Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Invasive Plant Spread and Control Monitoring Report

TEMP-2018-05

KEEYASK

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KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2018-05

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. This report describes the results of invasive and other non-native plant monitoring conducted during the fourth summer of Project 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 things on the land. Non-native plants are also a concern because they could be invasive in some local conditions or in the future with changing climate, or they could interfere with rehabilitating native habitat in sites 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 species are found, and to help decide where to carry out measures to control the plants that can become quite a problem in the Project footprint.

What was done?

In 2017, non-native plant surveys were carried out within most of the cleared Project areas from July 5 to 10, and again from August 20 to 31. Some areas were not surveyed because the people doing the surveys could not safely access them due to construction activity, or because they were very recently cleared and non-native plants would not yet have had time to establish.

What was found?

The late summer cover and extent of all non-native plants combined increased from the 2016 to the 2017 surveys. However, non-native plants still covered less than 1% of the surveyed area. As was the case in 2016, most of the non-native plant cover was within cleared areas that were either there before the Project (e.g., cutlines, borrow areas and ditches along Butnau Road portion of the South Access Road) or were created by the Keeyask Infrastructure Project (KIP), and are now being used by the Project.

Twenty-two non-native plant species were found in the Project footprint during the 2017 monitoring surveys. While three species recorded in previous years were not found again in 2017, one new species (ox-eye daisy) was found for the first time. Lamb's quarters more than doubled its cover from 2016, remaining the most abundant and widespread species by far.

Of the 22 non-native plant species found in 2017, ox-eye daisy and scentless chamomile are the ones of highest invasive concern for the Project site. ECOSTEM field staff manually removed and disposed of all the ox-eye daisy and scentless chamomile plants as soon as they were found during the surveys. Scentless chamomile was not found at the two locations where it had been removed and disposed of in previous years.

Six of the 22 non-native plant species found in 2017 are of moderate invasive concern for the Project site. In most of the places where only a few plants were found, ECOSTEM field staff manually removed and disposed of all the plants as soon as they were found during the surveys.

To minimize further spreading of invasive plants, herbicides were applied in a few key Project areas in late August, 2016. These areas were surveyed in 2017 to find out how well the herbicide application worked in these situations. The surveys found that, in general, the treatments had neither reduced total non-native plant cover nor stopped the spread of these plants.

What does it mean?

As expected, some further spreading of some non-native plant species is happening during Project construction. However, all species combined still cover a very small portion (less than 1%) of the Project footprint.

Given their potential to spread rapidly, an evaluation was made as to 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 footprint.

Monitoring results from 2017 showed that immediate removal and disposal of invasive plants was effective for locations with only a few plants present. Staff conducting the monitoring surveys will continue applying this control measure in 2018.

The herbiciding treatment completed in 2016 probably was not effective because it was applied after most of the plants had already produced their seed. It is recommended that future herbicide applications occur in the early summer after plants are fully emerged but before they produce their seed.

What will be done next?

Control recommendations for the 2018 growing season are being developed based on the results to date. It is likely these recommendations will include herbicide application at key sites

within the Project footprint. Monitoring to document the spread of non-native plants at the Project site will continue in 2018. 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 2017 was conducted by Brock Epp, Nathan Ricard and Alanna Sutton.

Data analysis and report writing in 2017 were completed by Brock Epp and James Ehnes. GIS analysis and cartography was completed by Brock Epp and Nathan Ricard.

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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. 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. 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 2015a) 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 from 2015 to 2017. ECOSTEM (2016) provides results for the monitoring conducted in 2015, and ECOSTEM (2017b) provides results for the monitoring conducted in 2016. The following presents the monitoring conducted during 2017.

2.0 METHODS

Section 3.3.2 of the TEMP details the methods for this study. The following summarizes the activities conducted in 2017.

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, and to identify areas of concern. Therefore, the Project footprint was subdivided and grouped into major 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, which means there is a poor seedbed for non-native plant colonization. Note that, because this is a generalized grouping, there may be small areas within a grouping that include a type of construction activity that is characteristic of a different category. Nevertheless, this categorization aids in the interpretation of broad patterns and trends across the Project site. Map 2-3 shows the locations of the Project components as well as some of their constituent features.

Table 2-1: General Project components and their associated activity in 2017

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
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 and excavation
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	Vegetation clearing in the reservoir areas that are close to Project areas that will be outside of the reservoir	Clearing only

A second level of analysis was based on the length of time that an area has been cleared, and the current level of construction activity. Both of these factors can influence non-native plant distribution and abundance. Portions of areas cleared for the KIP are also being used for the Project. On this basis, the project that originally completed the clearing and the time since original clearing were also considered in the analysis. The categories used for this analysis included:

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

Areas used for KIP only are included because they may be an important seed source for the spreading of non-natives into other nearby areas.

2.2 DATA COLLECTION

Early and late summer surveys have been conducted in each year from 2014 to 2017, inclusive.

The survey approach for the 2017 early summer surveys was modified from that used in 2016. In 2016, a comprehensive non-native plant survey was conducted for all accessible cleared

Project areas in both the early and late summer. In 2017, the early summer survey collected less detailed information in the accessible areas that had been newly cleared since August 2016, and in the areas already cleared as of August 2016 that had few to no non-native plants.

This change arose for several reasons, based on past results from non-native plant surveys for this Project and the Wuskwatim Generation Project (ECOSTEM 2018b). First, while overall non-native plant distribution and abundance generally did not increase substantially between the late and early summer surveys, it was still important to discover if there were any new early summer infestations so they could be controlled as needed. Second, non-native plant cover and species composition in late summer data is generally more meaningful for characterizing trends and year-to-year changes for several reasons (*e.g.*, species that emerge later in the spring can be missed or have relatively low cover in the early summer survey). Third, the effort required to record and map non-native plants in the expanding and maturing (*i.e.*, fewer areas with ongoing construction activity) Project footprint was steadily increasing, making a comprehensive early summer survey inefficient and unnecessary to facilitate a rapid response to new infestations. A rapid, spatially focused early summer survey still allowed for early detection and control of non-native plants spreading into new areas.

There were two situations where the comprehensive mapping methods were still used during the 2017 early summer surveys:

1. Whenever a species of high invasive concern for the Project (Section 3.5.1) was encountered.
2. In areas treated with herbicide in August, 2016 to monitor the effectiveness of this treatment.

Early summer surveys were conducted from July 5 to 10, 2017 at the locations shown in Map 2-1. Late summer surveys were conducted from August 20 to 31, 2017 at the locations shown in Map 2-2.

For the early summer surveys, a GPS waypoint was recorded where non-native plants were encountered, along with notes on species abundance and extent. The exception was when a species of high invasive concern for the Project (Section 3.5.1) was encountered. In these situations, detailed data were collected using the late summer method (see below).

Methods for the 2017 late summer non-native plant surveys were the same as those used during the 2015 and 2016 surveys. These 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, were not surveyed in 2017. For the same reason, some areas were walked to but surveyed from a short distance (i.e., the maximum distance from which the species could be identified and cover estimates obtained).

For the North and South Access roads, a stop was generally made every 2 km along the road (exceptions were stops where construction or haul truck activity made stopping unsafe). At each

stop, a 100 m transect on each side of the road (*i.e.*, two 100 m transects at each stop) was surveyed by foot. Additionally, the roadsides were scanned while driving between each stop and observations of species of high concern or something unusual are recorded.

Spatially focused foot surveys were conducted in the cleared areas along the south dyke in 2017 because large portions of this footprint had only recently been cleared, this clearing was distant from known non-native plant seed sources, and access was difficult. Locations for the foot surveys were selected in two ways. First, by flying over the newly cleared areas in a helicopter and identifying the areas most likely to support non-native plants. Second, by targeting areas that had non-native plants in 2016. Because searches were focused on areas that were believed to have a higher likelihood to support non-native plants, results were expected to overestimate percentage cover for non-native plants within the south dyke footprint.

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. The “point with number of individuals” method was typically used in locations where there less than 20 individual plants covering a very small area. In these situations, the number of plants and a GPS waypoint (using a Garmin Map 62 or Map 78) were recorded as close to centre of the patch as possible for the species.

For the remaining non-native plant locations, recorded patch data included estimated non-native plant cover in the vegetation patch by species and the patch boundaries. Patch boundaries were obtained using a handheld GPS for each vegetation patch that included one or more non-native plant species. The percent cover of each non-native species within the vegetation patch boundaries was then visually estimated.

Vegetation patch boundaries were recorded in one of three ways:

1. **Point:** Used for small patches (20 or fewer 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.

For each non-native species patch, percent plant cover was estimated and recorded into one of the six classes listed in Table 2-2.

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

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

2.3 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 2016 annual report (ECOSTEM 2017b).

The analysis evaluated non-native plant distribution and abundance in the context of precise clearing and disturbance mapping produced for 2017 (see ECOSTEM 2018a). The primary focus of this report is on the patterns and changes observed in 2017. 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.

Non-native plant distribution and abundance maps for the later summer and the spatially focussed early summer surveys were produced by converting species spatial extent and cover

data from the field surveys into GIS polygons. Where the patch extent method (Section 2.1) was used to record non-native species in the field, patch polygons were created from the GPS tracklogs. Polygons for locations where plants were recorded as individuals in the field were created by applying a fixed radius buffer around the location 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). 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 almost always be lower than plant extent due to less than complete canopy closure within some of the mapped patches.

Non-native plant cover was derived from the patch cover class (Table 2-2) for locations recorded using the “patch method” or from multiples of individual plant area (Appendix 1) for locations 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 on the order of 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 of interest.

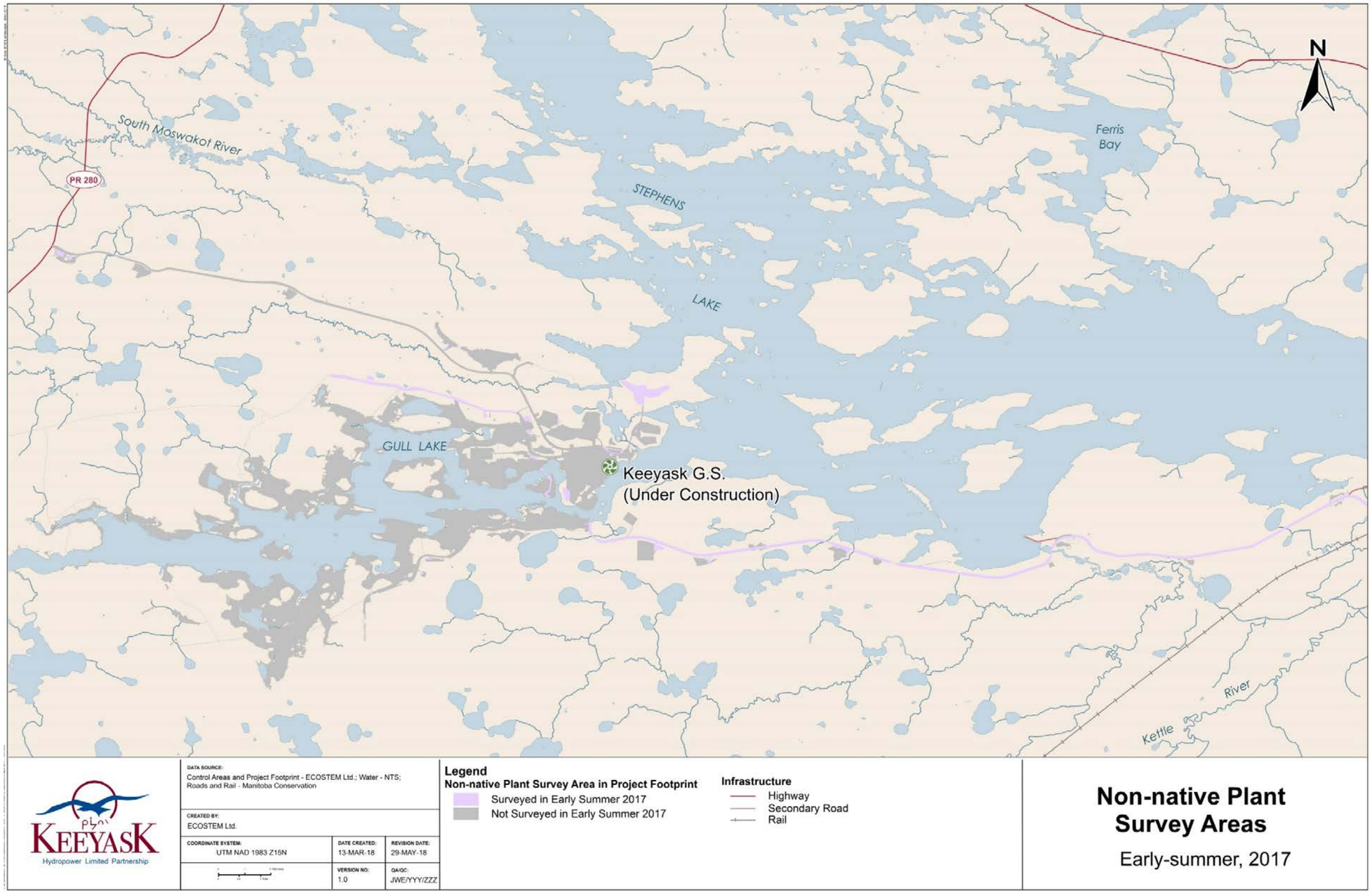
While efforts were made to calibrate plant cover estimates between the different individuals conducting the surveys, some individual bias is always inherent in this measurement method. Furthermore, even for the same individual, there may have been differences in the approach taken to map a particular 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.

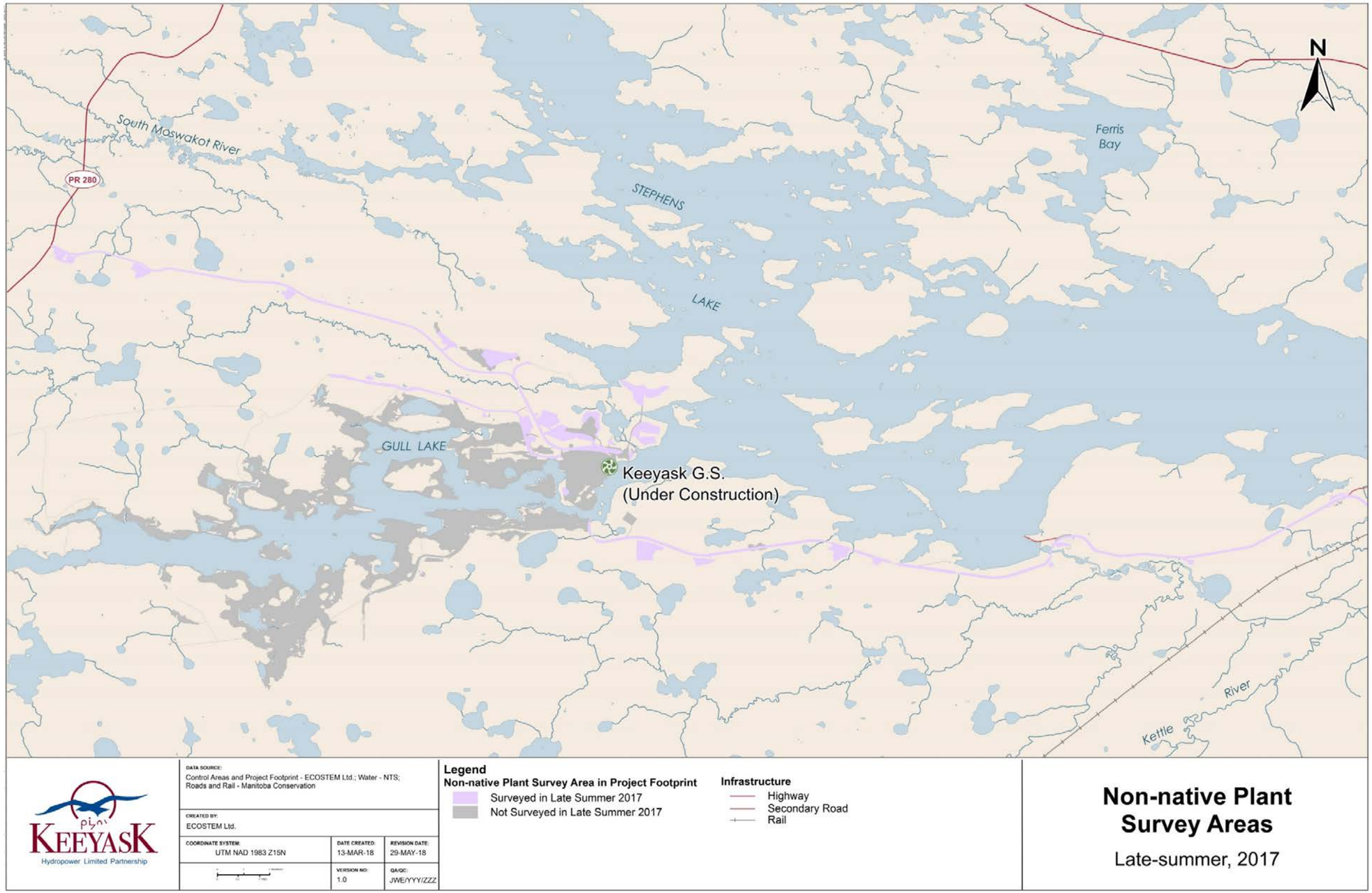
As cleared areas regenerate, native vegetation cover may obscure non-native plants, confounding estimates of cover. This could result in a bias toward underestimating non-native plant cover in areas with dense or taller native plants. This could also result in a seasonal bias in which non-native plant 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., generating station area, Excavated Materials Placement Area D12). 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.

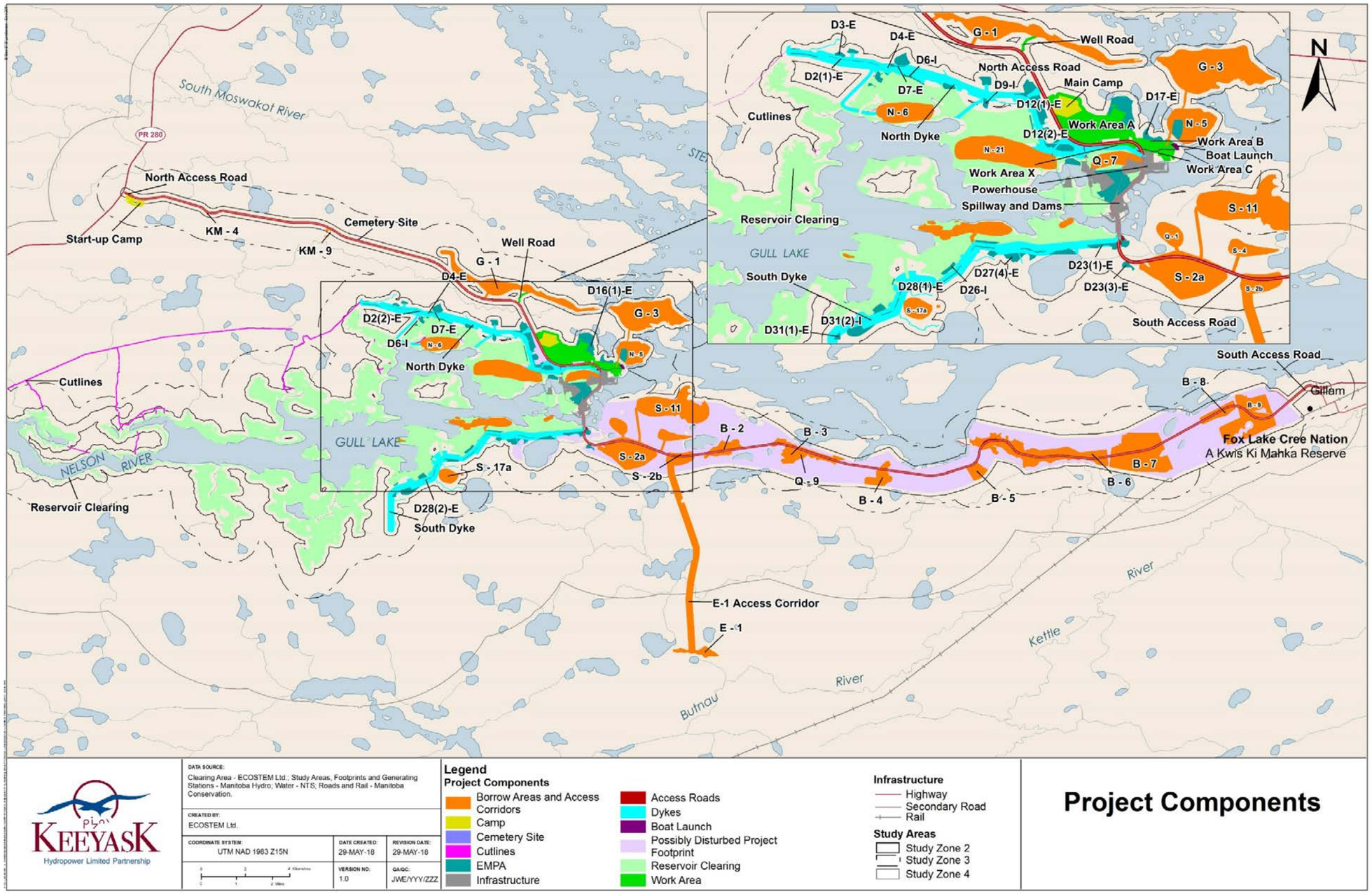
Due to the above factors (particularly the first two), derived species cover, rather than polygon extents, were considered to be a more meaningful measure for interpreting changes in non-native plant abundance between years. Non-native species polygon extents should only be considered as an indication of overall distribution as well as a very broad measure of area covered.



