Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Invasive Plant Spread and Control Monitoring Report

TEMP-2017-05

KEEYASK

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

2016 - 2017

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2017-05

INVASIVE PLANT SPREAD AND CONTROL MONITORING REPORT

A Report Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

June 2017

This report should be cited as follows:

ECOSTEM Ltd. 2017. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2017-05: Invasive Plant Spread and Control Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2017.

SUMMARY

Background

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

This report describes the results of invasive and non-native plant monitoring conducted during the third summer of Project construction.

Why is the study being done?

Invasive and other non-native plants are of concern because they can crowd out other plant species. In extreme cases, invasive plants change the kind of vegetation, soils or other natural things in the environment. Surveys are being done to determine how Project development is affecting how many invasive or non-native plants are present, where these species are found, and to help decide where to carry out measures to control invasive plants.

What was done?

Invasive plant surveys were done within most of the cleared Project areas (construction activity prevented some areas from being accessed) from July 5 to 11, 2016 and from August 22 to 28, 2016.

What was found?

Twenty-one non-native plants species were found during the 2016 monitoring surveys. Nine of these 21 non-native species are considered to be invasive in the Project area. Six of the nine invasive species were recorded for the first time in the Project footprint in 2016.

Most of the non-native plant cover was in the areas created by the Keeyask Infrastructure Project (KIP), and which are also being used by the Project. It was found that lamb's quarters, which remained the most abundant and widespread invasive species in the Project site, had decreased in total cover from 2015. While other species continued to become more widespread and abundant in the Project site, all species combined covered approximately 0.3% of the Project site.

Scentless chamomile is an invasive species that can spread quickly. One plant was found in 2016. Manitoba Hydro site staff removed and disposed of this plant the following day.

What does it mean?

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

To minimize further spreading of invasive plants, several control measures were implemented in 2016. In late August, 2016, herbicides were applied in a few Project areas where invasive plants were most abundant, and were most likely to have vehicles or footwear pick up their seeds and carry them to other Project areas. Another measure was to train site environmental staff to recognize the invasive plant species of high concern so they could take steps to eradicate them before they have an opportunity to spread throughout the Project site.

What will be done next?

Control recommendations for the 2017 growing season are being developed based on the results to date. Monitoring to document the spread of invasive plants at the Project site will continue in 2017. Where appropriate, additional control measures will be recommended based on what is found during the monitoring.

ACKNOWLEDGEMENTS

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

Chiefs and Councils of Tataskweyak Cree Nation (TCN), War Lake First Nation (WLCN), York Factory First Nation (YFFN) and Fox Lake Cree Nation (FLCN) are gratefully acknowledged for their support of this program.

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

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

STUDY TEAM

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

Fieldwork in 2016 was conducted by Brock Epp, Ryan Sheffield, Alanna Sutton and Alex Snitowski.

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF APPENDICES

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. 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). The *Terrestrial Effects Monitoring Plan* (TEMP) was developed as part of the licensing process for the Project. 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.

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 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/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.

A previous monitoring study and report (ECOSTEM 2015a) evaluated invasive plant spread from the Keeyask Infrastructure Project (KIP), which ended in June 2014. To date, invasive plant monitoring for the Project was conducted in 2015 and 2016. ECOSTEM (2016) provides results for the monitoring conducted in 2015. The following presents the monitoring conducted during 2016.

The Invasive Plant Spread and Control study includes two components. The first component monitors invasive 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.

2.0 METHODS

The Invasive Plant Spread and Control study includes two components. The first component monitors invasive 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.

Section 3.3.2 of the TEMP details the methods for this study. The following summarizes the activities conducted in 2016.

2.1 DATA COLLECTION

Early summer surveys were conducted from July 5 to 11, 2016 at the locations shown in Map 2-1. Late summer surveys were conducted from August 22 to 28, 2016 at the locations shown in Map 2-2.

The data collection methods in 2016 were the same as those used during the 2015 invasive/non-native plant surveys. In general, invasive/non-native plant surveys were conducted in the portions of the Project footprint that had been cleared or disturbed prior to the surveys. A botanist 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 2016. 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. A few of the planned stops had to be skipped due to safety considerations from ongoing construction. At each of the sampled road locations, a 100 m transect on each side of the road was surveyed by foot.

