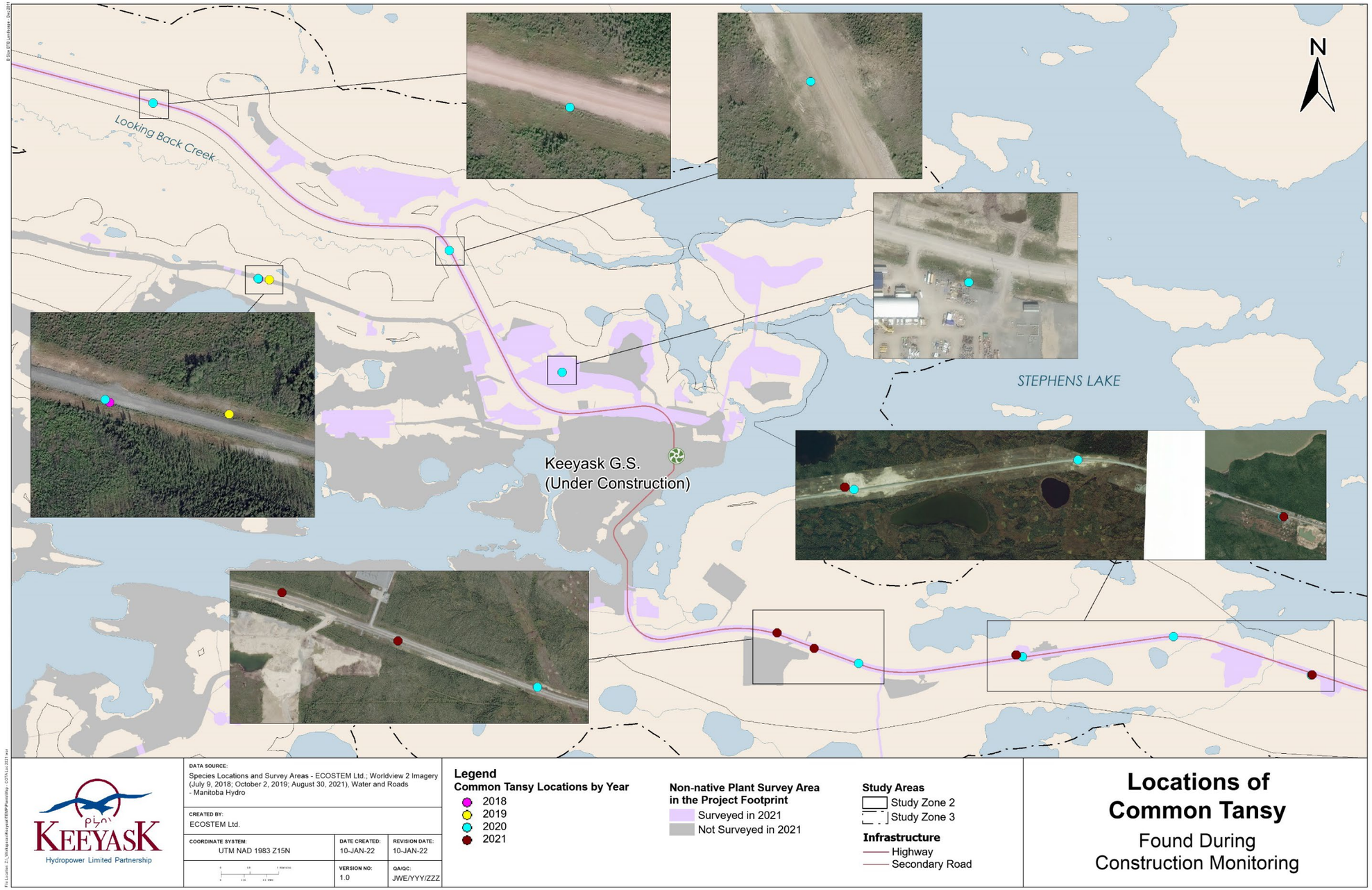
Map 8-25: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the South Dyke in late summer, 2021