Map 2-1: Early summer non-native plant survey areas in 2017



Map 2-2: Late summer non-native plant survey areas in 2017



Map 2-3: Project components

3.0 RESULTS

3.1 TOTAL AREA SURVEYED

In 2017, early summer non-native plant surveys occurred in approximately 509 ha (9%) of the cleared and disturbed Project footprint while approximately 671 ha (12%) were included in the late summer survey (Table 3-1; Table 3-2).

Compared with 2016, the total area included in the 2017 early summer survey was substantially lower because these surveys were spatially focused only on herbicide-treated areas, newly cleared areas, and areas that had little to no non-native plants in August, 2016 (see Section 2.1). Total area surveyed during late summer was 51 ha higher in 2017 than in 2016 primarily due to some inaccessible areas in 2016 being accessible in 2017.

As in 2016, surveys were not conducted in the cleared future reservoir areas because it was determined from previous surveys, and from low-level aerial surveys of the south reservoir in 2017 that non-native plants were virtually absent. This absence was thought to be primarily due to two factors. Reservoir clearing had only cut vegetation taller than 5 feet (leaving the ground vegetation largely intact) and the clearing had just been completed during the previous two winters. Surveys were thus deemed unnecessary given the large size of the reservoir clearing footprint and the high unlikelihood for any change in non-native plants.

Areas included in the late summer surveys in 2017 and 2016 were similar for most of the Project components (Table 3-1). The major exceptions were the North Dyke, where more than twice the area was surveyed in 2017, and the South Dyke, where surveyed area was substantially lower in 2017. Surveyed area increased for the North Dyke because construction activities were largely complete. Much of the North Dyke was surveyed by helicopter from a low altitude, and any potential patches of non-native plants were investigated and mapped on foot.

The area surveyed in the South Dyke footprint was lower than in 2016, because other than additional dyke clearing during the previous winter, there had been no new construction in the footprint. Only tree and tall shrub vegetation was cleared, leaving the organic substrate intact. As with the reservoir areas, previous surveys (ECOSTEM 2017b) found that these areas supported very few non-native plants, so survey effort remained low in 2017.

The areas surveyed increased for the North Access Road, South Access Road, and borrow area components. The surveyed area decreased slightly for the camp and work areas, and generating station area. These decreases were due to safety concerns for accessing certain areas with active construction and haul truck activity at the time of the surveys. Certain areas accessible in 2016 could not be accessed in 2017 (*e.g.*, Excavated Materials Placement Area D12(2), portions of Borrow Area G-1). This contributed to an overall decrease from 2016 in percent of cleared footprint surveyed (Table 3-2).

Table 3-1: 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	2014	2015	2016	2017
North Access Road[1]	9	9	9	0	10	9	8	10
South Access Road[1]	-	-	9	306[4]	-	-	10	16
Camp and Work Areas	126	109	163	19	138	111	186	182
Borrow Areas	112	119	323	79	120	131	329	334
North Dyke	-	-	52	88	1	-	56	120
South Dyke[2]	-	-	38	7	-	-	21	4
Generating Station Area	-	-	20	10	-	-	10	6
Reservoir Clearing Area	-	-	56	0	-	-	-	0
Total surveyed area	247	237	669	509	269	251	620	671
Total footprint area[3]	*540*	*1,438*	*3,643*	*5,372*	*540*	*1,438*	*3,643*	*5,372*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Sampled area is a systematic sample of entire road. See Section 2.1 for road survey methods.
[2] The south dyke was surveyed through a series of targeted spot checks.
[3] Approximately 75 ha of KIP borrow areas not used by the Project are included in these totals.
[4] Almost the entire south access road was surveyed by vehicle in early summer using rapid methodology (see Section 2.2).

Table 3-2: Percentage of total actual 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	2014	2015	2016	2017
North Access Road[1]	5	5	5	-	5	5	4	5
South Access Road[1]	-	-	3	94[3]	-	-	3	5
Camp and Work Areas	68	48	71	8	75	49	81	78
Borrow Areas	90	35	74	16	96	38	76	68
North Dyke	-	-	28	45	3	-	30	61
South Dyke[2]	-	-	31	4	-	-	17	2
Generating Station Area	-	-	9	4	-	-	4	3
Reservoir Clearing Area	-	-	3	0	-	-	-	0
All surveyed areas	46	17	18	9	50	17	17	12

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Sampled area consists of a systematic sample of the road. See Section 2.1 for road survey methods
[2] The south dyke was surveyed through a series of targeted spot checks.
[3] Almost the entire south access road was surveyed by vehicle in early summer using rapid methodology (see Section 2.2).

3.2 SEASONAL PATTERN IN NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

In general, early summer and late summer surveys conducted from 2014 to 2016 indicated that each year there was a seasonal increase in the number of non-native plant species, and an increase in plant extent and cover as a percentage of area surveyed (ECOSTEM 2017b).

Because a less detailed data collection method was used for the 2017 early summer survey (Section 2.1), comparisons of results from this survey with results from previous years or with 2017 late summer focus on locations with substantial changes.

Results from the 2017 early summer survey confirmed that non-native plants were continuing to grow at locations where they were found in 2016, and that plants had begun to establish in areas that had either no, or very few plants in August 2016. These new locations included ditches along the SAR west of the Butnau Marina, and at three locations around the perimeter of Borrow Area G-3 (Map 3-1).

A total of 16 non-native species were identified during the 2017 early summer survey (this includes species identified in the herbicide-treated areas which are not shown in Map 3-1). The species appearing most frequently at new locations were common dandelion (*Taraxacum officinale*), sweet clover (*Melilotus* spp.) and narrow-leaved hawks-beard (*Crepis tectorum*). Narrow-leaved hawks-beard was found at most of the new non-native plant locations along the SAR. In Borrow Area G-3, common dandelion and common timothy (*Phleum pratense*) were found growing at two locations. At the third location, wheat (*Triticum aestivum*) was found growing out of straw spread over a berm at the north side of the area. No non-native plants were found in Borrow Area G-3 the previous year.

3.3 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

The remaining results will focus on the late summer survey, since these data best reflect patterns and trends in non-native plant distribution and abundance (Section 2.2). See Section 3.5 for control measures or recommendations that were made based on the survey results.

As described in Section 2.2, plant extent and plant cover were the measures used to document changes in distribution and abundance, respectively. Plant extent was measured as the spatial limits of a vegetation patch that included one or more non-native plant species. Because canopy closure of a species within each mapped patch could range from very sparse to very high, the plant cover metric identified the surface area covered by each species (plant cover was derived from the cover class recorded during field surveys (Table 2-2)).

As of late summer, 2017, overall non-native plant extent had increased to 28.9 ha, or 4.3% of the total area surveyed (Table 3-3). This was twice the area recorded in 2016, or an increase of 14.1 ha.

Non-native plant extent increased in all surveyed Project components with one exception. In the generating station area, extent decreased between 2016 and 2017 due to the removal of most of the stockpiled straw that was supporting wheat plants in 2016.

Non-native plants were most widespread in the camp and work areas, borrow areas, along the NAR, and along the SAR, particularly east of the Butnau Marina. For these Project components, plants were distributed over between 2.8% and 5.9% of the surveyed areas.

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

Project Component	2014	2015	2016	2017	Percent Change[2]
North Access Road	0.3	0.9	3.5	4.4	27
South Access Road	-	-	0.2	2.8	1,452
Camp and Work Areas	3.2	4.7	4.0	5.9	78
Borrow Areas	0.3	3.1	2.1	5.1	138
North Dyke	-	-	0.1	0.3	281
South Dyke[1]	-	-	0.0	0.1	608
Generating Station Area	-	-	0.5	0.2	-65
Reservoir Clearing Area	-	-	-	-	-
All Types	1.8	3.7	2.4	4.3	80
Total non-native plant extent (ha)	*4.9*	*9.3*	*14.8*	*28.9*	
Total area surveyed (ha)	*269*	*251*	*620*	*671*	

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

[1] Proportion of non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.2.

[2] Percent change from 2016 to 2017; A negative sign means that cover decreased.

Total non-native plant cover increased to 3.0 ha by late summer, 2017, or 0.44% of the total surveyed area (Table 3-4), which was a 1.1 ha increase from 2016. Cover increased in all surveyed Project components with the exception of the generating station area; for the same reason that extent was reduced there.

Non-native plant cover was highest (0.73%) in the camp and work areas, followed by the borrow areas, and the NAR and SAR.

Non-native plant extent and cover were highest by far (29.4% and 2.3%, respectively) in areas that were utilized for the KIP, but have not been further used by the Project (Appendix 2). For both of these metrics, there was a substantial increase from 2016 in the KIP footprints. Areas

that were more recently cleared, and used only for the Project, had substantially lower non-native plant extent and cover (0.4% and 0.03%, respectively). There was little change in extent in these areas from 2016, and with respect to cover, there was an apparent reduction.

Table 3-4: Total late summer non-native plant cover as a percentage of total area surveyed, by year and Project component

Project Component	2014	2015	2016	2017	Percent Change[2]
North Access Road	0.01	0.07	0.25	0.38	54
South Access Road	-	-	0.01	0.36	5,184
Camp and Work Areas	0.34	0.77	0.58	0.73	25
Borrow Areas	0.05	0.48	0.24	0.46	95
North Dyke	-	-	0.00	0.01	278
South Dyke[1]	-	-	0.00	0.02	1,325
Generating Station Area	-	-	0.03	0.00	-84
Reservoir Clearing Area	-	-	-	-	
All surveyed area	0.20	0.59	0.31	0.44	45
Total non-native plant cover (ha)	*0.5*	*1.5*	*1.9*	*3.0*	
Total area surveyed (ha)	*269*	*251*	*620*	*671*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Proportion of non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.2.
[2] Percent change from 2016 to 2017; A negative sign means that cover decreased.

In 2017, the distribution of non-native plants on the north side of the Nelson River (Map 3-2 and Map 3-3) was broadly similar to that of 2016 (ECOSTEM 2017b). Since 2016, non-native plants expanded in the Start-up Camp, Borrow Area KM-1, KM-4 and KM-9, and in the surveyed portions of Borrow Area G-1 at KM-17.

Non-native plants had also expanded in Excavated Material Placement Area (EMPA) D16 since 2016. There did not appear to have been much excavation activity in that area since the previous year. Some haul trucks were being stored on the east side of this EMPA.

Non-native plants were also establishing in the northern section of EMPA D12 (adjacent to the north dyke in 2017), an area which had no recorded plants in 2016. Non-native plants were found in the southern section of this EMPA in 2016, but this section was not accessible in 2017 due to haul truck activity. Due to recent development of the southern section, it is likely that the plants found in 2016 had been covered by materials.

Non-native plant cover in 2017 remained similar to 2016 around the offices and Hydro yard in Work Area B. However, in Work Area X the extent appeared to have decreased from the previous year. In Work Area C, overall plant cover and extent decreased by late summer 2017, due to excavation of a large borrow pit since the August 2016 survey.

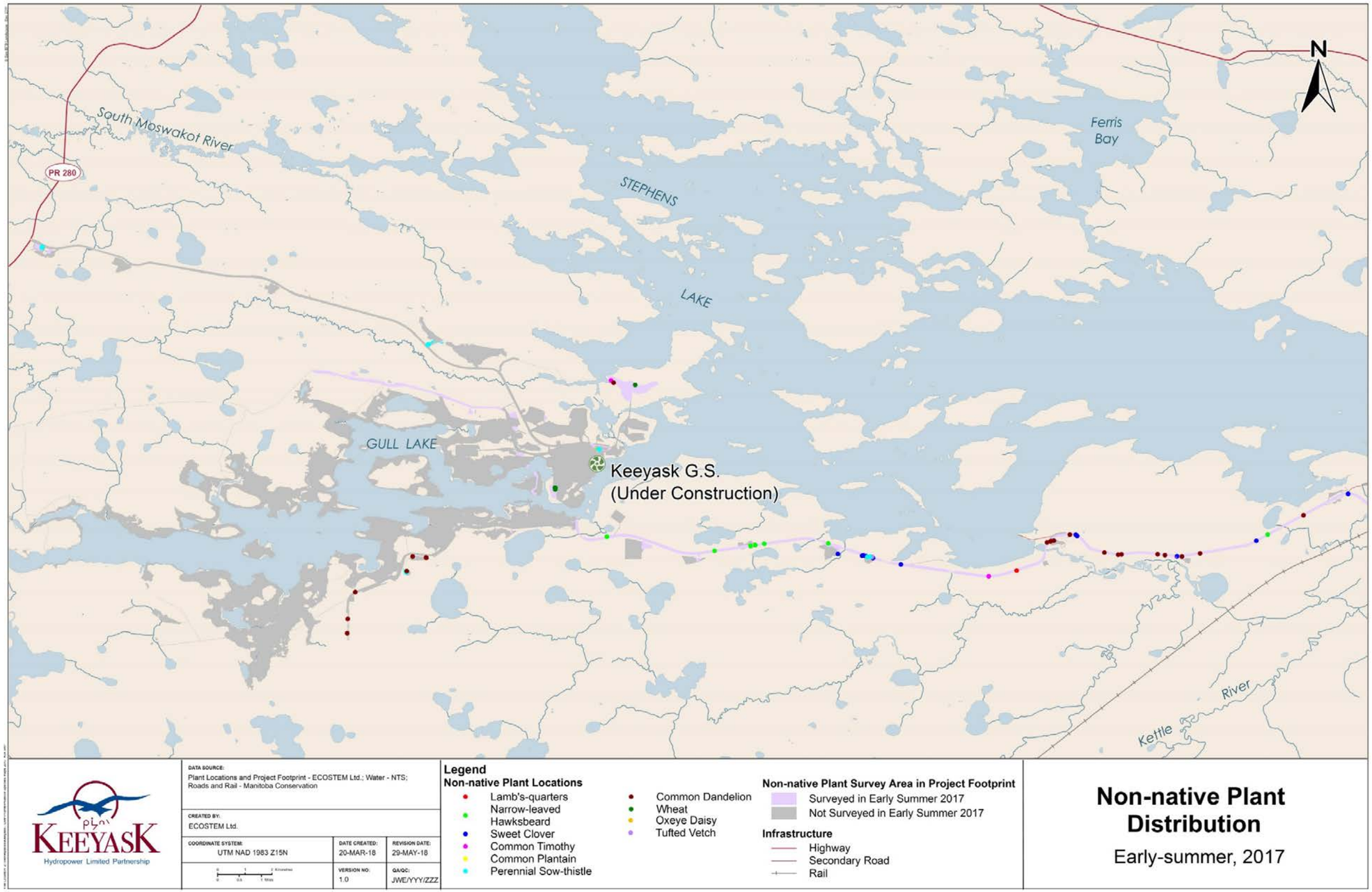
As of late summer 2017, non-native plants remained absent in Borrow Area G-3. In Borrow Area N-5, cover remained similar to that recorded in 2016.

Ground searches were not possible in several areas due to construction activity. These areas included portions of Work Area A (particularly around the rock crusher), in the generating station (GS) area, in portions of EMPA D12 and in portions of Borrow Area G-1. Based on previous results (ECOSTEM 2017b; WRCS and ECOSTEM 2017), it is unlikely that many non-native plants would have established in these areas due to the high volume of construction activity, including excavation, material stockpiling and vehicle traffic.

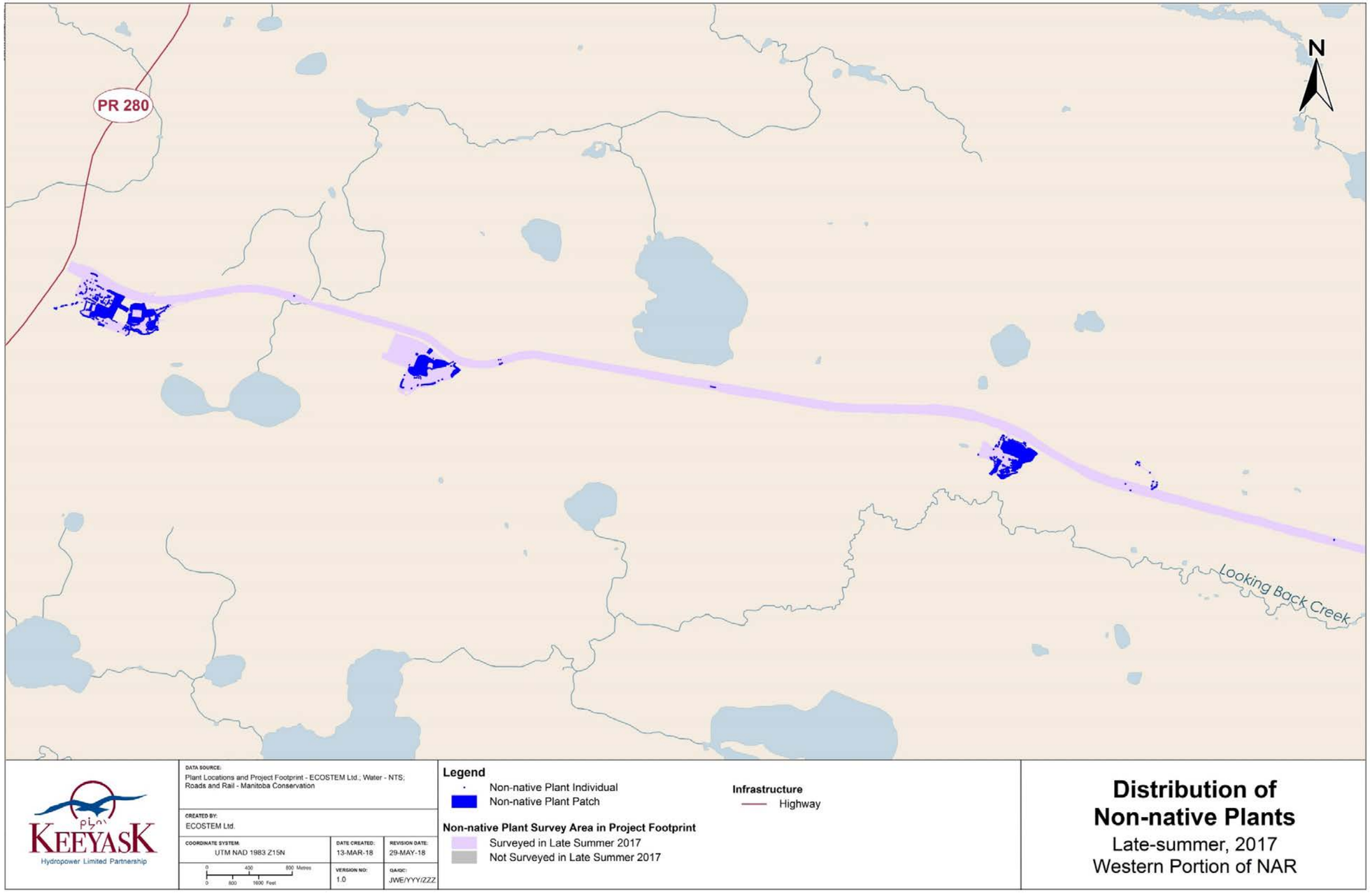
As of late summer 2017, the SAR roadbed and ditch construction had been completed. Construction activity was limited to road maintenance and development of borrow areas for south dyke construction. Overall, non-native plant cover remained low along the SAR west of the Butnau Marina (Map 3-5). Plants found along that reach of the SAR during early summer surveys were not found during late summer surveys. The distribution of plants remained similar to the previous year around the offices and SAR camp. Plants were found at three additional locations in Borrow Area Q-9, and were beginning to establish near the entrances to Borrow Areas S-2a and S-2b.