Along the south dyke clearing area, targeted foot surveys were conducted. Locations for the foot surveys were selected during helicopter surveys by identifying the areas most likely to support invasive/non-native plants. This method was used along the south dyke in 2016 because the footprint was only recently cleared and it was distant from known invasive/non-native plant seed sources, and due to access and time limitations. Because searches were focused on areas that were believed to have a higher likelihood to support invasive/non-native plants, results would overestimate percentage cover for invasive/non-native plants within the entire south dyke footprint.

For the remaining areas (which accounted for the majority of the surveyed area), field surveys traversed all cleared areas along a combination of predetermined transects and meandering surveys. Predetermined transects were generally situated near the edges of the cleared areas

because the invasive/non-native plants tended to be clustered along the edges. For meandering surveys, a botanist walked to all remaining vegetation patches within the cleared area that had the potential to include invasives and did not pose any safety concerns.

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

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

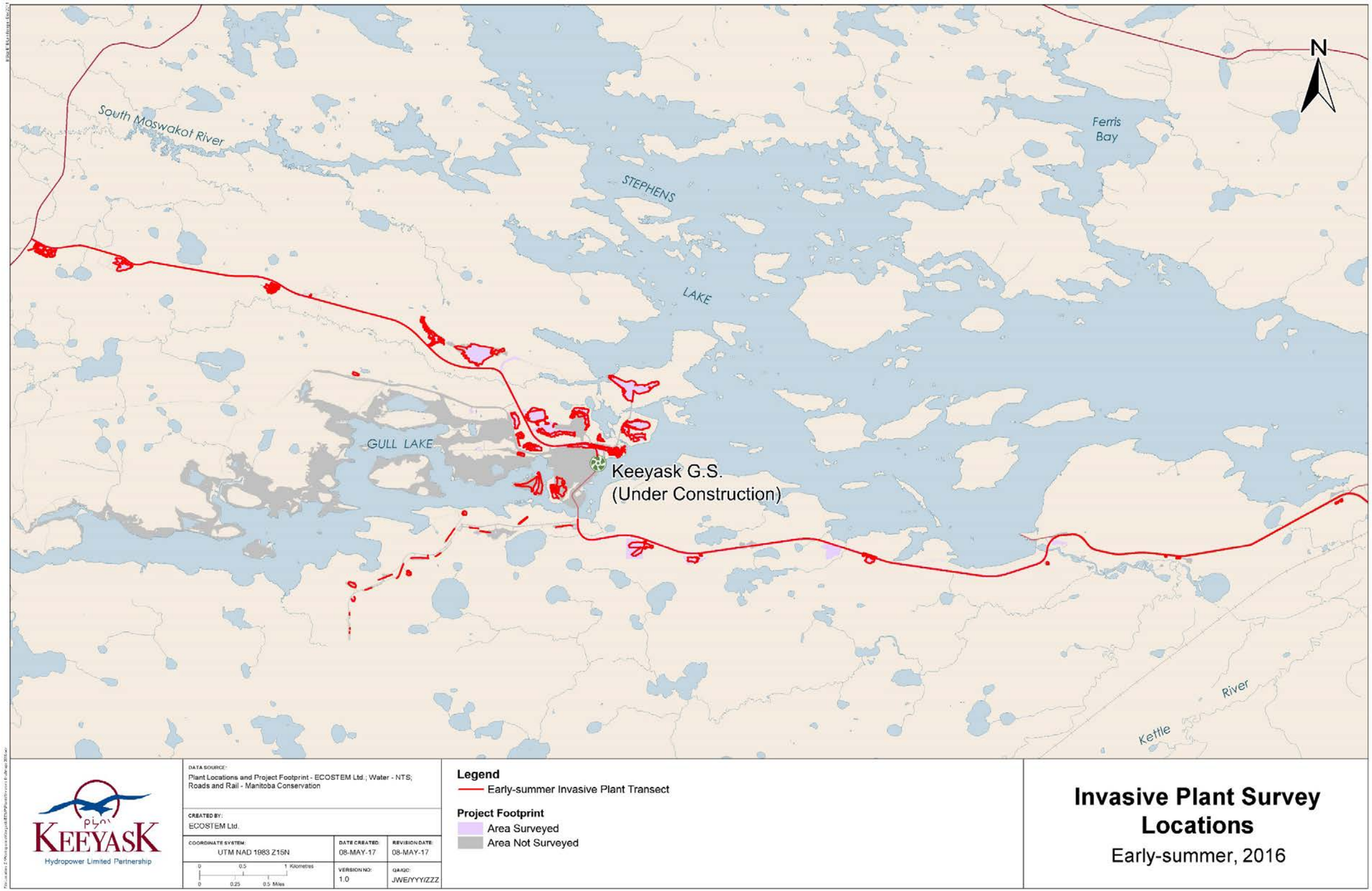
Vegetation patch boundaries were recorded in one of three ways:

1. **Point:** Used for small patches 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 had a relatively regular band shape. In these situations, the length of the band of the invasive 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 invasive 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 invasive 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 invasive/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.

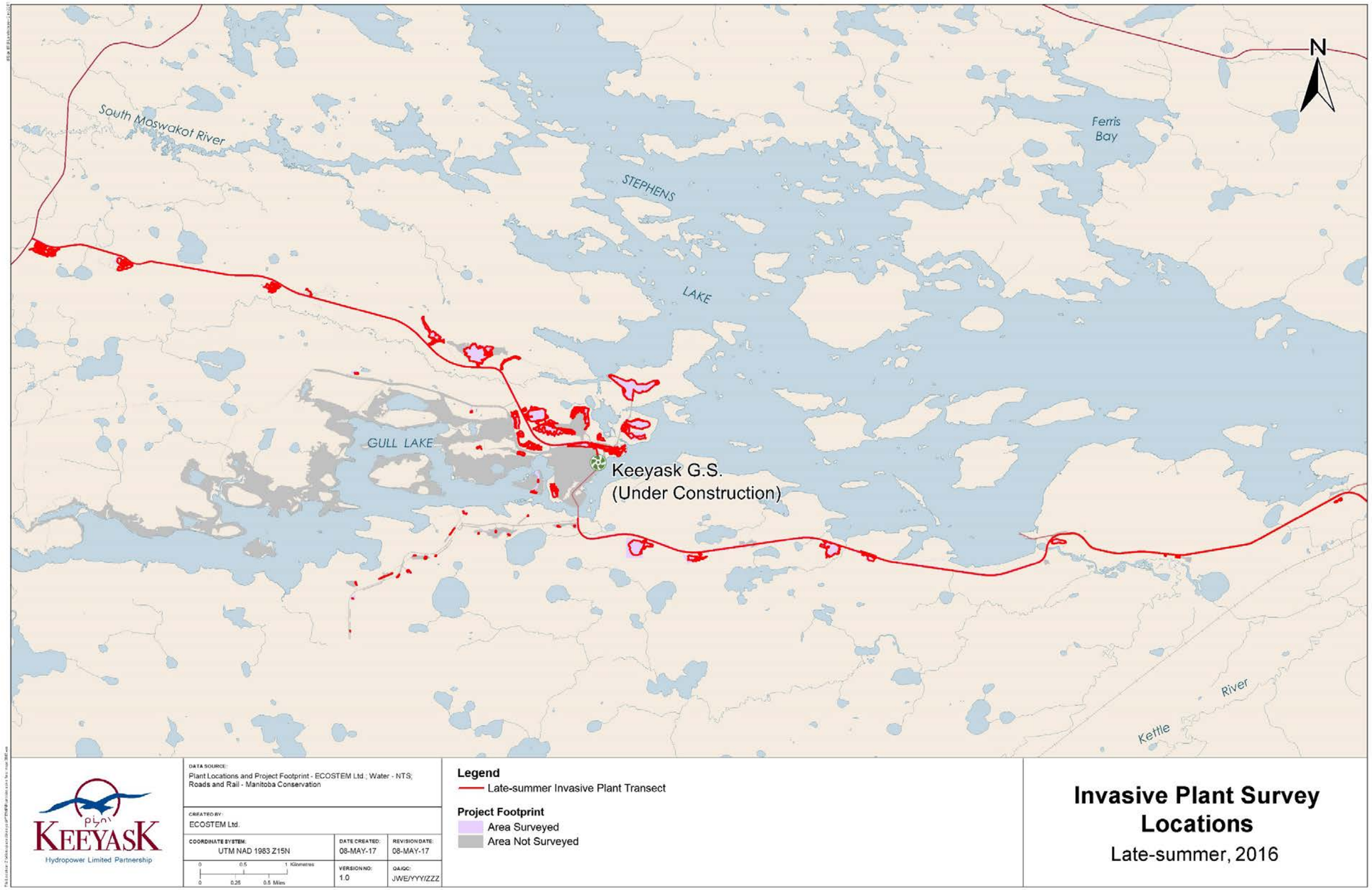
For each invasive species patch, plant cover was estimated and recorded into one of the six classes listed in Table 2-1.