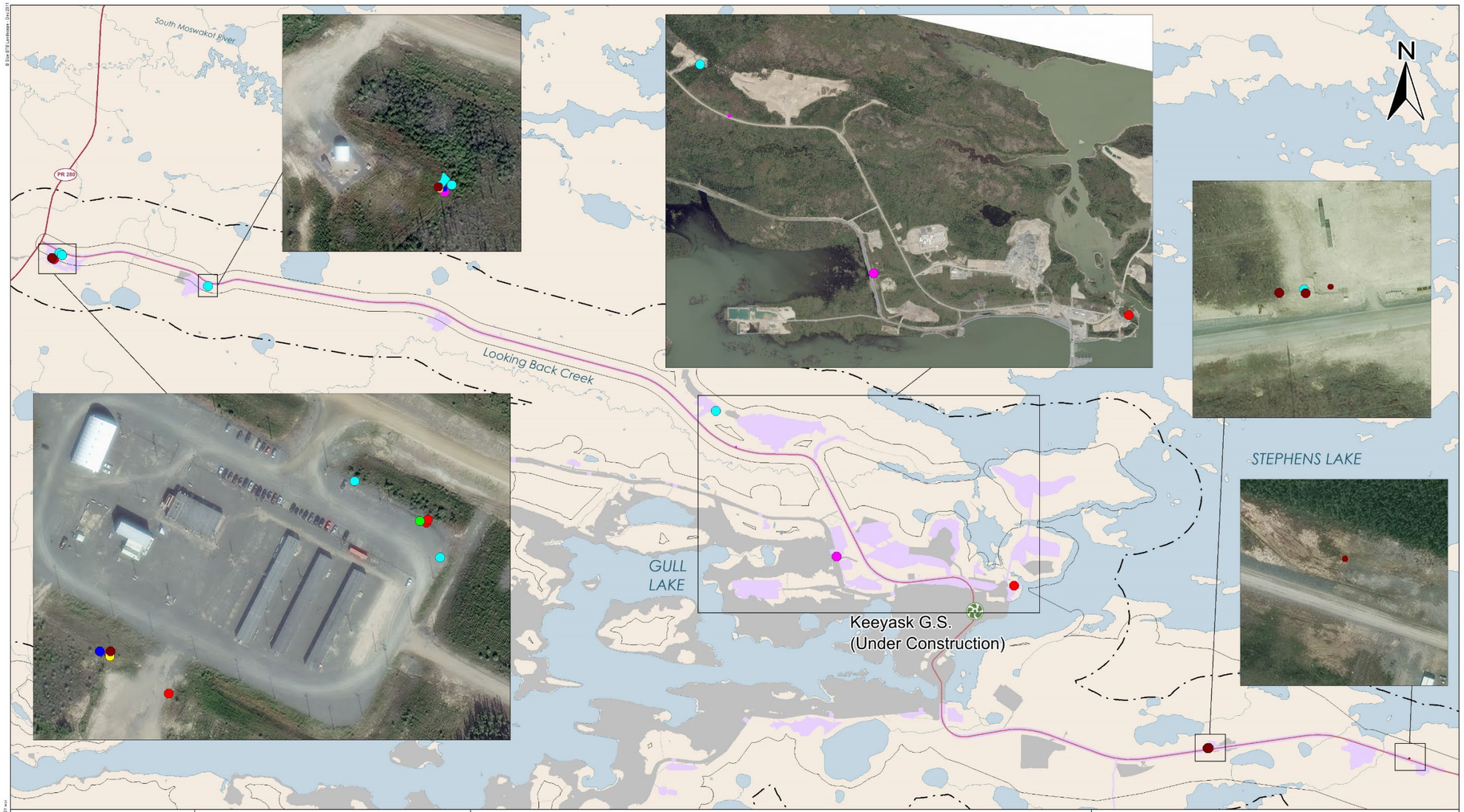
Map 8-26: Locations of scentless chamomile identified during Project construction monitoring