Most of the non-native plant cover along the SAR occurred in the ditches east of the Butnau Marina, where the ROW was either in close proximity to or overlapped the old Butnau Road (Map 3-5). Most of this portion of the SAR was not surveyed prior to 2017 due to ongoing construction activity, and this portion accounts for most of the large increase in cover and extent. Non-native plant cover was also higher in borrow areas east of the Butnau Marina. Plant cover had expanded since 2016 in the developed portion of Borrow Area B-6 just north of the Butnau River. One plant had also established in Borrow Area B-5, and patches had established in the developed portion at the west end of Borrow Area B-6. These latter two areas were not surveyed in 2016.

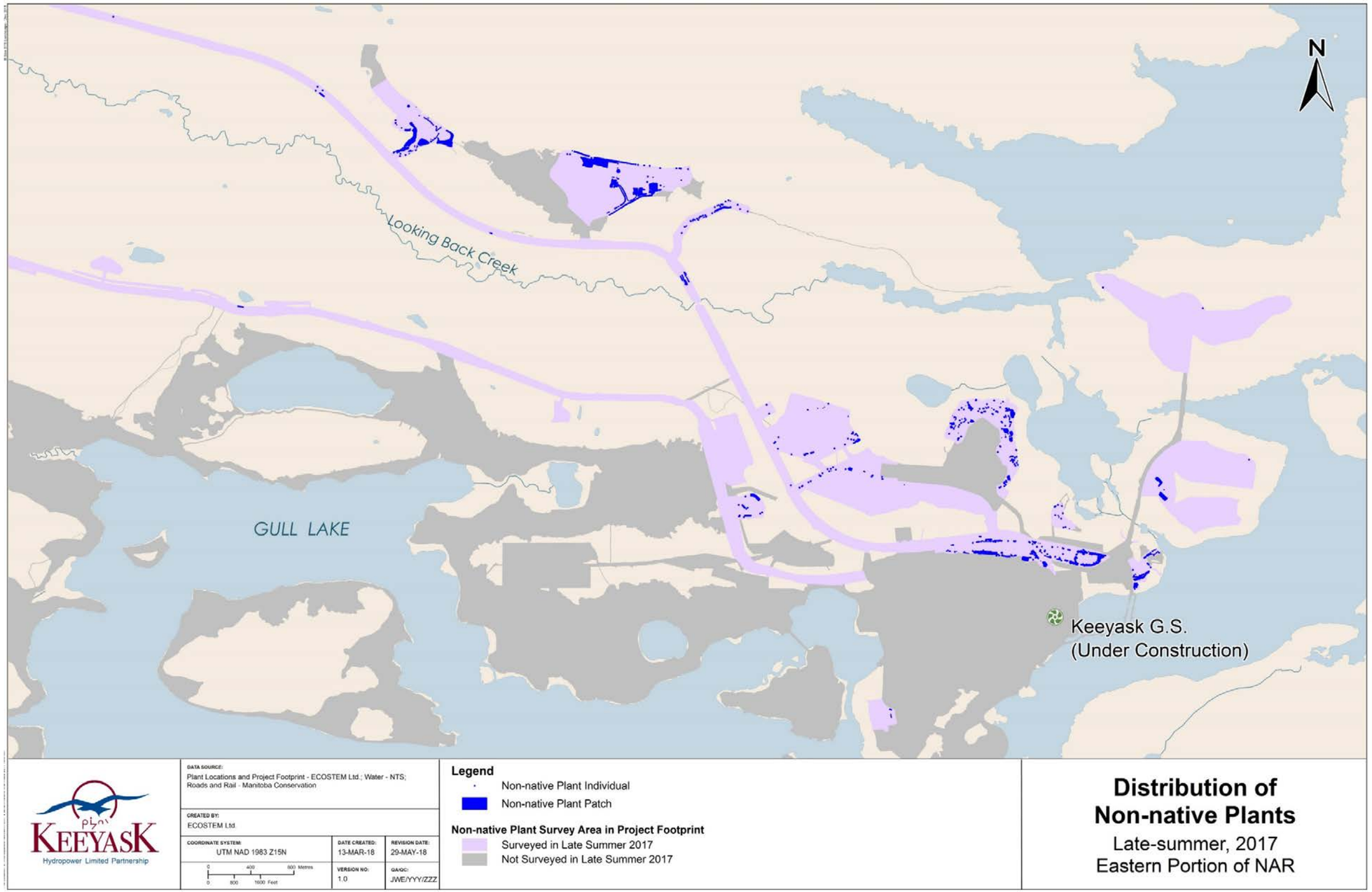
Non-native plant cover along the surveyed portions of the south dyke remained similar to that recorded in 2016 (Map 3-6). Plant cover had increased somewhat in Borrow Area S-17a, but no other locations were found during late summer surveys. Early summer surveys confirmed that non-native plants found near or on old cutlines in 2016 were still present in 2017, but had not noticeably expanded. Overall, non-native plant extent and cover remained very low in Project components south of the Nelson River, and west of the Butnau Marina.



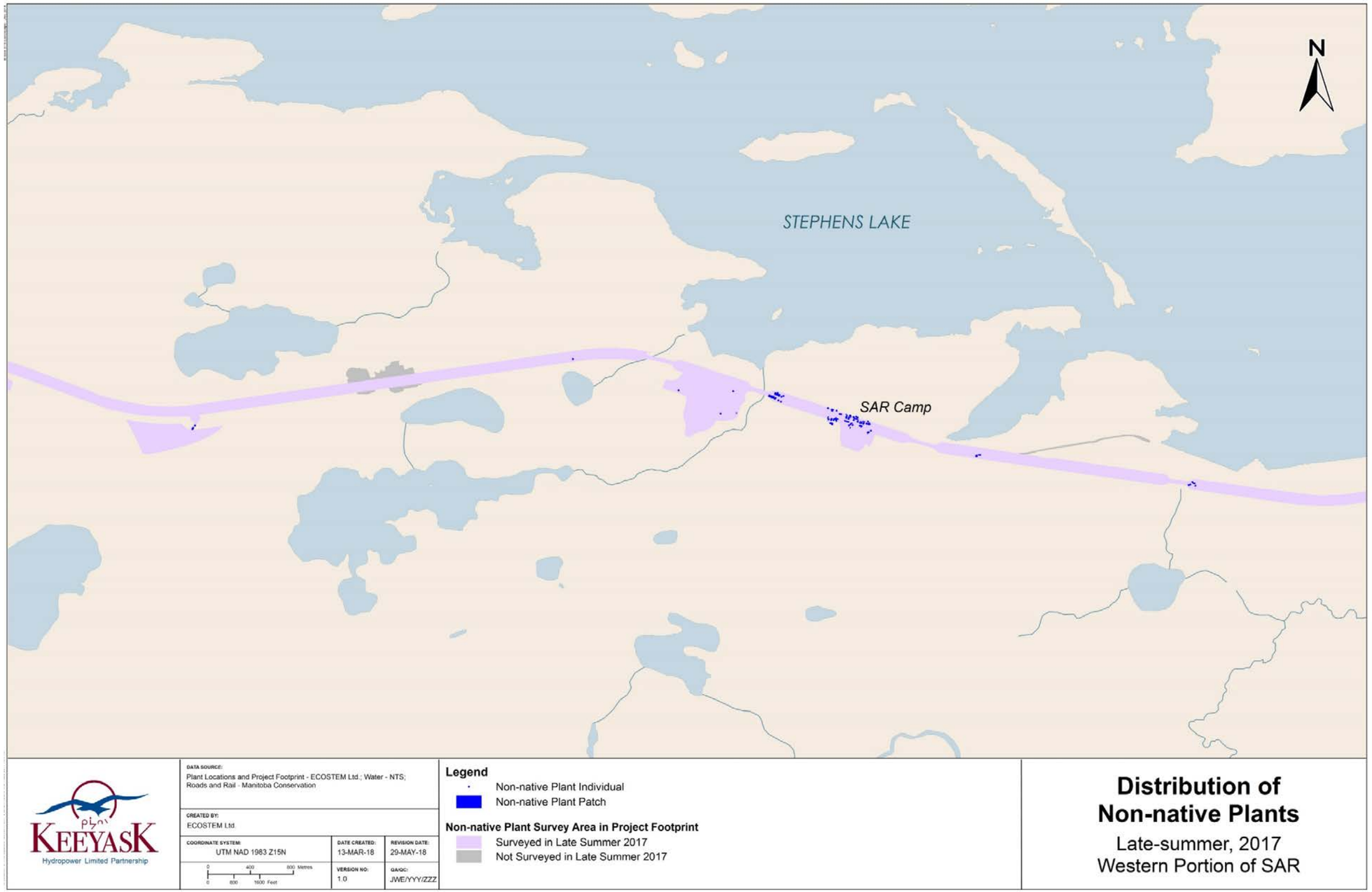
Map 3-1: Distribution of non-native plants within the Project footprint during early summer, 2017



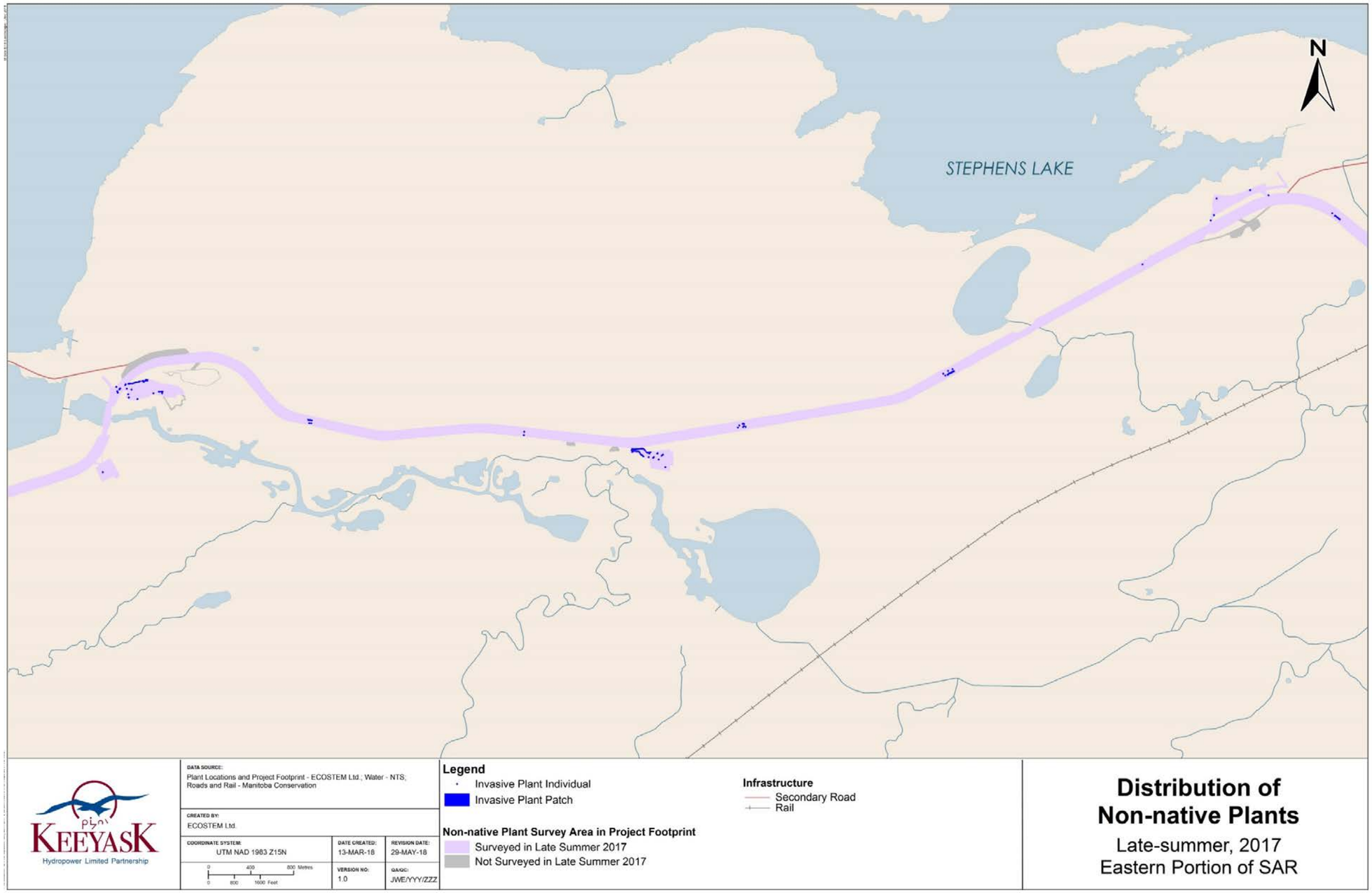
Map 3-2: Distribution of non-native plants during late summer 2017, in the Project footprint along the western portion of the North Access Road



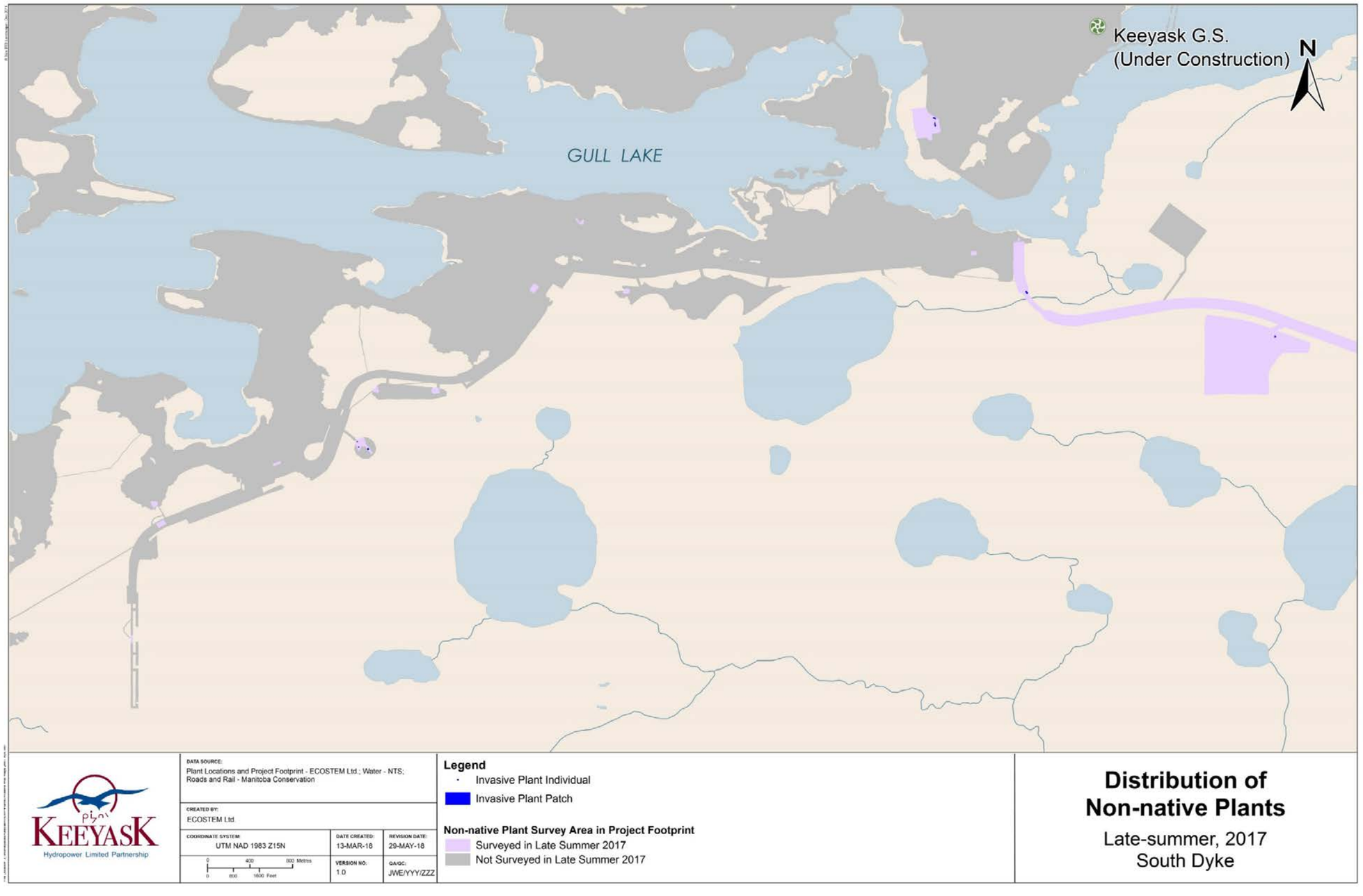
Map 3-3: Distribution of non-native plants during late summer 2017, in the Project footprint along the eastern portion of North Access Road



Map 3-4: Distribution of non-native plants during late summer 2017, in the Project footprint along the western portion of the South Access Road



Map 3-5: Distribution of non-native plants during late summer 2017, in the Project footprint along the eastern portion of the South Access Road



Map 3-6: Distribution of non-native plants during late summer 2017, in the Project footprint along the South Dyke

3.4 CHANGES TO SPECIES DISTRIBUTION AND ABUNDANCE

A total of 22 non-native plant species were observed during the early and late summer 2017 surveys combined (Appendix Table 6-4). This was the highest number of non-native species observed in all of the Project monitoring conducted to date (see ECOSTEM 2015a). The increasingly large Project footprint, and the amount of time since construction activity first began, were thought to be the primary factors contributing to the increasing number of non-native plant locations over time.

Map 3-7 to Map 3-16 use cover class to illustrate the distribution and abundance for the five most abundant non-native species recorded in 2017 in Project footprints north of the Nelson River, where they are most abundant.

The three most abundant non-native species (Table 3-5) were lamb's quarters (*Chenopodium album*), common dandelion, and white sweet clover (*Melilotus albus*), accounting for 51%, 19% and 17% of the total non-native cover in 2017, respectively (Table 3-6). The next most abundant species were perennial sow-thistle (*Sonchus arvensis*) and narrow-leaved hawks-beard. All of these five species increased in cover since 2016. Lamb's quarters and narrow-leaved hawks-beard each more than doubled in cover since August 2016.

Of the species recorded in 2017, one had not been recorded in previous years. This species was ox-eye daisy (*Leucanthemum vulgare*), which was found only in the early summer survey. This species was not found in the Project footprint previously, but it was found at one location approximately 460 m away in 2004, prior to any construction activity. 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. The plant was not found at the location in late summer because it was removed by field staff after it was recorded to prevent further spread.