Table 2-1: Cover class and associated percent cover ranges used for invasive/non-native plant surveys

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



Map 2-1: Early summer invasive / non-native plant survey locations



Map 2-2: Late summer invasive/non-native plant survey locations

2.2 MAPPING

The invasive/non-native plant mapping in this report includes additional details compared with that provided in the first annual report for this study (ECOSTEM 2016). The first annual report focused on invasive/non-native plant distribution since most of the actual Project footprint at that time was either newly cleared or it had been around for a few years and evaluated in the KIP monitoring report (ECOSTEM 2015a).

This report includes more detailed distribution mapping, as well as abundance mapping, based on invasive/non-native plant cover estimates. These maps show plant patches, by cover class, in surveyed portions of the footprint.

To support a more detailed analysis of changes in invasive/non-native plant distribution and abundance, the detailed mapping method was applied to data from the 2015 and 2016 surveys. The analysis also evaluated invasive/non-native plant distribution and abundance in the context of more accurate clearing and disturbance mapping recently produced for 2015 and 2016 (see ECOSTEM 2017). The primary focus of this report is on the patterns and changes present in 2016. A detailed comparison of invasive/non-native plant spread over all construction years will be provided at the end of Project construction in the monitoring synthesis report.

Invasive/non-native plant distribution and abundance maps for each monitoring survey 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 invasive 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).

The invasive/non-native plant mapping provided two measures of invasive/non-native plant cover in the footprint components. One measure was the overall spatial extent of one or more invasive/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. Invasive/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.

Invasive/non-native plant cover was derived from the patch cover class (Table 2-1) 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 2-1). For example, a 10 m^2 invasive/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 limited how the data generated from the mapping were interpreted included GPS accuracy, interpreter bias and variability, total plant cover and access. For GPS accuracy, invasive 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 botanists, some individual bias is always inherent in this measurement method. Furthermore, between botanists, and between surveys, there may have been differences in the approach taken to map a particular patch of invasive/non-native plants. 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 invasive/non-native plant extents. To minimize this effect, whenever possible, the same botanists were used to conduct the surveys over the monitoring period, an effort was made to subdivide the areas surveyed by each botanist in the same way each time. While this factor could create a relatively large site specific difference, it was not expected to create a large bias in the overall results.

As cleared areas regenerate, native vegetation cover may obscure invasive/non-native plants, confounding estimates of cover. This could result in a bias toward underestimating invasive/non-native plant cover in areas with dense or taller native plants. This could also result in a seasonal bias in which invasive/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 when surveys were conducted due to construction activity (e.g., GS area, batch plant, portions of Work Area A). While effort was made to observe these areas from a distance, it is possible that invasive/non-native plants were present but not recorded (note that this does not refer to sites where invasive/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 from survey to survey.

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 invasive/non-native plant abundance between years. Invasive species polygon extents should

only be considered as an indication of overall distribution as well as a very broad measure of area covered.

2.3 PROJECT FOOTPRINT TYPES

There were far too many individual project footprint components to evaluate each one individually for this report. To evaluate the patterns of invasive/non-native plant spread, and to identify areas of concern, the Project footprint was subdivided into major footprint types (Table 2-2), based on the general type of activity occurring in the components. Activity type may be an important influence on invasive/non-native plant spread or establishment. For example, the "Camp and Work Areas" footprint type is dominated by foot and light vehicle traffic, with minimal to no ongoing excavation, while the "Borrow Areas" type is often characterized by ongoing excavation and heavy equipment traffic. For reservoir clearing, the ground vegetation and soils are generally undisturbed, which leaves a poor seedbed for invasive/non-native plant colonization. Note that, because this is a generalized grouping, there may be areas within a grouping that actually falls within areas belonging to a different category. However, this subdivision was only introduced as a way to aid in the interpretation of broad trends in the results.