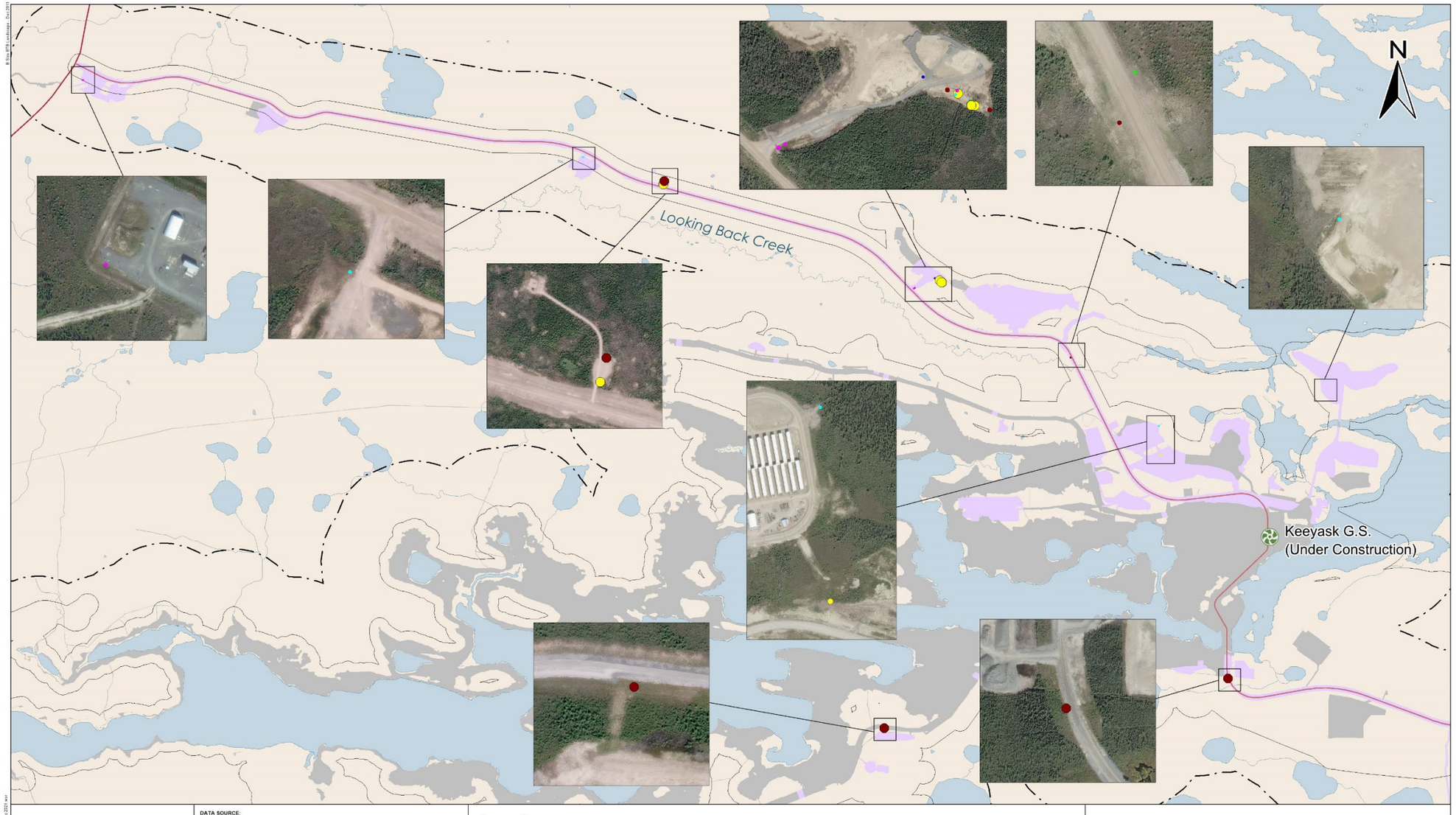
Map 8-27: Locations of Ox-eye Daisy identified during Project construction monitoring