Species found in previous years but not recorded again in late summer 2017 (Table 3-5) included common burdock (*Arctium minus*), rye (*Secale cereal*) and white clover (*Trifolium repens*). For common burdock, only a single individual was found at one location during previous monitoring. The dead plant and its burrs were removed from the location by survey staff in early summer 2017.

For rye, only a couple of individuals were found at one location during previous years. These plants were never found at the location again during subsequent surveys, and it is likely that the plants were unable to successfully seed prior to dying.

White clover cover was extremely low in surveys from previous years. It is likely that the plant is still present in the Project footprint, but was missed, or possibly misidentified as alsike clover, especially if there were no flowers present at the time of the 2017 surveys.

Table 3-5: 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
Common Burdock	*Arctium minus*	-	-	0	-
Wormwood	*Artemisia absinthium*	-	0	1	1
Lamb's-quarters	*Chenopodium album*	2,903	8,844	6,342	15,229
Canada Thistle	*Cirsium arvense*	-	0	0	1
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	586	1,314
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0
Pineappleweed	*Matricaria discoidea*	-	18	29	325
Black Medick	*Medicago lupulina*	0	1	-	0
Alfalfa	*Medicago sativa*	124	11	14	40
White Sweet Clover	*Melilotus albus*	532	2,252	3,015	4,949
Yellow Sweet Clover	*Melilotus officinalis*	0	2	109	254
Unidentified Sweet Clover	*Melilotus spp.*	72	-	1,838	67
Common Timothy	*Phleum pratense*	-	-	0	0
Common Plantain	*Plantago major*	80	121	268	246
Yellow or Curled Dock	*Rumex crispus*	-	-	100	19
Rye	*Secale cereale*	0	-	-	-
Smooth Catchfly	*Silene csereii*	-	5	26	32
Perennial Sow-thistle	*Sonchus arvensis*	252	972	1,111	1,656
Common Dandelion	*Taraxacum officinale*	1,291	2,422	5,268	5,521
Alsike Clover	*Trifolium hybridum*	25	242	190	91
Red Clover	*Trifolium pratense*	0	0	-	1
White Clover	*Trifolium repens*	0	0	0	-
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0
Wheat	*Triticum aestivum*	-	-	30	21
Tufted Vetch	*Vicia cracca*	-	-	0	38
All species		5,280	14,890	18,927	29,805

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] **Bolded** species are minor to moderate invasives in Canada (White *et al.* 1993). *Italicized* species are minor to moderate invasives in Manitoba (ISCM 2018). Underlined species are noxious weeds in Manitoba (Government of Manitoba 2017). Remaining species are non-native species that may become problematic in some locations and/or conditions (CDC personal communication).

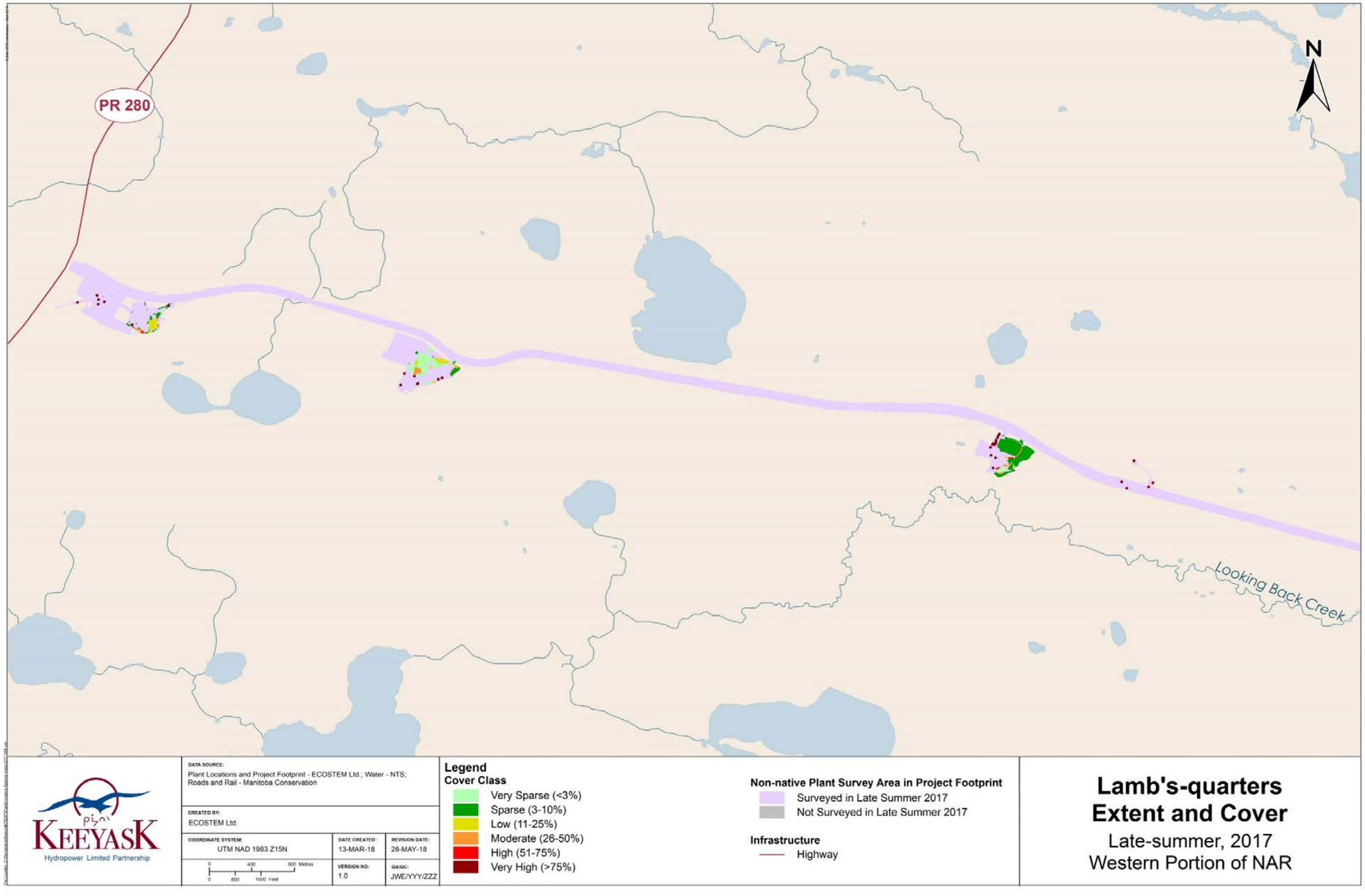
[2] Species difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

Table 3-6: Total approximate cover of a non-native species in the Project footprint as a percentage of cover for all non-native species, by year

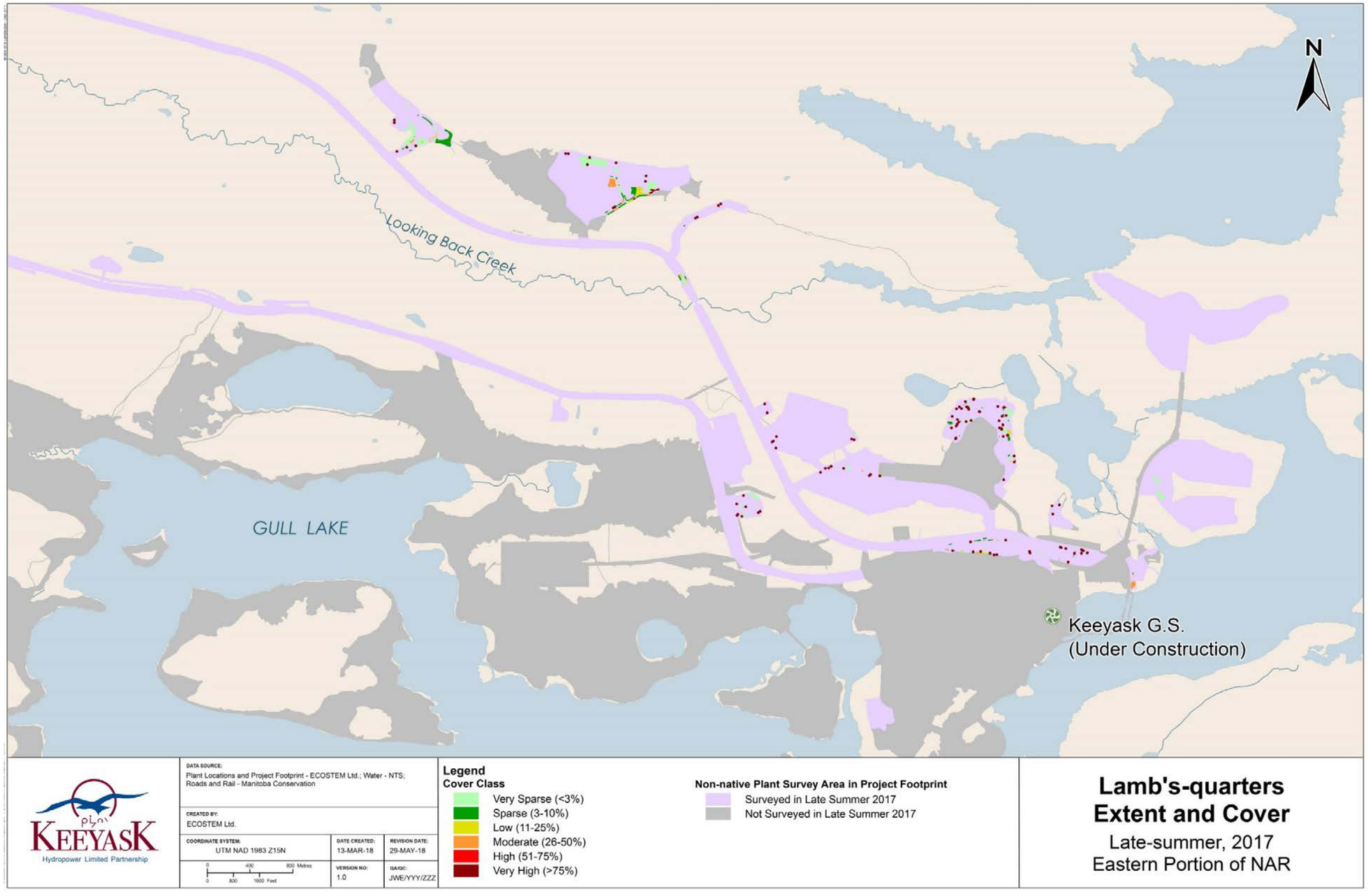
Common Name[1,2]	Species	2014	2015	2016	2017
Common Burdock	*Arctium minus*	-	-	0	-
Wormwood	*Artemisia absinthium*	-	0	0	0
Lamb's-quarters	*Chenopodium album*	55	59	34	51
Canada Thistle	*Cirsium arvense*	-	0	0	0
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	3	4
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0
Pineappleweed	*Matricaria discoidea*	-	0	0	1
Black Medick	*Medicago lupulina*	0	0	-	0
Alfalfa	*Medicago sativa*	2	0	0	0
White Sweet Clover	*Melilotus albus*	10	15	16	17
Yellow Sweet Clover	*Melilotus officinalis*	0	0	1	1
Unidentified Sweet Clover	*Melilotus* spp.	1	-	10	0
Common Timothy	*Phleum pratense*	-	-	0	0
Common Plantain	*Plantago major*	2	1	1	1
Yellow or Curled Dock	*Rumex crispus*	-	-	1	0
Rye	*Secale cereale*	0	-	-	-
Smooth Catchfly	*Silene csereii*	-	0	0	0
Perennial Sow-thistle	*Sonchus arvensis*	5	7	6	6
Common Dandelion	*Taraxacum officinale*	24	16	28	19
Alsike Clover	*Trifolium hybridum*	0	2	1	0
Red Clover	*Trifolium pratense*	0	0	-	0
White Clover	*Trifolium repens*	0	0	0	-
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0
Wheat	*Triticum aestivum*	-	-	0	0
Tufted Vetch	*Vicia cracca*	-	-	0	0
All species		100	100	100	100

Notes: Numbers that round to zero shown as "0"; absences shown as "-". 1 Bolded species are minor to moderate invasives in Canada (White et al. 1993). Italicized species are minor to moderate invasives in Manitoba (ISCM 2018). Underlined species are noxious weeds in Manitoba (Government of Manitoba 2017). Remaining species are non-native species that may become problematic in some locations and/or conditions (CDC personal communication).

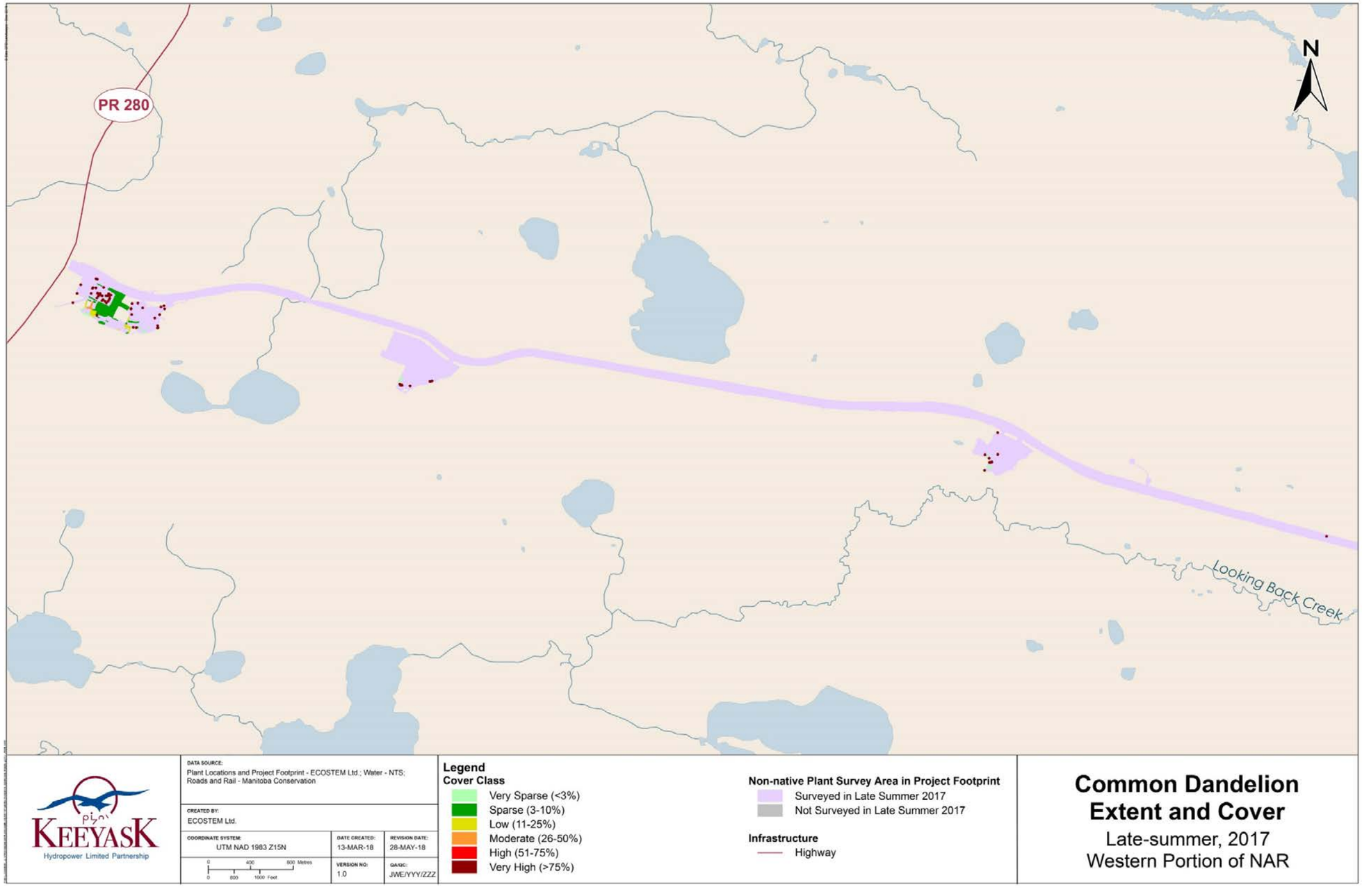
2 Species difficult to distinguish until they flower are combined into a broader taxon. Melilotus spp. includes M. albus and M. officinalis.



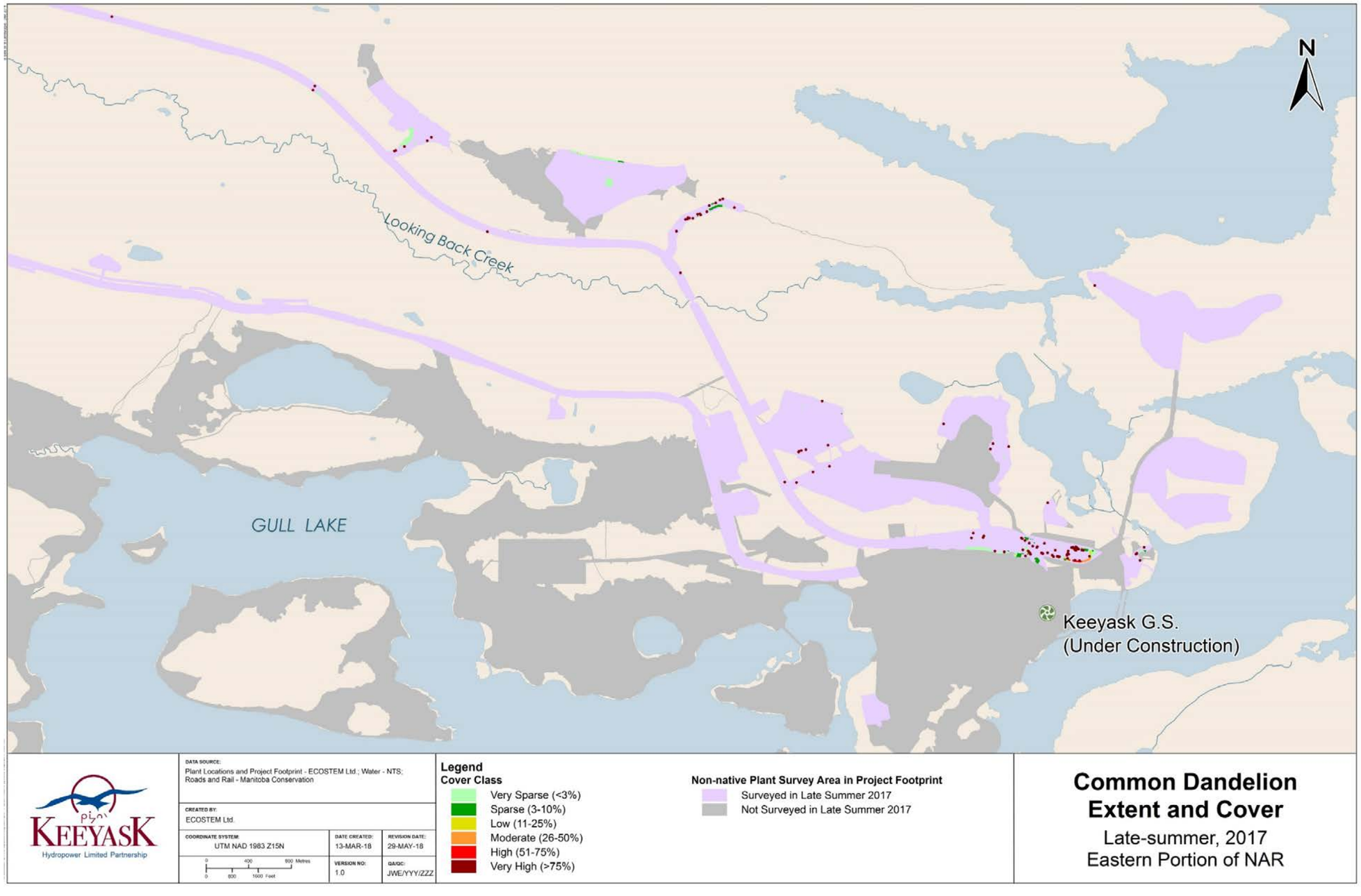
Map 3-7: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the western portion of the North Access Road in late summer, 2017



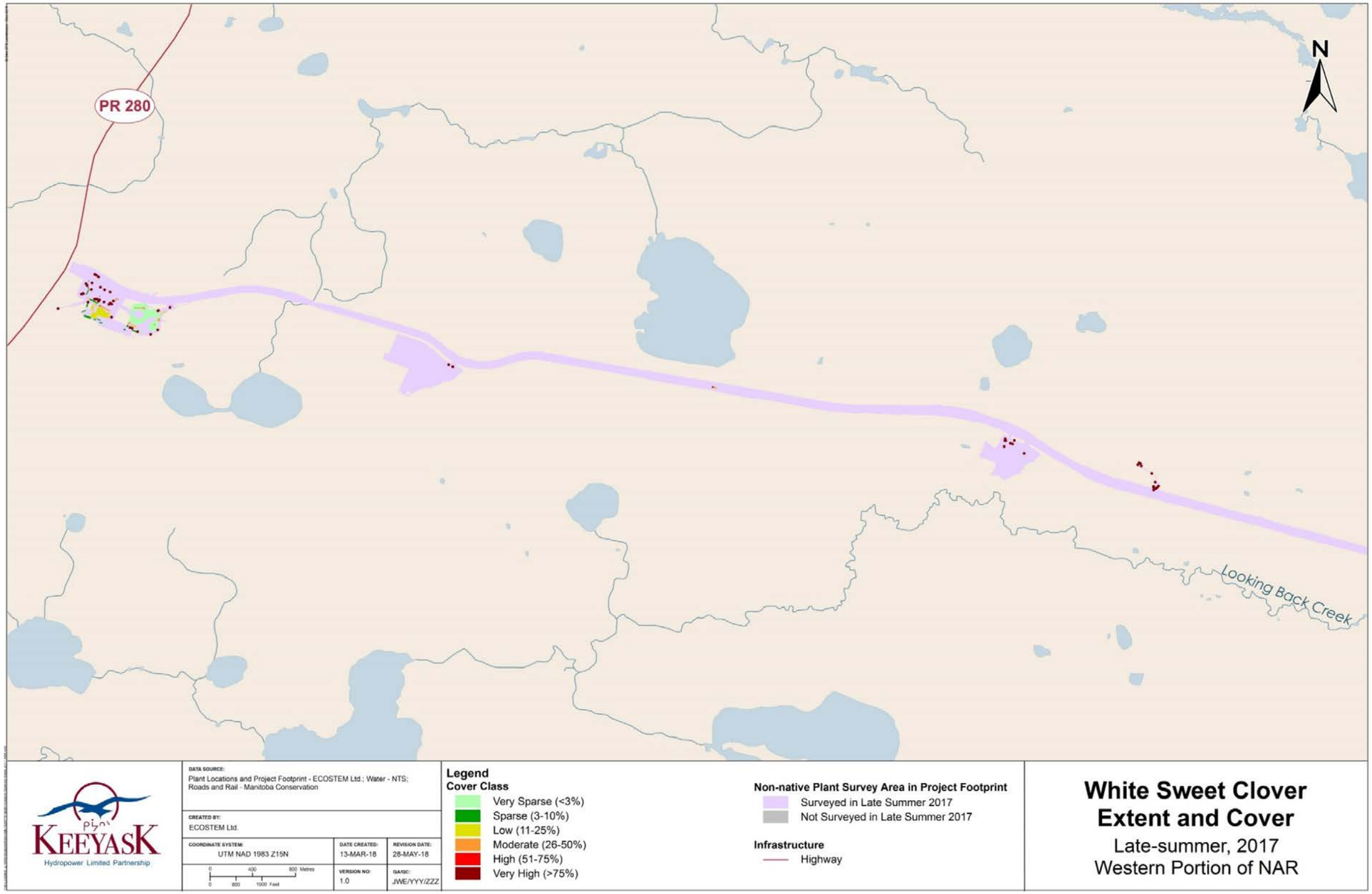
Map 3-8: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the eastern portion of the North Access Road in late summer, 2017



Map 3-9: 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, 2017

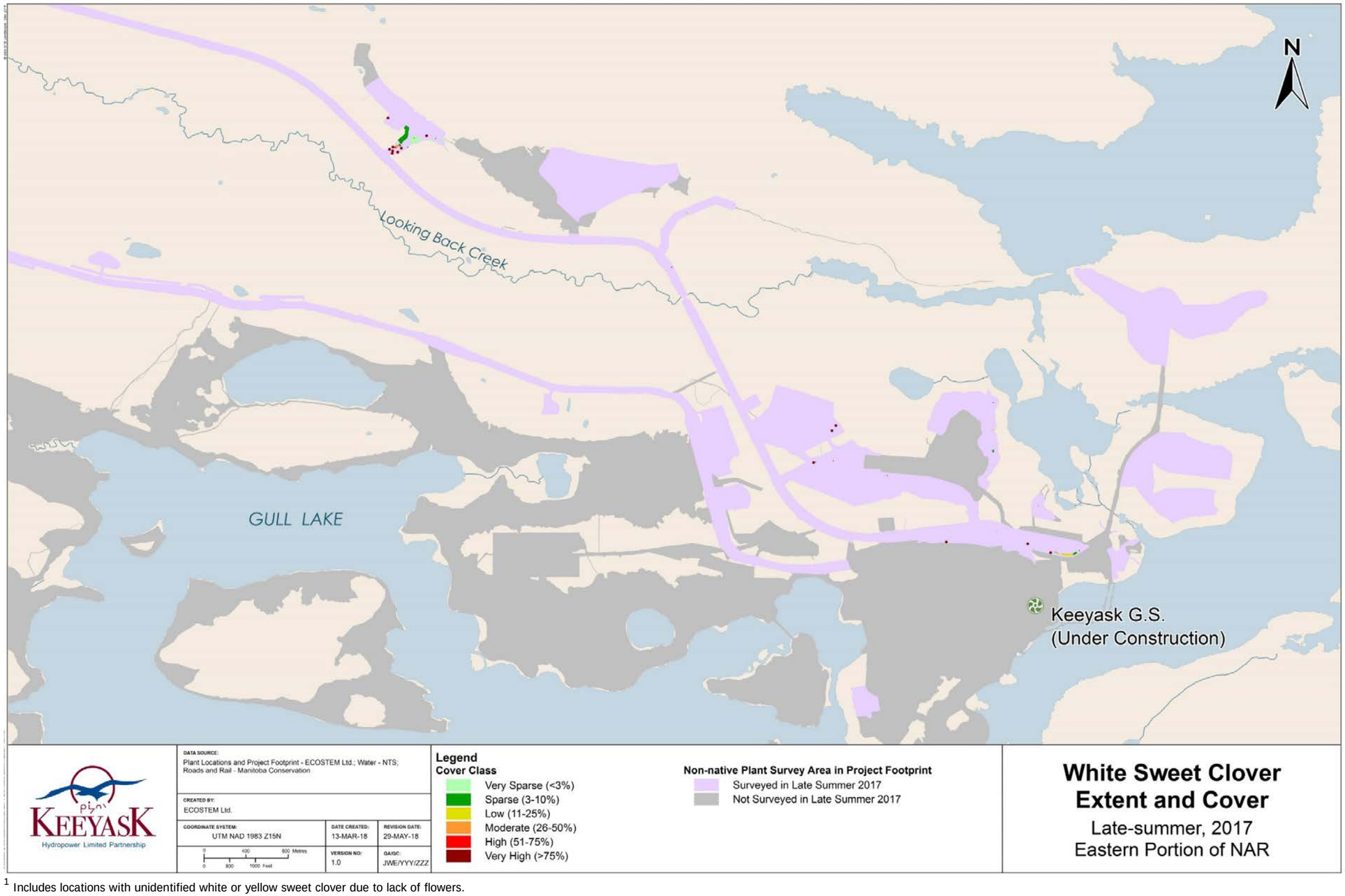


Map 3-10: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the North Access Road in late summer, 2017



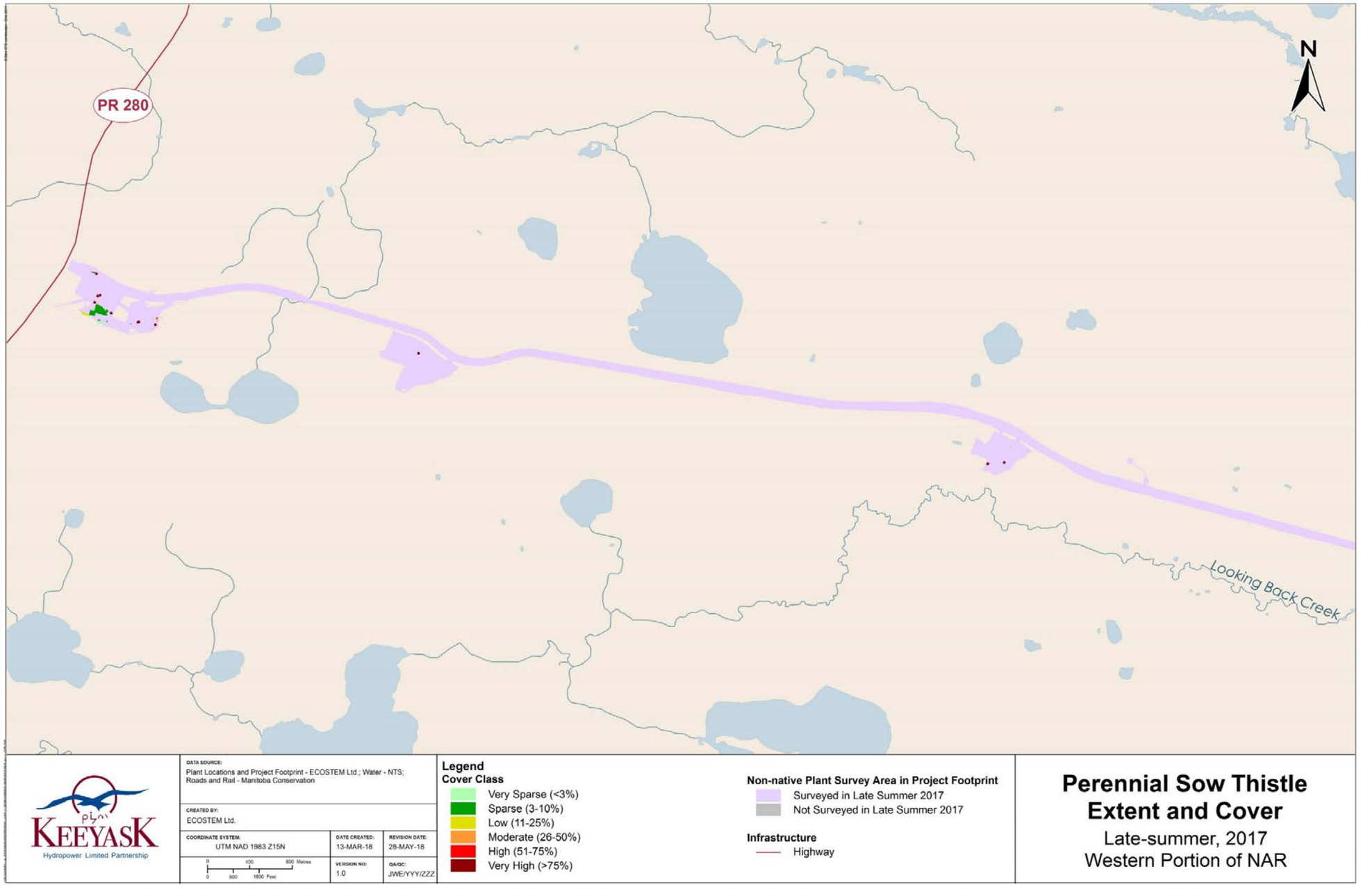
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 3-11: The distribution and abundance (cover class) of white sweet clover1 in the Project footprint along the western portion of the North Access Road in late summer, 2017

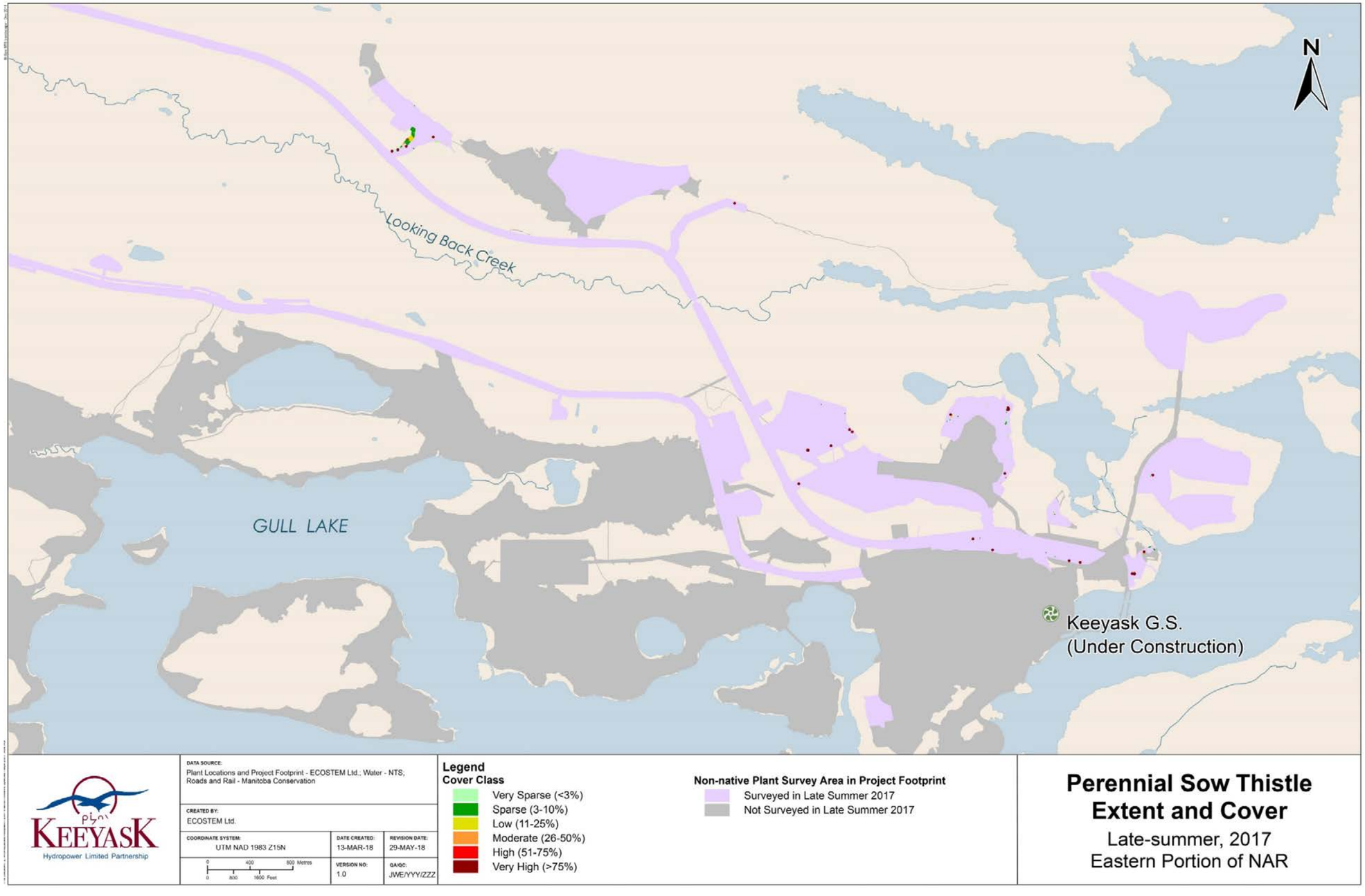


[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

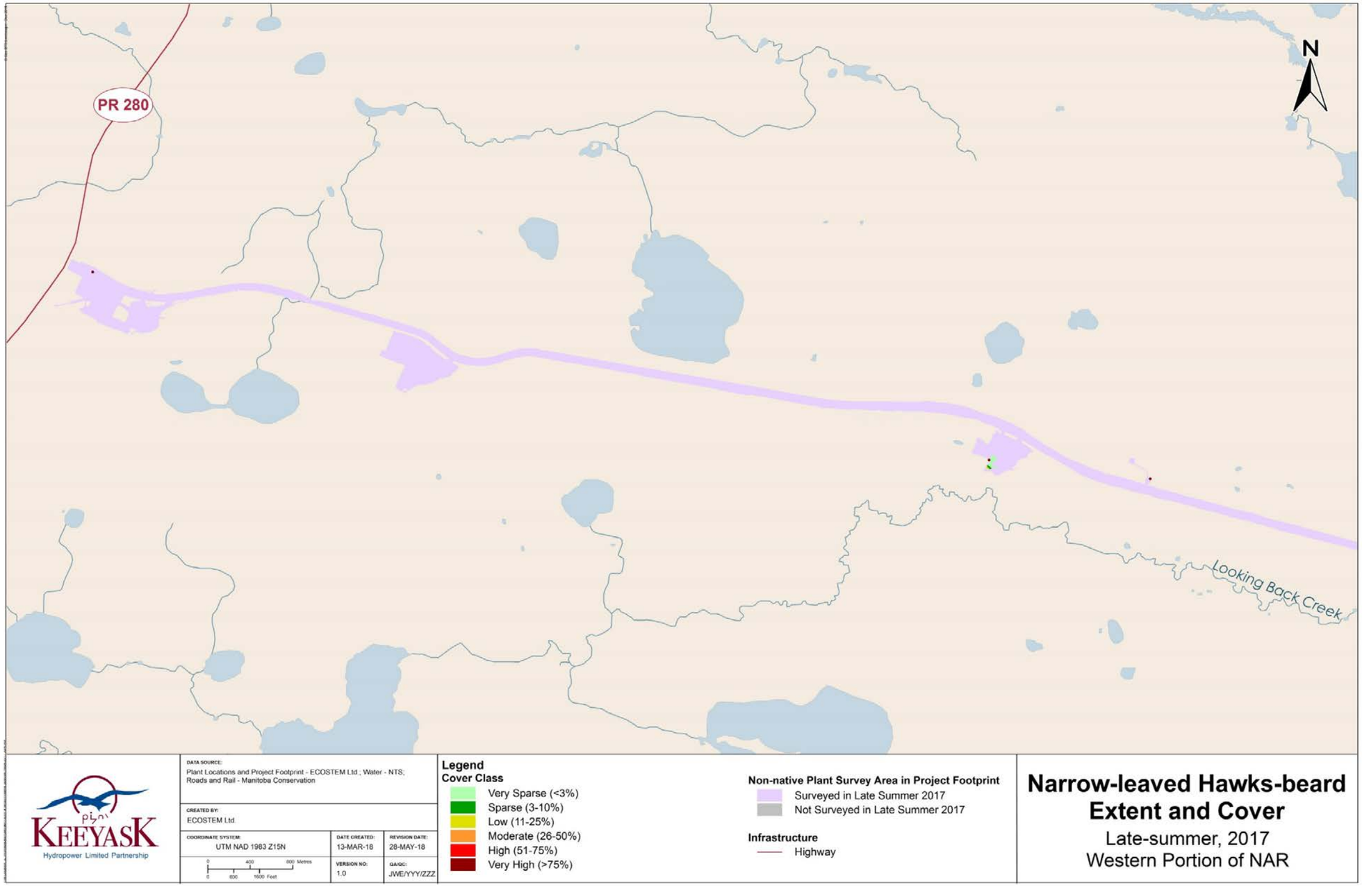
Map 3-12: The distribution and abundance (cover class) of white sweet clover1 in the Project footprint along the eastern portion of the North Access Road in late summer, 2017