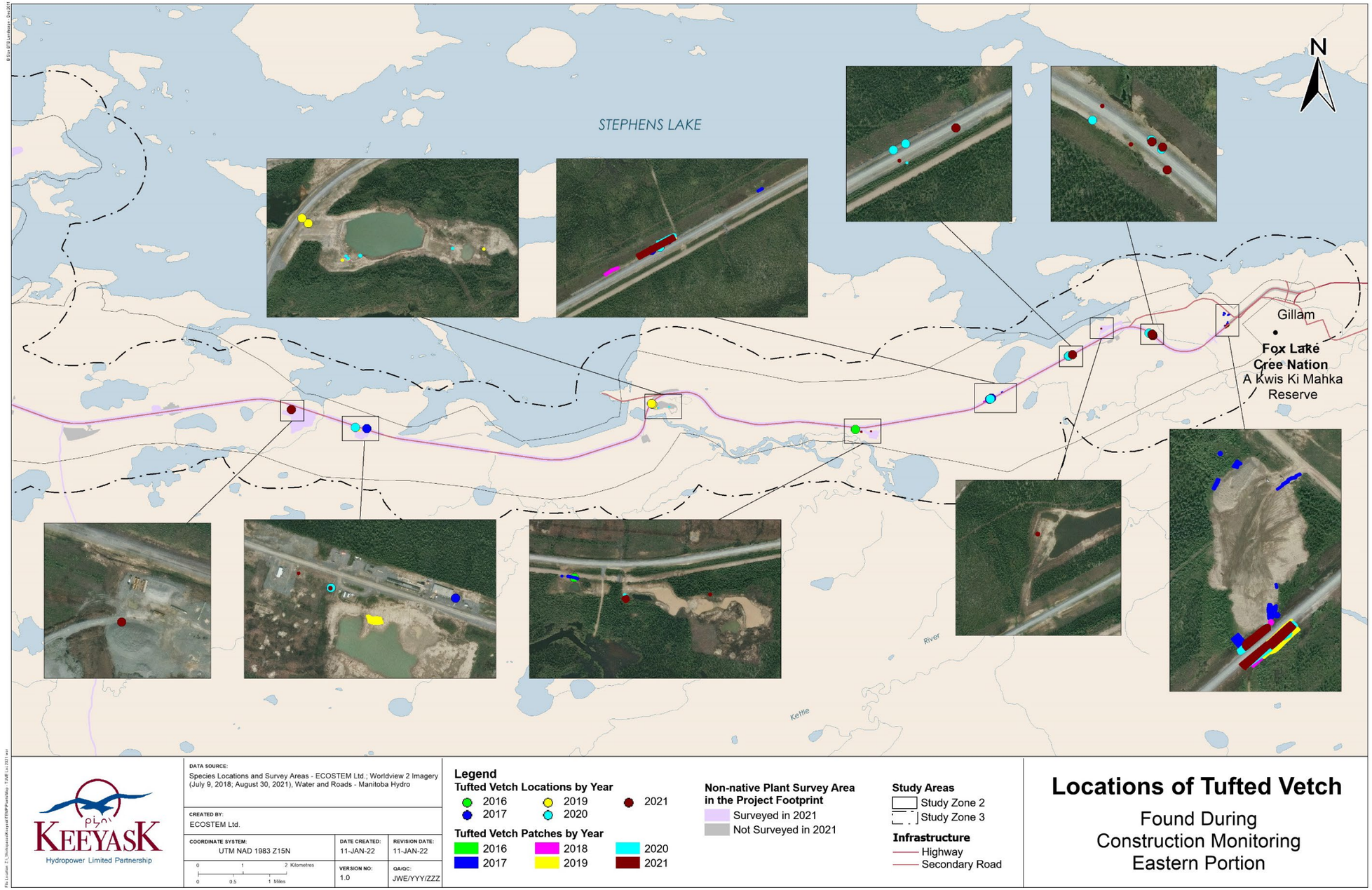
Map 8-28: Location of common tansy identified during Project construction monitoring



Map 8-29: Canada thistle locations identified during Project construction monitoring



Map 8-30: Tufted vetch locations identified during Project construction monitoring (western portion of Project footprint)



Map 8-31: Tufted vetch locations identified during Project construction monitoring (eastern portion of Project footprint)

APPENDIX 4:
ADDITIONAL NON-NATIVE PLANT RESULTS

Table 8-4: Total early and late summer non-native plant extent as a percentage of total area surveyed by year and Project component