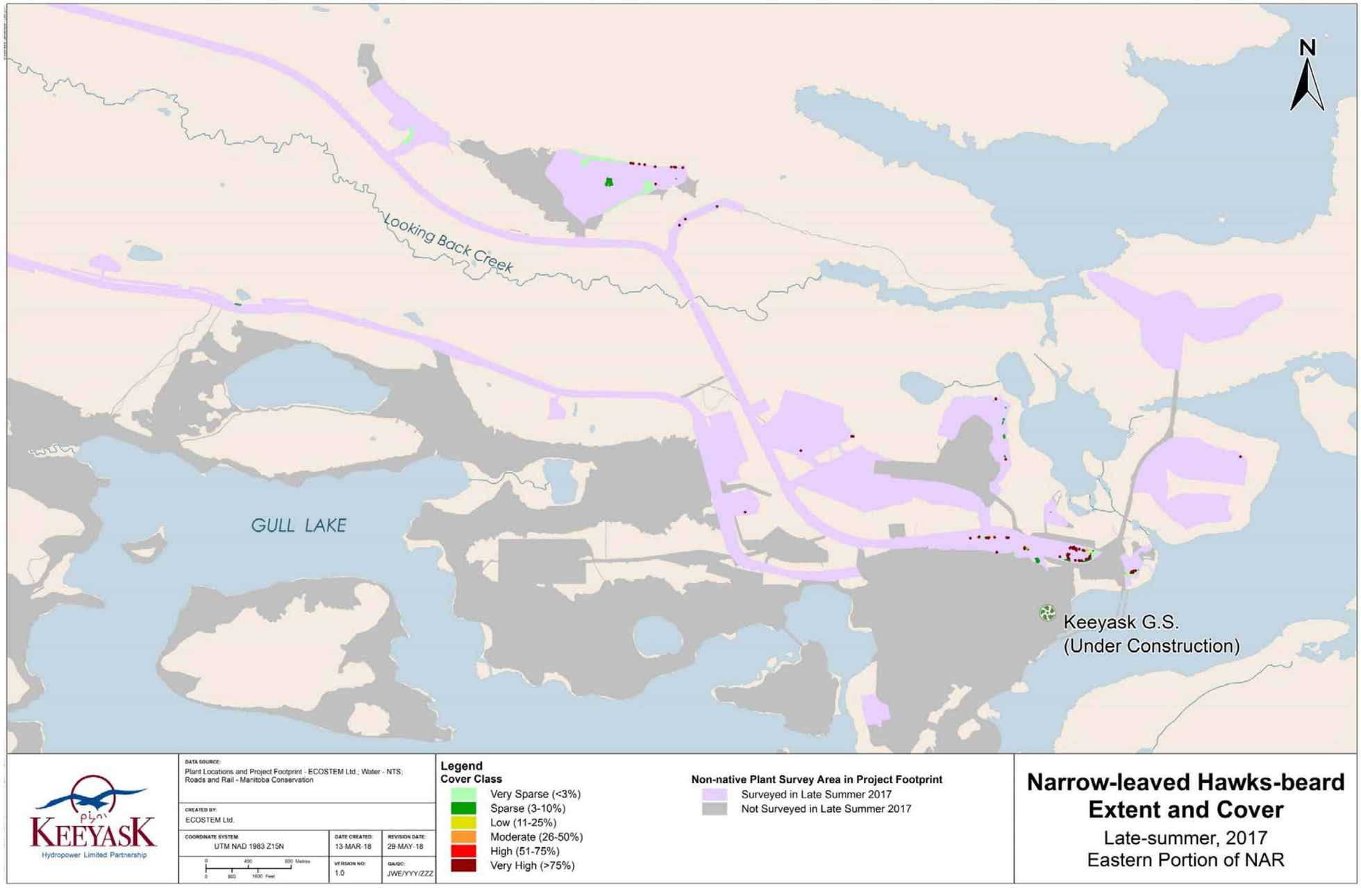
Map 3-13: The distribution and abundance (cover class) of perennial sow thistle in the Project footprint along the western portion of the North Access Road in late summer, 2017



Map 3-14: The distribution and abundance (cover class) of perennial sow thistle in the Project footprint along the eastern portion of the North Access Road in late summer, 2017



Map 3-15: 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, 2017



Map 3-16: 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, 2017

3.5 CONTROL OR ERADICATION MEASURES

3.5.1 GENERAL APPROACH

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

- 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.
- 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 study provides additional control or eradication recommendations during the Project monitoring. These recommendations focus on the plant species of highest invasive concern and the situations where there are practical ways to reduce these species or prevent further spreading. Many of the non-native species recorded during field surveys are commonly found in disturbed areas throughout the Province (e.g., perennial sow thistle, white clover), particularly along roadsides, making it difficult to prevent them from being spread by human or natural sources. At least three non-native species (white sweet clover, common plantain and common dandelion) were likely already well established in the Start-up Camp area when KIP construction began (ECOSTEM 2014). Each of these species were distributed throughout the Start-up Camp, including areas adjacent to the pre-KIP cleared areas. Additionally, non-native plants (e.g., white sweet clover) were found along PR 280 prior to the KIP (KHLP 2009).

Sources used to classify the potential for a non-native plant species to adversely affect native plants in the Project area included the Invasive Species Council of Manitoba (ISCM; 2018), White et al. (1993), the Provincial Noxious Weeds Act (Government of Manitoba 2017) and the Federal Weed Seeds Order (Government of Canada 2016).

ISCM (2018) and White et al. (1993) were considered the most relevant sources for this study. Because the government weed regulations originated from agricultural concerns, they focus on species that are problematic for crops. Also, these regulations list some native boreal plant species (e.g., foxtail barley) as weeds. Native boreal species are not considered to be invasive for the Project area.

As shown in Table 3-8, the non-native plant species recorded during the monitoring were classified into levels of invasive concern for the Project area, in order of highest to lowest concern.

Table 3-7: Species classification into level of invasive concern

Invasive Concern Level	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
Level 4	All remaining non-native plant species

The highest level of invasive concern for the Project (Level 1 species) included ISCM Category 1 and 2 species. ISCM Category 1 species are invasive plants which are not present in Manitoba, but may be present in cultivation and not yet known to have escaped (ISCM 2018). ISCM Category 2 species are invasive plants which are present in Manitoba, capable of further spread, have an established pathway for spread and easily identifiable with available resources. ISCM Category 1 and 2 species are on the early detection and rapid response list. Species that ISCM lists as “other” include invasive species that are present in Manitoba, and are of some concern but not on the early detection and rapid response list.

The second 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 high 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 final 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 3-8 provides the invasive concern classifications for the non-native plant species recorded in the Project footprint since 2015.

The preferred method for removal and disposal of Level 1 non-native species at sites with a small number of plants is to manually remove the plant(s) including roots, remove the soil from around the base of the plant, immediately place all plant and soil material into a double layer of garbage bags, and, dispose of all of the collected material, preferably by burning it.

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 ECOSTEM survey staff would immediately remove and dispose of the Level 1 plants and soil at sites where there were a small number of such plants. 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 field season, some locations were not treated in this manner.

As the 2017 surveys progressed, Level 2 plants were also immediately removed and disposed of at some locations, provided that the number of plants was low enough that it was practical to do so.

Table 3-8: Invasive concern classifications for non-native plant species recorded in the Project footprint

Invasive Concern	Common Name[1]	Scientific Name	ISCM Category[2]	White *et al.* Category[3]	Noxious Weed[4]	Weed Seed[5]
Level 1	Scentless chamomile	*Tripleurospermum inodorum*	Category 2		yes	secondary
	Ox-eye daisy	*Leucanthemum vulgare*	Category 2		yes	secondary
Level 2	Canada thistle	*Cirsium arvense*	other	moderate	yes	primary
	Common burdock	*Arctium minus*	other		yes	
	Perennial sow thistle	*Sonchus arvensis*	other		yes	primary
	Tufted vetch	*Vicia cracca*	other			
	White sweet clover	*Melilotus albus*		moderate		
	Yellow sweet clover	*Melilotus officinalis*		moderate		
Level 3	Wormwood	*Artemisia absinthium*		minor	yes	
	Alfalfa	*Medicago sativa*		minor		
	Lamb's quarters	*Chenopodium album*			yes	
	Common dandelion	*Taraxacum officinale*			yes	
	Narrow-leaved hawks-beard	*Crepis tectorum*			yes	
Level 4	Pineappleweed	*Matricaria discoidea*				
	Bird's-foot trefoil	*Lotus corniculatus*				
	Black medick	*Medicago lupulina*				
	Common plantain	*Plantago major*				
	Smooth catchfly	*Silene csereii*				
	Alsike clover	*Trifolium hybridum*				
	Red clover	*Trifolium pretense*				
	White clover	*Trifolium repens*				
	Wheat	*Triticum aestivum*				

Notes: [1] In decreasing order of concern for the Project area. [2] Invasive Species Council of Manitoba (2018). [3] White et al. (2003). [4] Government of Manitoba (2017). [3] Government of Canada (2016).

Eight of the 22 non-native species recorded in 2017 (Appendix Table 6-4) are considered to be of the highest invasive concern for the Project site (i.e., Level 1 or 2 non-native plants; Table 3-8). Of these, none are an ISCM Category 1 species.

3.5.2 LEVEL 1 NON-NATIVE SPECIES

The two Level 1 non-native species were recorded in 2017 were ox-eye daisy and scentless chamomile, and both were ISCM Category 2 species.

Ox-eye daisy is an introduced ornamental perennial. It can quickly spread by both seed and rhizomes (ISCM 2018). In July 2017, a single ox-eye daisy plant was found for the first time at one location in the ditch in front of the Manitoba Hydro and BBC offices in Work Area B (Figure 3-3, Map 3-17). This plant had not yet seeded, and was immediately removed by ECOSTEM field staff after it was recorded. This species was not found again during late summer 2017 surveys.

Scentless chamomile 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 on the path to the well in 2015, and in EMPA D17 in 2016 (Map 3-18). Shortly after these plants were found, it was recommended that Manitoba Hydro site staff removed and disposed of these plants using the preferred method. Manitoba Hydro site staff carried out the scentless chamomile plant removal shortly thereafter. There were no scentless chamomile plants at these treated locations in 2017.

In August 2017, a single scentless chamomile plant was found growing in EMPA D16 (Photo 3-1). This plant was immediately removed and disposed of by ECOSTEM field staff.

3.5.3 LEVEL 2 NON-NATIVE SPECIES

Six Level 2 non-native species were recorded in 2017. Of these, the ISCM “other” species included Canada thistle, perennial sow thistle and tufted vetch. White et al. (1993) classify Canada thistle, white sweet clover, yellow sweet clover as moderately invasive in Canada.

In addition to being an ISCM “other” and a White et al. moderate invasive, Canada thistle is classified as a weed seed in Canada (Table 3-8). On this basis, it was recommended that plants be removed where feasible. The preferred disposal method was the same as the one described above for scentless chamomile.

The 2015 and 2016 surveys found three Canada thistle locations (Map 3-19). Plants have not been observed again at one of the locations. The remaining two locations were included in the areas treated with herbicides (see Section 3.5.6). Surveys in 2017 found two additional locations, one with two individuals near the south ditch surrounding the Start-up Camp, and one small patch at the eastern corner of Borrow Area KM-4. The plants at the latter location were

removed and disposed of by ECOSTEM field staff on August 31, 2017. The former location will be visited in early summer 2018 and plants will be removed and disposed of if practical.

Perennial sow thistle is classified as an ISCM “other” species and a weed seed in Canada (Table 3-8). This species would be difficult to effectively control as it is commonly found in disturbed areas, including along PR 280. Some of the areas containing perennial sow thistle were sprayed with herbicides in August 2016 (see Section 3.5.6). Where one to a few plants were found during the 2017 surveys, these plants were removed and disposed of by ECOSTEM field staff.

The three specific locations where perennial sow thistle was found were in the SAR Camp during 2017 early summer surveys (Map 3-20). This plant had not been previously well-established there. Plants at all three locations were removed immediately by ECOSTEM field staff. During late summer surveys, new plants were found growing at two of the three locations recorded in early summer, and at an additional seven locations around the SAR Camp. These plants appeared to have germinated from seed after the early summer removal. Plants at eight of these locations were removed immediately by ECOSTEM field staff. The ninth location will be visited in early summer 2018 and removed if practical.

The SAR Camp will be visited in early summer 2018 to determine if immediate removal is preventing further perennial sow thistle establishment in the area.

Tufted vetch can spread aggressively, crowding out native vegetation. Tufted vetch plants were found at ten locations during the 2017 surveys (Map 3-21). The plants at one location in the SAR camp in July 2017 were removed immediately by ECOSTEM field staff. One plant found in Borrow Area G-1 during the 2017 late summer survey will be removed in early summer 2018.

The remaining tufted vetch locations were along the SAR and in an attached borrow area east of the Butnau Marina near the old Butnau Road. Previous observations indicated that tufted vetch was already well established in this area, along the old Butnau Road, and in the Town of Gillam. On this basis, it was decided that removing these plants would not effectively prevent establishment in the area.

White and yellow sweet clover, which White et al. (1993) classify as moderate invasives, appeared to be expanding rapidly in extent and/or cover in 2016. In 2017, overall cover increased primarily along the south and north access roads, while in other footprints total cover increased slightly, or declined in the case of the borrow areas. Both of these species are commonly found in disturbed areas throughout the Province, particularly along roadsides, making it difficult to prevent them from spreading. No control measures in addition to the herbiciding of selected areas to control multiple species (see Section 3.5.6) are recommended at this time.

Common burdock is an ISCM “other” species and a Manitoba noxious weed (Table 3-8). One plant was found near the Main Camp during 2016 surveys. The location was visited in early summer, 2017, and the remains of the dead plant, including all burrs, were removed and disposed (Figure 3-2). No living plants were found during 2017 surveys.

3.5.4 LEVEL 3 NON-NATIVE SPECIES

At Level 3 invasive concern, six of the 12 remaining non-native species recorded in the Project footprint are considered to be noxious weeds, weed seed species and/or minor invasives in Canada (Table 3-8).

Lamb's quarters was among the species at this level of invasive concern. Results from the 2016 surveys suggested that lamb's quarters cover was possibly beginning to decline (ECOSTEM 2017b). This species had started to spread within cleared areas during the KIP construction, and continuing through Project construction to late summer 2016 (particularly in the work areas and borrow areas), but its extent decreased locally in the Start-up Camp and Borrow Area KM-4 (Map 3-7). Total cover in most Project components appeared to peak in late summer 2015, and then declined substantially by late summer 2016. However, late summer surveys in 2017 found that lamb's-quarters extent and cover had increased substantially to its highest level since construction began. Cover was more than twice as high as it was in late summer 2016. Most of the increase was in older footprints established during the KIP along the NAR. Control recommendations for the 2018 growing season are being developed based on the results to date (see Section 5.0).

Narrow-leaved hawks-beard was another species that was beginning to spread rapidly. This species was first recorded during 2016 surveys. Since late summer 2016, the plant has more than doubled in cover (Table 3-5). Patches of this plant were establishing throughout the Project footprint, and were most extensive in Work Areas B, C and X, and in Borrow Area G-1 (Map 3-16). Seeds of this plant are wind-dispersed (Table 3-8), which makes control more difficult. Control recommendations for the 2018 growing season are being developed based on the results to date.

Common dandelion was another species that appeared to be expanding rapidly in both extent and cover in 2016. This species is commonly found in disturbed areas throughout the Province, particularly along roadsides, making it difficult to prevent spreading. By 2017, common dandelion had increased only slightly in cover overall in most footprints, and cover decreased in the borrow areas.

3.5.5 LEVEL 4 NON-NATIVE SPECIES

Surveys in 2016 reported the presence of healthy wheat plants growing from straw being stored in the Spillway Laydown Area (ECOSTEM 2017b). These straw bales were brought to site to control erosion. It was thought that the straw bales contained viable wheat seeds.

Given the developmental stage of the plants at the time of the 2016 surveys, it appeared unlikely that they could produce viable seed before a fall frost would kill the plants. The area was surveyed in early summer 2017, and it was found that the bales had been moved to Borrow Area G-3. A substantial amount of wheat was growing out of the remnants of straw on the

ground in the Spillway Laydown Area (Figure 3-3), indicating that either the plant was able to seed, or that other seed contained in the straw survived the winter to germinate. Plants were also observed growing from straw that was spread in Borrow Area G-3 and in EMPA D16. No plants were found growing outside of areas where straw was spread or stored. If the straw is no longer being used, it is recommended that it be burned to kill any viable seed remaining in it. These locations will continue to be monitored in 2018 to determine if more plants appear.

The remaining non-native species were fairly common in disturbed areas surrounding the Project. Few of these species appeared to be spreading at the same rate as lamb's quarters had. The only other species that appeared to be expanding rapidly in both extent and/or cover was pineappleweed (*Matricaria discoidea*).

3.5.6 OTHER CONTROL OR ERADICATION TREATMENTS

The first recommended herbicide treatment (ECOSTEM 2016) was implemented on August 25, 2016 in five key sites shown in Map 3-22. All of these sites except for the single site off the SAR were sprayed with herbicides. The herbicide mixture was 5.0 liters Vantage/ 0.5 liters Milestone/ 0.375 liters Esplanad applied at a rate of 700 liters per hectare.

The most abundant species prior to spraying were as follows. In the Start-up Camp treatment area, white and yellow sweet clover were the most abundant species (90.5% of total non-native plant cover), followed by common dandelion and field sow-thistle (Table 3-9). In the Borrow Area KM-1 treatment area, sweet clover made up almost all the cover (98.4%). In the Borrow Area G-1 treatment area cover was a mixture of sweet clover and lamb's quarters (47.5% and 43.2%, respectively), with field sow-thistle making up most of the remaining cover. In the Work Area B treatment area, common dandelion made up most of the cover (84.1%), with most of the remaining cover a mixture of sweet clover, lamb's-quarters, narrow-leaved hawks-beard and common plantain.

Table 3-9: Species composition (cover a species as a percentage of all species) of herbicide-treated areas in late summer 2016 and late summer 2017.

Common Name	Start-up Camp			Borrow Area KM-1			Borrow Area G-1			Work Area B		
	2016	2017	Percent Change[1]	2016	2017	Percent Change[1]	2016	2017	Percent Change[1]	2016	2017	Percent Change[1]
Alfalfa	0.5	0.1	-74	0.6	3.7	541	-	0.0	Int.	-	-	-
Alsike Clover	1.2	0.1	-91	0.1	0.2	65	-	0.1	Int.	-	0.0	Int.
Bird's-foot Trefoil	0.1	-	-100	-	-	-	-	0.0	Int.	-	-	-
Canada Thistle	0.0	-	-100	-	-	-	-	-	-	-	-	-
Common Dandelion	4.0	62.6	1,367	0.8	0.0	-95	0.0	4.2	56,130	84.1	73.2	-1
Common Plantain	0.1	0.1	68	-	-	-	1.4	0.0	-98	2.5	1.1	-50
Common Timothy	-	-	-	-	-	-	-	-	-	-	0.0	Int.
Field Sow-thistle	3.2	3.1	-9	-	-	-	5.9	30.6	678	0.0	0.1	510
Lamb's-quarters	0.3	0.1	-62	0.0	0.9	2,216	43.2	26.0	-9	4.1	0.3	-92
Narrow-leaved Hawks-beard	-	-	-	0.0	-	-100	1.0	3.9	469	3.5	11.9	288
Pineappleweed	0.0	0.1	2,737	-	-	-	0.1	0.1	-42	0.1	-	-100
Red Clover	-	0.0	Int.	-	-	-	-	-	-	-	-	-
Smooth Catchfly	0.0	0.0	200	-	-	-	0.0	0.3	3,371	-	-	-
Tufted Vetch	-	-	-	-	-	-	0.0	-	-100	-	-	-
White and Yellow Sweet Clover	90.5	33.7	-65	98.4	95.1	-1	47.5	34.8	10	5.7	13.4	167
White Clover	0.0	-	-100	-	-	-	-	-	-	-	-	-
Wormwood	-	-	-	-	-	-	0.0	0.0	-	-	-	-
Yellow or Curled Dock	-	-	-	-	-	-	0.8	-	-100	-	-	-
All	100.0	100.0	-5	100.0	100.0	2	100.0	100.0	50	100.0	100.0	14
Total cover (m^2)	*697*	*661*		*958*	*978*		*1,404*	*2,111*		*1,621*	*1,853*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".[1] Percent change from 2016 to 2017; A negative sign means that cover decreased; "Int." = Species was first recorded in 2017.