Project Component	2014		2015		2016		2017[2]	2018	2019	2020	2021
	ES	LS	ES	LS	ES	LS	LS	LS	LS	LS	LS
North Access Road	0.00	0.32	0.32	0.89	0.01	3.5	4.4	7.6	4.9	4.6	20.7
South Access Road	-	-	-	-	-	0.2	2.8	7.9	7.7	7.9	10.4
Camp & Work Areas	0.56	3.24	3.59	4.66	1.26	4.0	5.9	12.8	13.1	13.9	26.3
Borrow Area	0.02	0.33	0.64	3.09	0.85	2.1	5.1	8.9	8.0	11.5	15.2
North Dyke[1]	-	-	-	-	-	0.1	0.3	7.6	11.5	9.9	16.2
South Dyke[1]	-	-	-	-	0.00	0.0	0.1	0.2	0.2	10.7	43.7
Generating Station Area	-	-	-	-	-	0.5	0.2	-	-	1.0	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-	-	-	-
All	0.30	1.83	1.98	3.70	0.72	2.4	4.3	9.6	9.9	11.9	20.9
Total non-native plant extent (ha)	*0.7*	*4.9*	*4.7*	*9.3*	*4.8*	*14.8*	*28.9*	*64.0*	*69.4*	*73.2*	*145.5*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*	*668*	*703*	*618*	*695*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".ES="Early Summer"; LS="Late Summer".
[1] Due to change in survey methods, 2020 values not directly comparable to previous years. See Section 2.2.1.
[2] Full early summer survey not undertaken in 2017, 2018, 2019, 2020 and 2021.

Table 8-5: Total early and late summer non-native plant cover as a percentage of total area surveyed by year and Project component

Project Component	2014		2015		2016		2017[2]	2018	2019	2020	2021
	ES	LS	ES	LS	ES	LS	LS	LS	LS	LS	LS
North Access Road	0.00	0.01	0.02	0.07	0.00	0.25	0.38	0.62	0.45	0.50	3.53
South Access Road	-	-	-	-	-	0.01	0.36	1.21	2.17	3.96	3.62
Camp & Work Areas	0.06	0.34	0.46	0.77	0.18	0.58	0.73	1.20	1.05	1.54	1.84
Borrow Area	0.00	0.05	0.05	0.48	0.04	0.24	0.46	0.74	0.64	0.66	0.74
North Dyke[1]	-	-	-	-	-	0.00	0.01	0.79	1.10	0.43	0.69
South Dyke[1]	-	-	-	-	0.00	0.00	0.02	0.02	0.00	1.21	3.70
Generating Station Area	-	-	-	-	-	0.03	0.00	-	-	0.11	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-	-	-	-
All	0.03	0.20	0.24	0.59	0.06	0.31	0.44	0.88	0.86	0.99	1.41
Total non-native plant cover (ha)	*0.08*	*0.53*	*0.57*	*1.49*	*0.43*	*1.89*	*2.98*	*5.85*	*6.02*	*6.13*	*9.77*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*	*668*	*703*	*618*	*695*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".ES="Early Summer"; LS="Late Summer".
[1] Due to change in survey methods, 2020 values not directly comparable to previous years. See Section 2.2.1.
[2] Full early summer survey not undertaken in 2017, 2018, 2019, 2020 and 2021.

Table 8-6: Total approximate non-native species cover (m^2) and number of species in the Project footprint, by year and season

Common Name	2014		2015		2016		2017		2018		2019		2020	2021
	ES	LS	ES	LS	ES	LS	ES[1]	LS	ES[1]	LS	ES[1]	LS	LS	LS
Common Burdock	-	-	-	-	-	0	-	-	2	5	-	5	-	-
Wormwood	-	-	0	0	0	1	0	1	-	1	-	-	1	3
Canola	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Shepherd's-Purse	-	-	-	-	-	-	-	-	-	-	-	0	0	1
Lamb's-quarters	89	2,903	1,115	8,844	990	6,342	131	15,229	-	19,709	0	25,817	11,113	32,493
Canada Thistle	-	-	0	0	-	0	-	1	1	2	-	1	5	4
Narrow-leaved Hawks-beard	-	-	-	-	-	586	191	1,314	-	11,040	0	10,808	13,778	12,548
Flixweed	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Wormseed Mustard	-	-	-	-	-	-	-	-	-	-	-	495	470	81
Ox-eye Daisy	-	-	-	-	-	-	0	-	-	0	-	0		0
Bird's-foot Trefoil	-	-	-	-	0	0	-	0	-	-	-	0	2	1
Pineapple-weed	-	-	7	18	0	29	-	325	-	74	-	32	78	86
Black Medick	-	0	-	1	-	-	-	0	-	-	-	-	3	-
Alfalfa	119	124	0	11	4	14	4	40	-	98	-	102	139	319
White Sweet Clover	-	532	1,742	2,252	900	3,015	11	4,949	-	11,508	-	7,839	8,907	18,799
Yellow Sweet Clover	-	0	-	2	7	109	-	254	-	543	0	1,235	2,652	3,861
Unidentified Sweet Clover	387	72	-	-	565	1,838	1,372	67	-	307	0	851	567	1,537
Spotted Lady's-Thumb	-	-	-	-	-	-	-	-	-	-	-	77	752	2,529
Common Timothy	-	-	-	-	-	0	101	0	-	0	0	0	13	12
Common Plantain	27	80	56	121	68	268	97	246	-	741	0	674	1,108	1,667
Curled Dock	-	-	-	-	-	100	19	19	-	148	0	204	465	97
Rye	-	0	-	-	-	-	-	-	-	-	-	-	-	-