To assess the efficacy of the 2016 herbicide application, the herbicide-treated sites were surveyed in detail in early and in late summer 2017. Evaluation of non-native plant cover over four surveys from early summer 2016 to late summer 2017 indicated that, overall, the herbicide treatment had no apparent lasting effect in any of the treated sites, nor did it prevent further spread (Table 3-10). Invasive and other non-native plant cover continued to expand in 2017.

The herbicide treatment did not reduce overall plant cover at three of the four sites. Total non-native plant cover in the herbicide-treated areas in each of Borrow Area KM-1, Borrow Area G-1 and Work Area B was substantially higher in early summer 2017 than it was in early summer 2016 (Table 3-10; Figure 3-4 shows example sites). In Work Area B, early summer 2017 plant cover was higher than late summer 2016 cover. Late summer 2017 plant cover in these three areas was higher than late summer 2016 plant cover. Cover in the Borrow Area G-1 treatment area was more than twice as high as at the same time in 2016.

The Start-up Camp treated area was the only one where 2017 early summer non-native plant cover was lower over the short-term, but still exhibited an increasing trend. The presence of dead plants from the previous year in the treated areas (Figure 3-4) indicated that the herbicide treatment was effective in killing plants, however it did not prevent new plant growth or establishment in the following year. Total non-native cover in early summer 2017 was approximately half that of early summer 2016, but had increased to being only slightly lower by late summer (Table 3-10).

By late summer 2017, non-native plant composition in all treated areas except Borrow Area KM-1 had changed somewhat (Table 3-9). In the Start-up Camp, common dandelion made up more than half (62.6%) of the total non-native plant cover, with sweet clover falling to approximately one-third of the total cover. In Borrow Area G-1, the proportion of field sow-thistle increased, forming an even mixture with sweet clover and lamb's-quarters. In Work Area B, common dandelion was still the dominant species, but the proportions of sweet clover and narrow-leaved hawks-beard increased.

Control recommendations for the 2018 growing season are being developed based on the results to date.

Table 3-10: Total approximate invasive and non-native species cover (m^2) in herbicide-treated areas for each survey from 2016 to 2017

Treatment Area	2016		2017	
	Early Summer	Late Summer	Early Summer	Late Summer
Start-up Camp	350	697	198	661
Borrow Area KM-1	201	958	775	978
Borrow Area G-1	424	1,404	975	2,111
Work Area B	407	1,621	1,698	1,853
All areas	*1,381*	*4,681*	*3,646*	*5,603*

Figure 3-1: Ox-eye daisy in Work Area B on July 8, 2017

Photo 3-1: Scentless chamomile growing in EMPA D16 on August 25, 2017

A

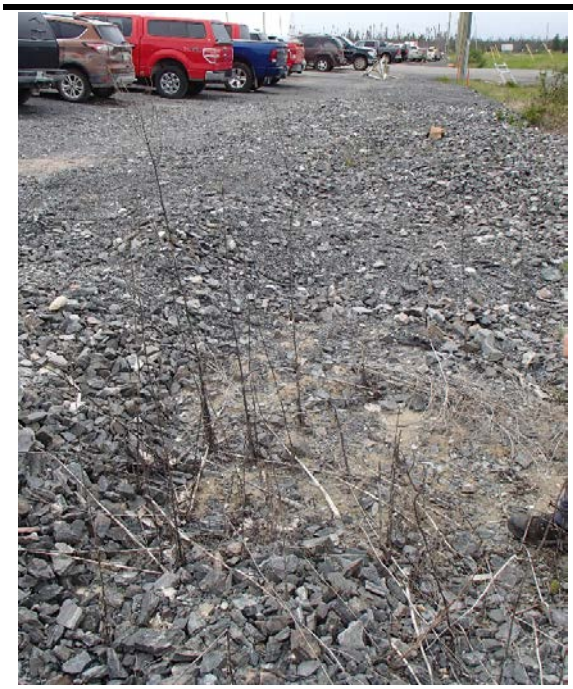
B

Figure 3-2: 2016 common burdock plant remains (A) on July 7, 2017, and site after plant removal (B).

A: Spillway Laydown Area on July 8, 2017

B: Borrow Area G-3 on July 10, 2017 C: EMPA D16 on August 25, 2017

Figure 3-3: Wheat plants growing on the ground in remnants of wheat straw in 2017.



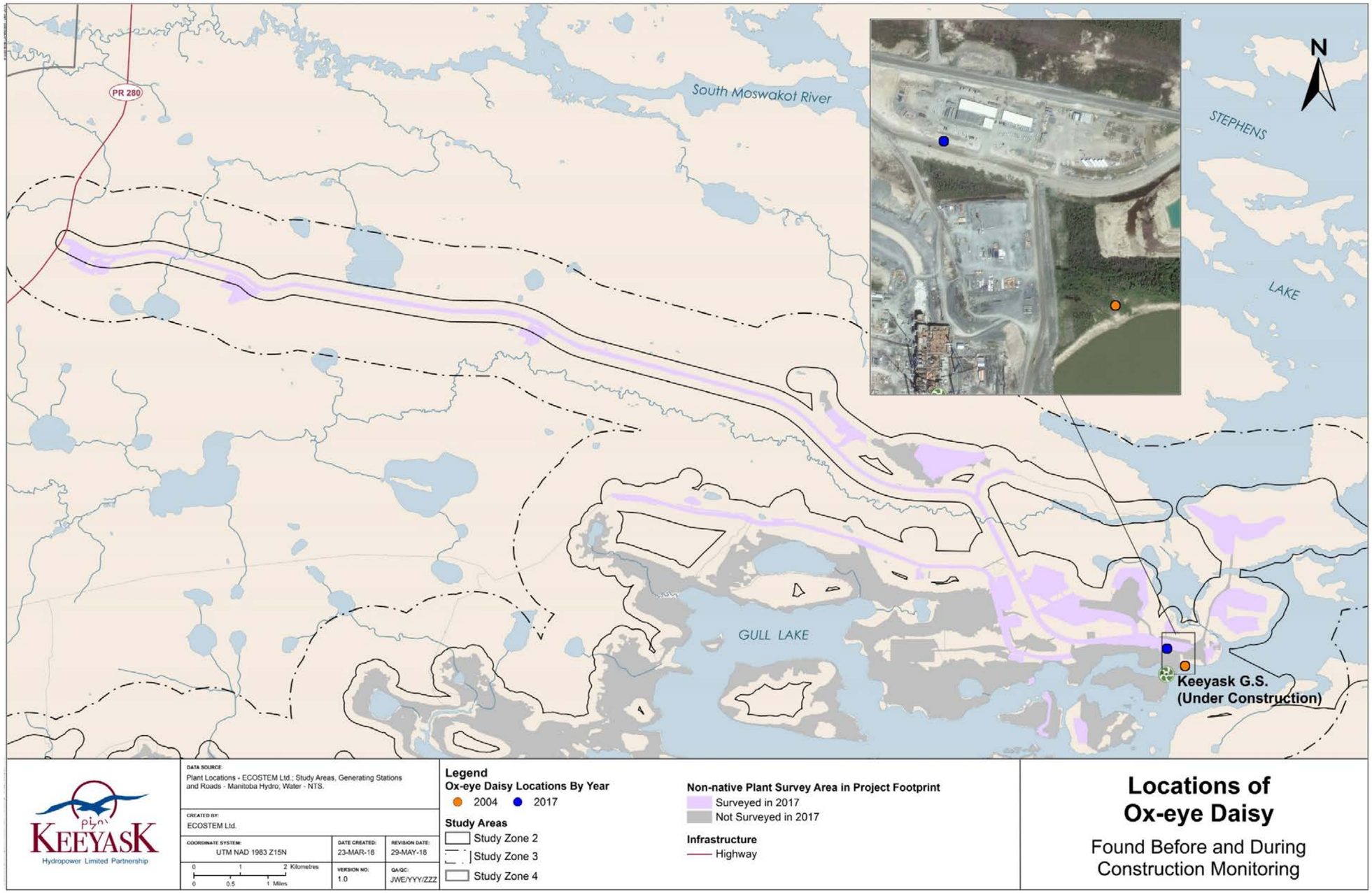
A: Herbicide-killed perennial sow thistle at Start-up Camp, July 5, 2017

B: Regenerating sweet clover in Borrow Area KM-1 herbicide treatment area, July 6, 2017

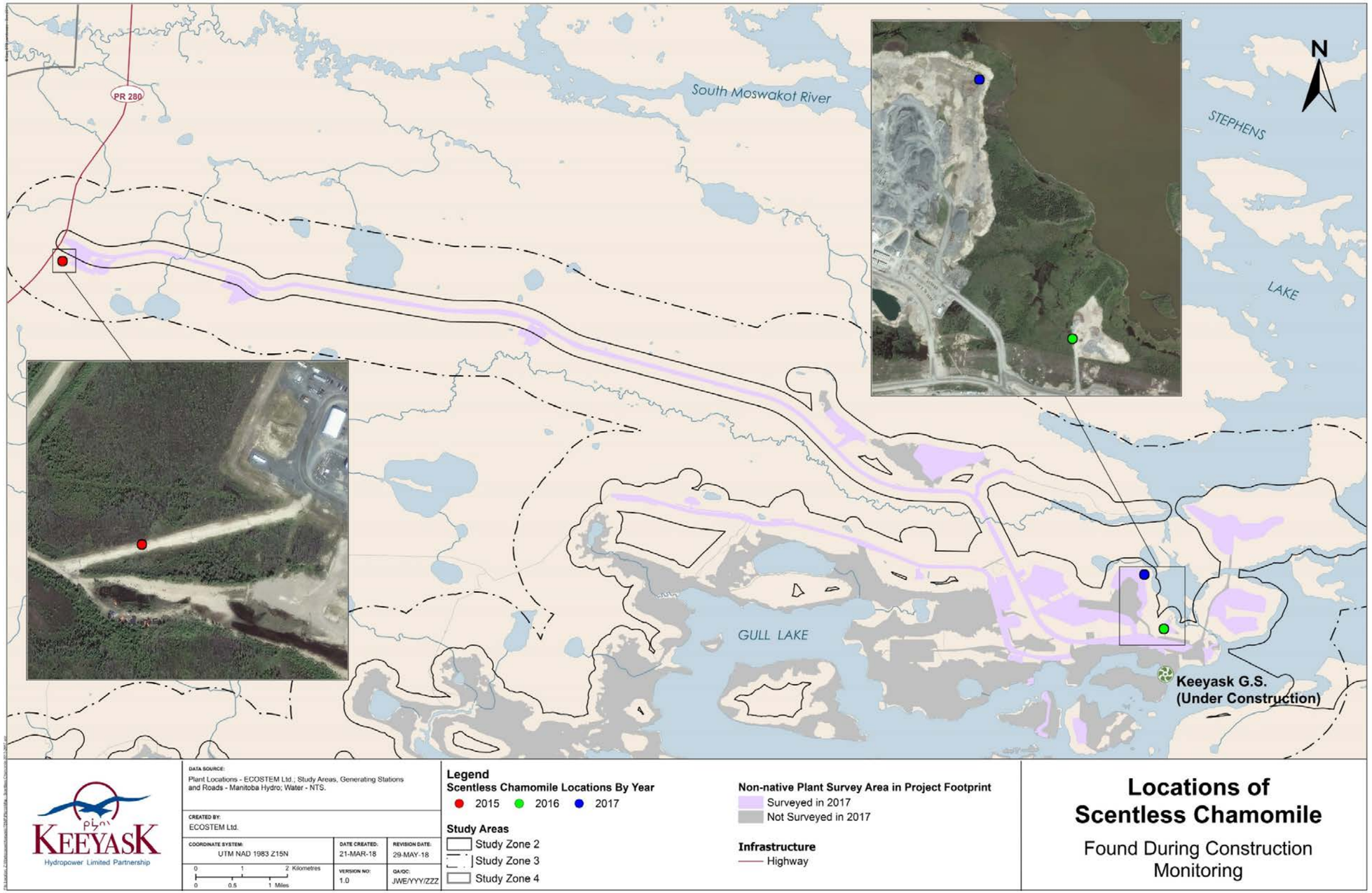
C: Herbicide-killed lamb's quarters surrounded by seedlings in Borrow Area G-1, July 10, 2017

D: Herbicide-killed dandelion and sweet clover with regenerating danelion in Work Area B, July 8, 2017

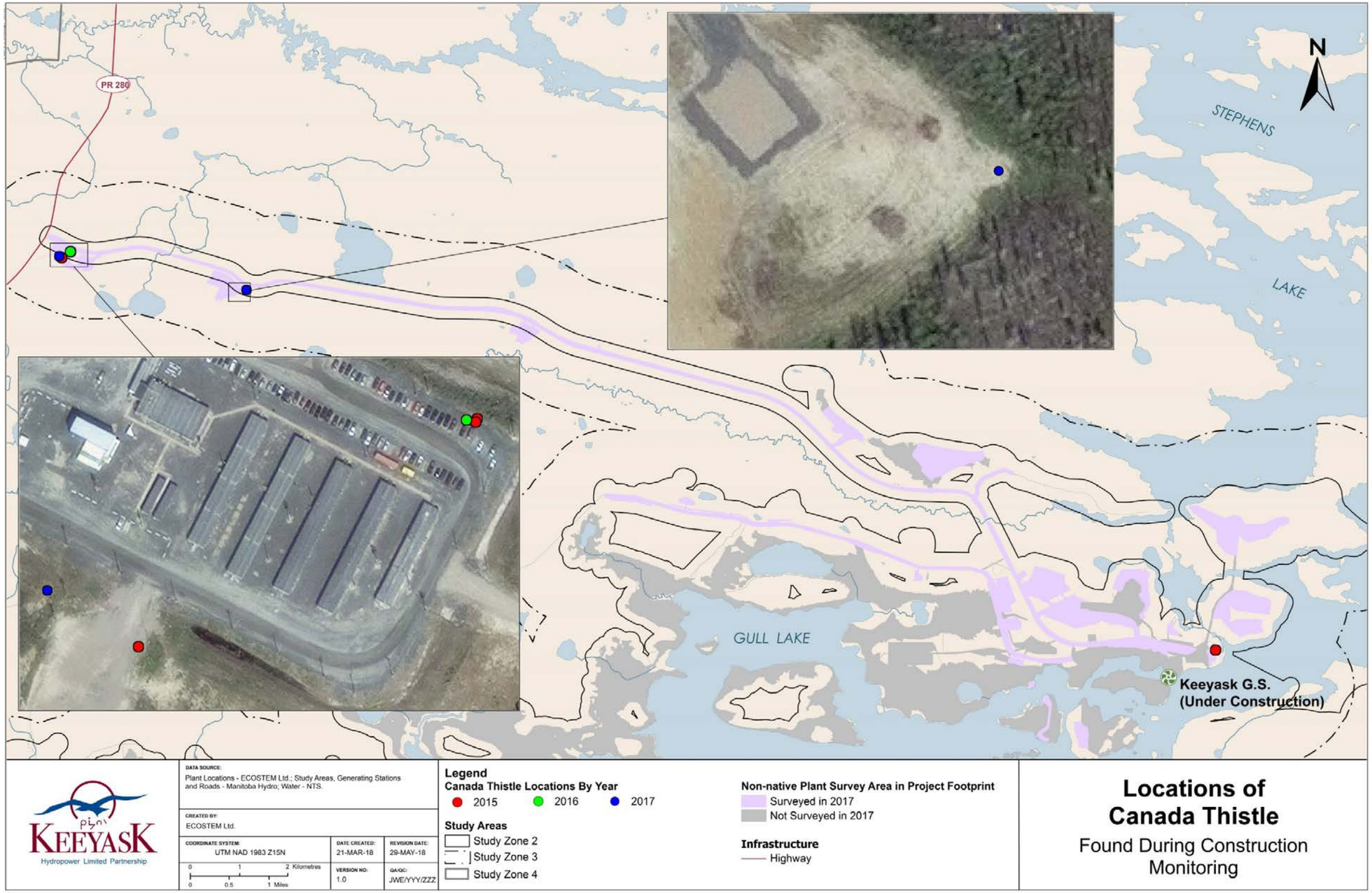
Figure 3-4: Herbicide treatment areas in July, 2017



Map 3-17: Locations of ox-eye daisy found before and during Project construction monitoring

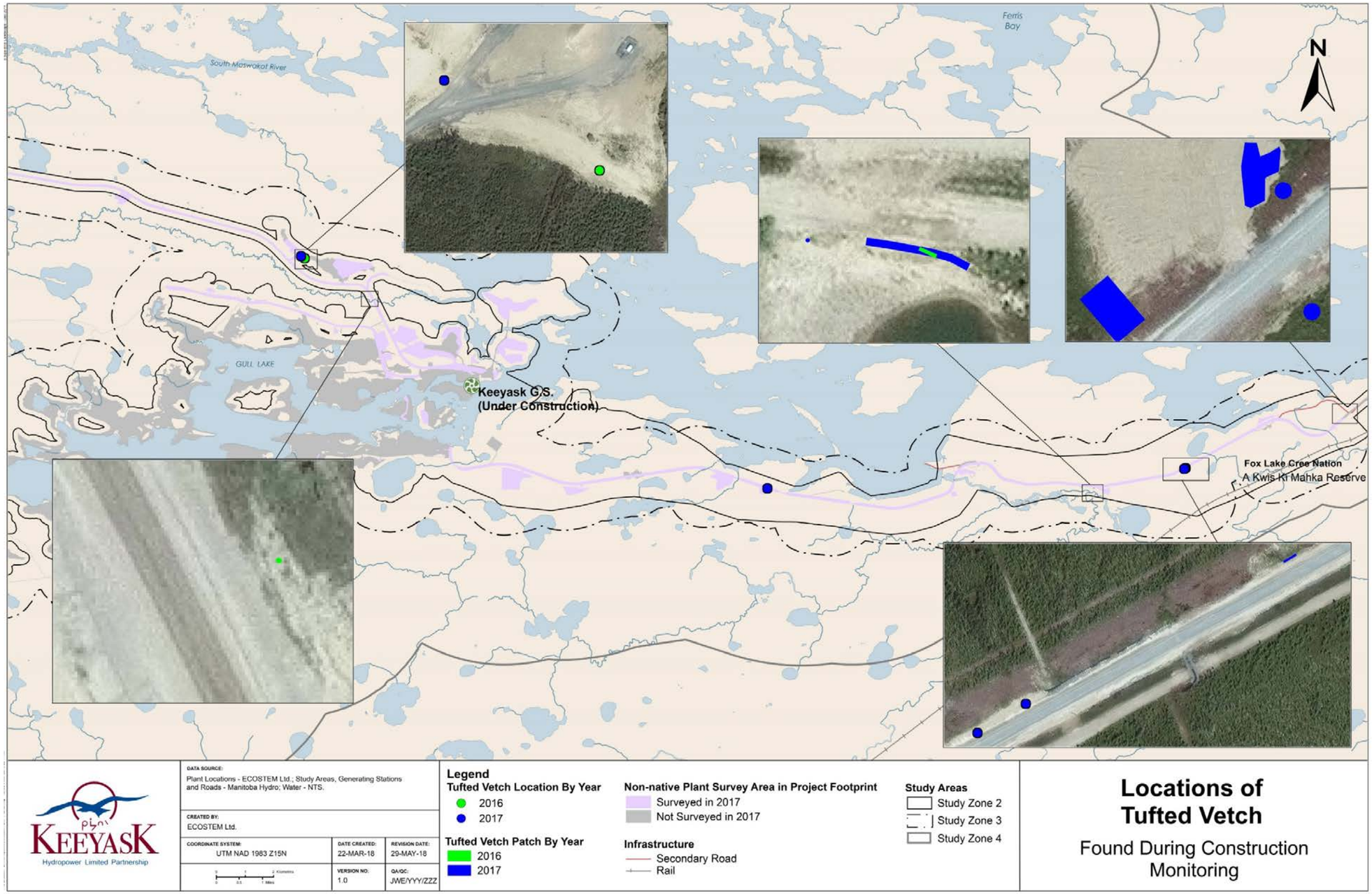


Map 3-18: Locations of scentless chamomile identified during Project construction monitoring