Common Name	2014		2015		2016		2017		2018		2019		2020	2021
	ES	LS	ES	LS	ES	LS	ES[1]	LS	ES[1]	LS	ES[1]	LS	LS	LS
Smooth Catchfly	-	-	0	5	16	26	1	32	-	294	-	338	855	1,048
Field Sow-thistle	38	252	301	972	52	1,111	420	1,656	14	2,543	0	3,338	2,674	2,580
Common Tansy	-	-	-	-	-	-	-	-	-	0	-	0	2	4
Common Dandelion	143	1,291	2,316	2,422	1,654	5,268	1,465	5,521	-	10,199	0	6,792	14,638	18,189
Alsike Clover	-	25	145	242	43	190	2	91	-	833	0	1,021	2,250	839
Red Clover	-	0	-	0	-	-	0	1	-	0	-	0	6	14
White Clover	-	0	-	0	0	0	-	-	-	-	-	0	0	1
Scentless chamomile	-	-	-	0	-	0	-	0	-	1	-	0	0	4
Wheat	-	-	-	-	-	30	-	21	0	-	-	-		-
Tufted Vetch	-	-	-	-	0	0	2	38	2	170	0	563	821	1,032
Number of non-native species	7	12	11	16	13	21	16	21	5	21	10	25	27	25

Notes: Numbers that round to zero shown as "0"; absences shown as "-". ES="Early Summer"; LS="Late Summer".
[1] Full early summer survey not undertaken in 2017, 2018 and 2019. Cover only includes patches mapped using full method.
[2] Species difficult to distinguish until they flower are combined into a broader taxon. Unidentified sweet clover includes white sweet clover and yellow sweet clover.

Table 8-7: Total late summer non-native plant extent by project and year as a percentage of area surveyed

Footprint Use	2014	2015	2016	2017	2018	2019	2020	2021
Keeyask Infrastructure Project	0.5	3.7	7.5	29.4	23.2	21.0	20.0	34.2
Both Keeyask Infrastructure and Keeyask Generation Projects	2.4	3.7	4.2	6.9	15.1	16.2	18.3	24.7
Keeyask Generation Project	-	-	0.3	0.4	4.1	5.2	5.2	17.1

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

Table 8-8: Total late summer non-native plant cover by project and year as a percentage of area surveyed

Footprint Use	2014	2015	2016	2017	2018	2019	2020	2021
Keeyask Infrastructure Project	0.1	0.6	1.1	2.3	1.1	0.8	0.8	2.0
Both Keeyask Infrastructure and Keeyask Generation Projects	0.2	0.6	0.5	0.8	1.5	1.4	1.5	1.6
Keeyask Generation Project	-	-	0.06	0.03	0.4	0.5	0.6	1.2