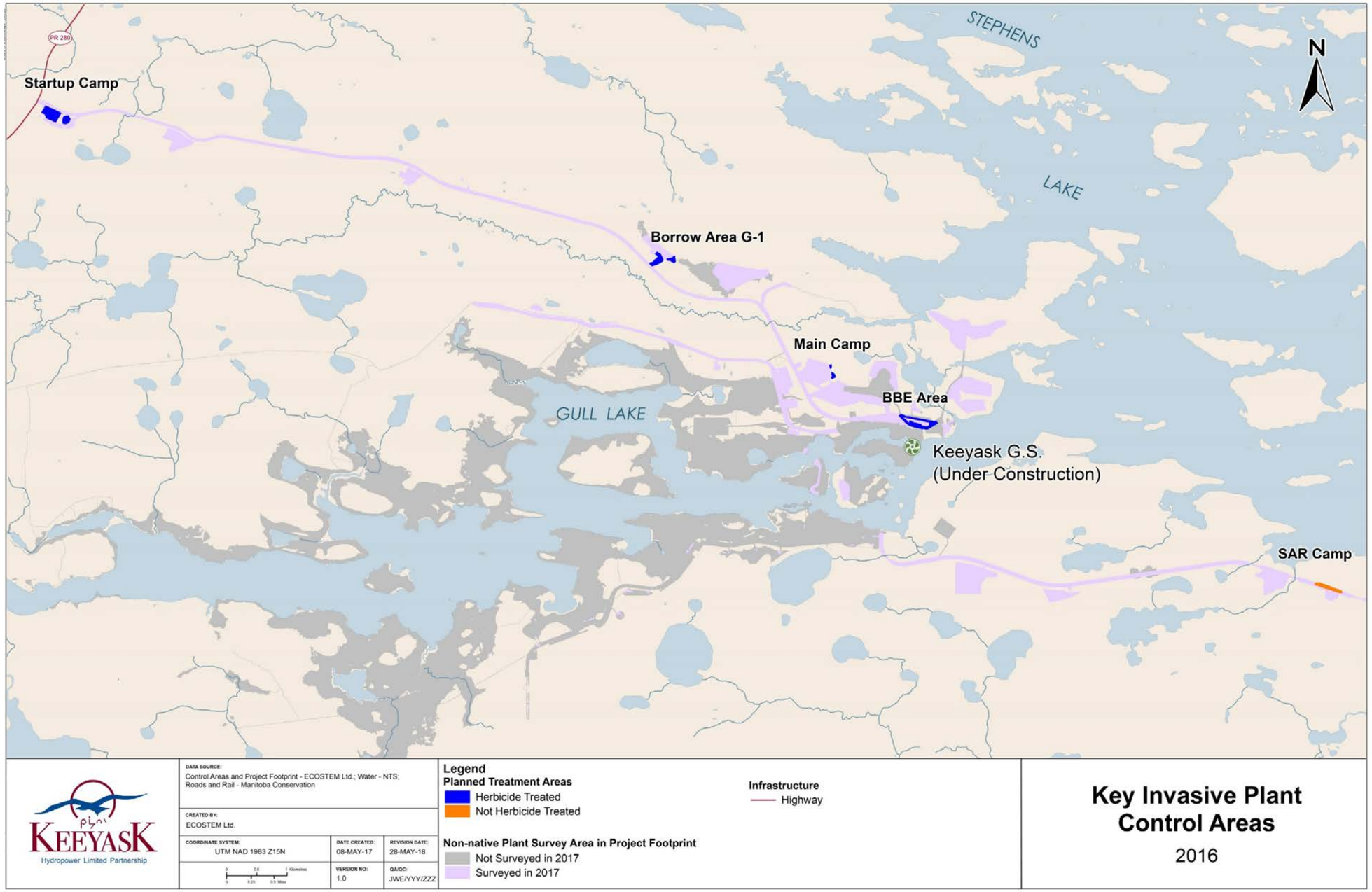


Map 3-19: Canada thistle locations identified during Project construction monitoring

Map 3-20: Perennial sow thistle locations near the South Access Road Camp, 2017



Map 3-21: Tufted vetch locations identified during Project construction monitoring



Map 3-22: Key areas selected for invasive plant herbicide control in 2016

4.0 DISCUSSION

A total of 22 non-native plant species were found during the 2017 surveys, which was one more than recorded in 2016. Total non-native plant cover was also higher in 2017 than in 2016. However, all species combined still covered less than 1% of the Project footprint.

The increased number of species and total cover were primarily attributed to three factors: human activities were transporting seeds into Project areas; the higher amount of construction activity; and, a longer time since construction began.

Many of the non-native species recorded during field surveys are widespread in human disturbed areas within the Keeyask region, particularly along roadsides (KHLP 2012b). Based on surveys conducted prior to the KIP construction, it was likely that at least three non-native species were already well established near the Start-up Camp area, along PR 280 and in an adjacent pre-existing borrow area used during the KIP when construction began. The non-native plants present along PR 280 prior to the KIP were likely were acting as a seed source for the KIP (KHLP 2009) and for the Project.

The non-native species recorded during field surveys are easily transported into the Project footprint areas on vehicles, footwear, equipment and materials that come from elsewhere or move around within it. While non-native plants also continued to colonize or spread in the more recently cleared areas, their cover remained comparatively low in these areas. The majority of the non-native species found in each year since 2015 were in the portions of the Project footprint originally created by or existing before KIP, and which are still being used by the Project (e.g., Start-up Camp, Borrow Area G-1 at KM-15).

The increased amount of construction activity and number of vehicles (both in the most recent year and cumulatively since construction began), likely contributed to spreading these species. This was particularly the case for the portions of the Project footprint that already contained non-native species when Project construction began (e.g., the Start-up Camp).

The cumulative time since construction began provided more opportunity for natural sources (e.g., wind or animal dispersion), the seed bank and human sources to spread seeds.

As noted above, it is difficult to prevent vehicles and people from inadvertently spreading non-native plant species into the Project footprint. Therefore, control or eradication recommendations in addition to the standard measures included in the EIS and EnvPPs focused on the plant species of highest invasive concern and on the situations where there are practical ways to control these species or prevent them from spreading further.

To facilitate this management approach, all of the non-native plant species recorded since Project monitoring began were classified into one of four levels of invasive concern for the Project area (i.e., Levels 1 to 4; see Section 3.5.1). Species at the first and second levels of invasive concern for the Project were the primary focus of management recommendations.

Species at the third and fourth levels of concern were still considered as they may become problematic in some locations and/or conditions.

The preferred approach for dealing with Level 1 non-native species is to remove and dispose of the plants shortly after finding them when they occur as one to a few plants. Ideally, this is accomplished by manually removing the plant(s), removing the soil from around the base of the plant, immediately placing all material into a double layer of garbage bags, and, disposing of all of the bagged material, preferably by burning it.

When plants falling into the highest level of invasive concern were found in 2015 and 2016, their locations were reported to Manitoba Hydro environmental site staff, who carried out their removal shortly thereafter. Part way through the 2017 surveys, it was decided that ECOSTEM survey staff would immediately remove plants of these species at locations having one to a few plants. Immediate removal was intended to reduce the possibility for these plants to disperse seed or become well-established. As this decision was made during the field season, some locations were not included in the immediate manual treatment. These latter locations will be revisited in early summer 2018, and the plants will be removed if practical to do so.

Level 1 non-native species (Section 3.5.1) recorded in 2017 included ox-eye daisy and scentless chamomile, which are both ISCM Category 2 species. One plant was found for each of these species. Immediately after discovery, ECOSTEM field staff carefully removed both plants using the preferred method described above. Monitoring surveys in 2018 will determine if hand removal was effective at controlling perennial sow thistle spread here.

The 2015 and 2016 surveys had found a single scentless chamomile plant at two other locations. These plants were removed and disposed of shortly thereafter by Manitoba Hydro environmental staff. Monitoring in 2017 did not find any plants at these locations. Manual removal shortly after discovery was effective in these cases.

The 2017 monitoring surveys recorded five Level 2 species, including Canada thistle, perennial sow thistle, tufted vetch, white clover and yellow sweet clover. As Canada thistle is both an ISCM “other” and a White et al. moderate invasive, the plants at one location were removed by ECOSTEM field staff during the 2017 surveys. Two plants at a second location will be hand treated during 2018 early summer surveys.

Tufted vetch was found at 10 locations. Two of these locations had a small number of plants and were relatively distant from pre-existing infrastructure. The plants at one of these locations were manually removed by ECOSTEM field staff as soon as they were discovered. Attempts will be made to manually remove plants at the other location during 2018 early summer surveys.

Eight of the tufted vetch locations were along the SAR east of the Butnau Marina. In these cases, immediate manual removal was not recommended since tufted vetch was well established at these locations and in adjacent and nearby human footprints. These locations are among those being considered for herbicide treatment (see below).

Perennial sow thistle, the third ISCM” other” species recorded in 2017, was already fairly widespread in the footprint, and in disturbed areas throughout the Keeyask region. Locations

where only a small number of plants were present were hand treated by ECOSTEM field staff when encountered during the surveys.

At locations around the SAR camp, perennial sow thistle was absent or not well established in 2016. Several plants were manually removed by ECOSTEM field staff in this general area during early and late summer surveys. Monitoring surveys in 2018 will determine if immediate removal was effective at controlling perennial sow thistle spread here.

It would be difficult to effectively control perennial sow thistle by manual removal at the remaining locations as this species was abundant there. Such locations are among those being considered for a herbicide or other type of treatment.

White clover and yellow sweet clover appeared to be expanding rapidly in extent and/or cover in 2016, but only increased slightly between 2016 and 2017, with most of the recent expansion occurring along roadsides, making it difficult to prevent them from spreading further. The sites that were treated with herbicides in 2016 included these species. As suggested by herbicide treatment results (see below), it is likely that an aggressive approach would be needed to control these species with herbicides in areas where they are well-established.

The 2017 surveys recorded six Level 3 species (alfalfa, common dandelion, lamb's quarters, narrow-leaved hawks-beard, smooth catchfly, wormwood). Six Level 4 species (alsike clover, common plantain, black medick, red clover, wheat, white clover) were also found.

Lamb's quarters was by far the most widespread and abundant (51% of total non-native plant cover) of the Level 3 and 4 species, followed by common dandelion (19% of total non-native plant cover). The remaining 9 species combined accounted for just over 2% of total non-native plant cover.

Results from the 2016 surveys suggested that lamb's quarters cover was possibly beginning to decline, since plant cover was lower than in 2015. However, 2017 surveys found that late summer cover was more than twice that of late summer 2016, and had reached its highest level since construction began. Most of this increase was in older project footprints, indicating that the decrease observed in 2016 may have been an anomaly. Continued monitoring will determine if lamb's quarters cover is on an increasing trend.

In 2016, wheat plants were found growing out of straw bales being stored in the spillway laydown area. At the time, it seemed unlikely that the plants would survive the winter. Surveys in 2017 found that the plants continued to germinate in the remnants of straw in the spillway laydown area, as well as at other locations where the straw had been stored or spread (EMPA D16 and Borrow Area G-3). These locations will continue to be monitored in 2018 to determine if more plants appear. If the straw is no longer being used, it is recommended that it be burned to kill any viable seed remaining in it.

Locations having abundant species of high invasive concern for the Project footprint are candidates for herbicide treatment. The first recommended herbicide treatment (ECOSTEM 2016) was implemented on August 25, 2016 in four key sites. 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. The most abundant species at these sites were white and/or yellow sweet clover, and common dandelion.

With one exception, monitoring surveys in 2017 found that the 2016 herbicide treatments had neither reduced invasive and other non-native plant cover, nor had it noticeably slowed the spread of these plants by the time of the surveys. The single exception was the treated sites in the Start-up Camp area, where total non-native cover in late summer 2017 was slightly lower than in late summer 2016. However, total non-native cover in the Start-up Camp appeared to be increasing, so it is quite possible that the 2018 surveys may find that the cover has become higher than it was prior to the herbicide treatment.

While target plants of the target species were killed by the herbicide treatment, these species were able to recover by the following growth season. It is possible that this was because the treatment occurred late in the growing season, likely after the plants had seeded. Herbicide treatment earlier in the season, after plants have fully emerged but before they seed, should be more effective in reducing cover.

5.0 SUMMARY AND CONCLUSIONS

A total of 22 non-native plant species were found during the 2017 surveys, which was one more than recorded in 2016. Total non-native plant cover was also higher in 2017 than in 2016. However, all species combined still cover a very small portion less than 1% of the Project footprint.

The 2017 monitoring found one plant for each of two species at the highest level of invasive concern. These species were ox-eye daisy and scentless chamomile, both of which are ISCM Category 2 species. Immediately after discovery, ECOSTEM field staff carefully removed and disposed of both plants. Monitoring surveys in 2018 will determine if manual removal was effective at controlling perennial sow thistle spread here.

For the non-native species of highest invasive concern for the Project footprint, removal shortly after discovery appears to generally be an effective eradication method for locations having one to a few plants. Of the two locations where removal and disposal occurred in 2015 and 2016, none had the same species in 2017. This control measure will be continued in 2018 as it appears to be effective.

Four key sites in the Project footprint were treated with herbicides on August 25, 2016. These sites were selected based on where then non-native species of high invasive concern 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. Monitoring surveys in 2017 found that the herbicide treatments had neither reduced invasive and other non-native plant cover, nor had it halted the spread of these plants by the time of the surveys. A potential explanation for why the herbicide treatment was not effective is that the application occurred after most of the plants had already seeded. An early summer application, shortly after the plants fully emerge but before they seed, should be more effective in controlling those plants. A second application later in the season may be required.

5.1 NEXT STEPS

Invasive plant control recommendations, in addition to immediate manual removal, are being developed for the 2018 growing season based on the monitoring results to date. It is likely these recommendations will include herbicide application at key sites within the Project footprint. Monitoring fieldwork for invasive and other non-native plants will continue in 2018.

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APPENDIX 1:
NON-NATIVE PLANT INDIVIDUAL AREAS

Table 6-1: Estimated radius and derived area for individual plant species

Species	Estimated Radius (cm)	Derived Area (m^2)
Arctium minus	25	0.196
Artemisia absinthium	25	0.196
Avena sativa	4	0.005
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 sophoides	15	0.071
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
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
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:
FURTHER NON-NATIVE PLANT RESULTS

Table 6-2: 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]
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer	Late Summer
North Access Road	0.00	0.32	0.32	0.89	0.01	3.5	4.4
South Access Road	-	-	-	-	-	0.2	2.8
Camp & Work Areas	0.56	3.24	3.59	4.66	1.26	4.0	5.9
Borrow Area	0.02	0.33	0.64	3.09	0.85	2.1	5.1
North Dyke	-	-	-	-	-	0.1	0.3
South Dyke[1]	-	-	-	-	0.00	0.0	0.1
Generating Station Area	-	-	-	-	-	0.5	0.2
Reservoir Clearing Area	-	-	-	-	-	-	-
All	0.30	1.83	1.98	3.70	0.72	2.4	4.3
Total non-native plant extent (ha)	*0.7*	*4.9*	*4.7*	*9.3*	*4.8*	*14.8*	*28.9*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Proportion of non-native cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.2.
[2] Full early summer survey not undertaken in 2017.

Table 6-3: 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]
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer	Late Summer
North Access Road	0.00	0.01	0.02	0.07	0.00	0.25	0.38
South Access Road	-	-	-	-	-	0.01	0.36
Camp & Work Areas	0.06	0.34	0.46	0.77	0.18	0.58	0.73
Borrow Area	0.00	0.05	0.05	0.48	0.04	0.24	0.46
North Dyke	-	-	-	-	-	0.00	0.01
South Dyke[1]	-	-	-	-	0.00	0.00	0.02
Generating Station Area	-	-	-	-	-	0.03	0.00
Reservoir Clearing Area	-	-	-	-	-	-	-
All	0.03	0.20	0.24	0.59	0.06	0.31	0.44
Total non-native plant cover (ha)	*0.08*	*0.53*	*0.57*	*1.49*	*0.43*	*1.89*	*2.98*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Proportion of non-native cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.2.
[2] Full early summer survey not undertaken in 2017.

Table 6-4: 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	
	ES	LS	ES	LS	ES	LS	ES[1]	LS
Common Burdock	-	-	-	-	-	0	-	-
Wormwood	-	-	0	0	0	1	0	1
Lamb's-quarters	89	2,903	1,115	8,844	990	6,342	131	15,229
Ox-eye Daisy	-	-	-	-	-	-	0	-
Canada Thistle	-	-	0	0	-	0	-	1
Narrow-leaved Hawks-beard	-	-	-	-	-	586	191	1,314
Bird's-foot Trefoil	-	-	-	-	0	0	-	0
Pineappleweed	-	-	7	18	0	29	-	325
Black Medick	-	0	-	1	-	-	-	0
Alfalfa	119	124	0	11	4	14	4	40
White Sweet Clover	-	532	1,742	2,252	900	3,015	11	4,949
Yellow Sweet Clover	-	0	-	2	7	109	-	254
Unidentified Sweet Clover[2]	387	72	-	-	565	1,838	1,372	67
Common Timothy	-	-	-	-	-	0	101	0
Common Plantain	27	80	56	121	68	268	97	246
Yellow or Curled Dock	-	-	-	-	-	100	19	19
Rye	-	0	-	-	-	-	-	-
Smooth Catchfly	-	-	0	5	16	26	1	32
Field Sow-thistle	38	252	301	972	52	1,111	420	1,656
Common Dandelion	143	1,291	2,316	2,422	1,654	5,268	1,465	5,521
Alsike Clover	-	25	145	242	43	190	2	91
Red Clover	-	0	-	0	-	-	0	1
White Clover	-	0	-	0	0	0	-	-
Scentless chamomile	-	-	-	0	-	0	-	0
Wheat	-	-	-	-	-	30	-	21
Tufted Vetch	-	-	-	-	-	0	2	38
Number of non-native species	**7**	**12**	**11**	**16**	**13**	**21**	**16**	**21**

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Full early summer survey not undertaken in 2017. 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 6-5: Total late summer non-native plant extent by project and year

Footprint Use	2014	2015	2016	2017
Keeyask Infrastructure Project	0.5	3.7	7.5	29.4
Both Keeyask Infrastructure and Keeyask Generation Projects	2.4	3.7	4.2	6.9
Keeyask Generation Project	-	-	0.3	0.4

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

Table 6-6: Total late summer non-native plant cover by project and year

Footprint Use	2014	2015	2016	2017
Keeyask Infrastructure Project	0.1	0.6	1.1	2.3
Both Keeyask Infrastructure and Keeyask Generation Projects	0.2	0.6	0.5	0.8
Keeyask Generation Project	-	-	0.06	0.03

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