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

APPENDIX 5:
REED CANARYGRASS RESULTS

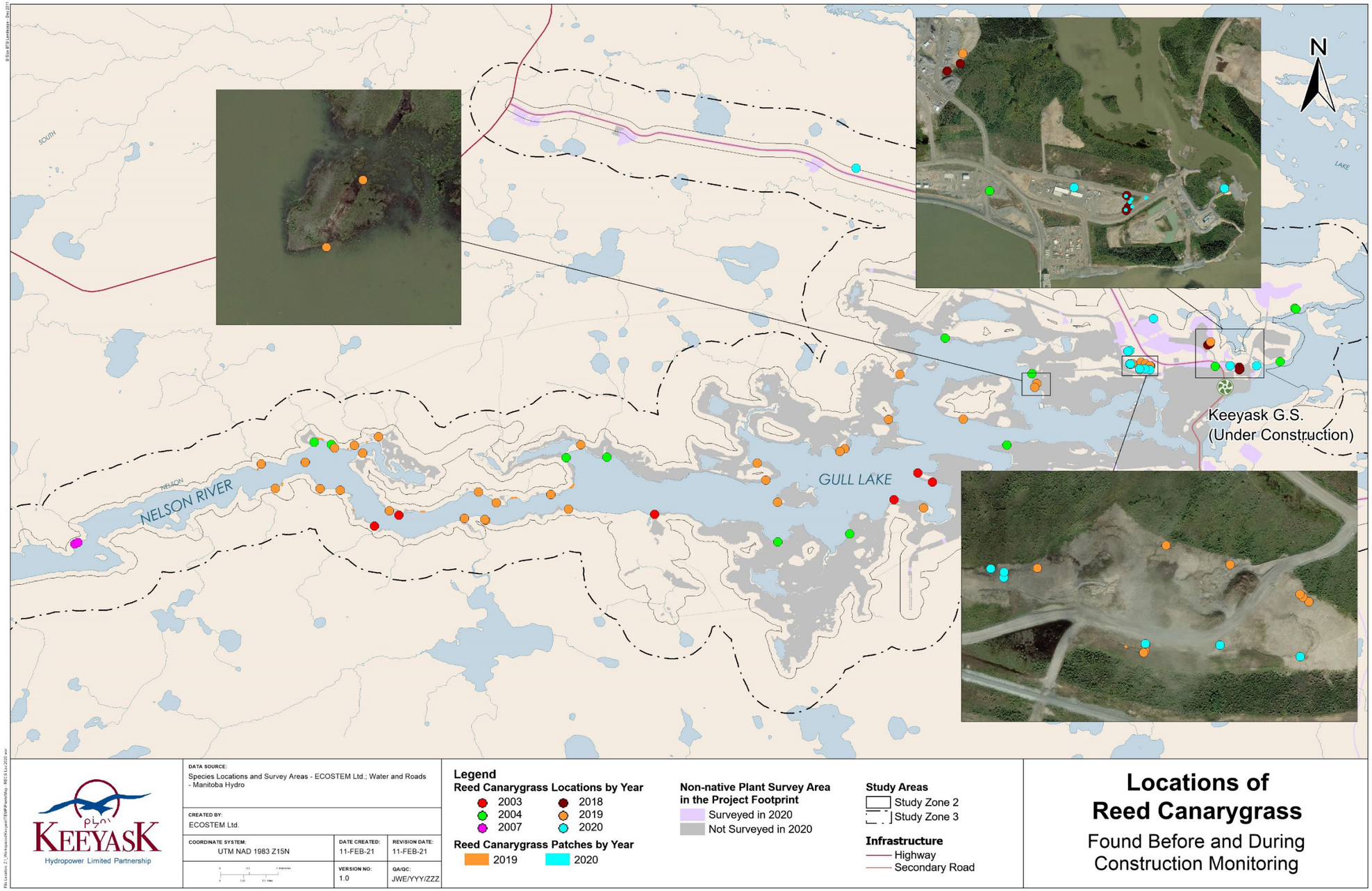
Reed Canarygrass

In 2021, reed canarygrass (*Phalaris arundinacea*; Photo 8-1) was not encountered.

The plant has previously been found at 26 sites near and along the Nelson River shoreline between Clark and Stephens Lakes during plant surveys in 2003, 2004 and 2007, at five sites in the Project footprint in 2018, in 2019 it was found at 10 sites in the footprint, and 42 sites along the shoreline upstream of the Keeyask Generating Station and in 18 sites in 2020. It is uncertain whether the plant was introduced by Project construction activity, or if it spread to this location from a pre-existing population outside of the Project footprint.

Due to the reasons stated in Section 2.7, reed canarygrass found during the monitoring is not being included as a non-native species. Recorded plant locations will be monitored, however, and mitigation options will be considered in the future if the plant appears to become invasive.

Photo 8-1: Reed canarygrass growing in Work Area B on August 26, 2018



Map 8-32: Reed canarygrass locations identified before and during Project construction monitoring