Table 2-2: General Project footprint types and their associated activity in 2016

Footprint Type	Description	Use
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 Area	Generating station, spillway, dam and coffer dam infrastructure, and associated excavated material placement areas	Excavation, construction, heavy and light vehicle traffic
Reservoir Clearing	Vegetation clearing in the reservoir areas	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 invasive/non-native plant distribution and abundance. Portions of areas cleared for the KIP are also being used for the Project. On this basis, the original source project and 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 only for KIP are included because they may be an important seed source for the spreading of invasives into other nearby areas.

3.0 RESULTS

This section begins with an overview of clearing or disturbance. Subsequent sections detail clearing or disturbance in the various Project components.

3.1 TOTAL AREA SURVEYED

In 2016, approximately 669 ha (18%) of the cleared and disturbed Project footprint was surveyed for invasive/non-native plants during early summer. Approximately 620 ha (17%) was surveyed during late summer (Table 3-1; Table 3-2). Total area surveyed was considerably higher in 2016 than in 2015, including increases of 431 ha and 369 ha for the early and late summer surveys, respectively.

The total area surveyed was lower in late summer than in early summer, predominantly due to a late summer survey not being conducted in the reservoir clearing area. A late summer survey was not conducted in the north reservoir area because it was determined from early summer and other surveys that invasive/non-native plants were virtually absent, likely for two reasons. Only the taller vegetation (i.e., greater than 5 feet) was cut down and the clearing had just been completed during the previous winter. Given the large size of the reservoir clearing footprint and the high unlikelihood for any change in invasive/non-native plants, a second survey was deemed unnecessary. An early summer survey will be conducted in 2017.

Surveyed area for most footprint types increased slightly from the early to late summer surveys. Surveyed area decreased for the north access road (NAR), generating station area, south dyke, and reservoir area. The area surveyed for the NAR decreased because one less road stop was made for safety reasons. The surveyed area decreased for the generating station area because a portion of the area surveyed in the early summer was part of the reservoir clearing.

The area surveyed in the south dyke footprint decreased because most of the south dyke was only cleared of tree and tall shrub vegetation, leaving the organic substrate intact. As with the larger reservoir clearing footprint, invasive/non-native plant surveys and incidental information from other terrestrial surveys indicated that very few invasive/non-native plants were present. Surveys in late summer targeted the areas expected to have highest likelihood of supporting invasive/non-native plants. These included exposed mineral areas, areas with thin organic surface substrate, and areas within or near pre-existing cutlines or clearings.

Table 3-1: Total area (ha) surveyed for invasive/non-native plants by year and footprint type

Footprint Type	Early Summer Surveys			Late Summer Surveys		
	2014	2015	2016	2014	2015	2016
North Access Road[1]	9	9	9	10	9	8
South Access Road[1]	-	-	9	-	-	10
Camp and Work Areas	126	109	163	138	111	186
Borrow Areas	112	119	323	120	131	329
North Dyke	-	-	52	1	-	56
South Dyke[2]	-	-	38	-	-	21
Generating Station Area	-	-	20	-	-	10
Reservoir Clearing	-	-	56	-	-	-
Total surveyed area (ha)	*247*	*237*	*669*	*269*	*251*	*620*
Total footprint area (ha)	*540*	*1,438*	*3,643*	*540*	*1,438*	*3,643*

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 footprint type was surveyed through a series of targeted spot checks.

Table 3-2: Percentage of total actual footprint area included in the invasive/non-native plant surveys by year and footprint type

Footprint Type	Early Summer Surveys			Late Summer Surveys		
	2014	2015	2016	2014	2015	2016
North Access Road[1]	5	5	5	5	5	4
South Access Road[1]	-	-	3	-	-	3
Camp and Work Areas	68	48	71	75	49	81
Borrow Areas	90	35	74	96	38	76
North Dyke	-	-	28	3	-	30
South Dyke[2]	-	-	31	-	-	17
Generating Station Area	-	-	9	-	-	4
Reservoir Clearing	-	-	3	-	-	-
All surveyed areas	46	17	18	50	17	17

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 footprint type was surveyed through a series of targeted spot checks.

3.2 SEASONAL PATTERN IN INVASIVE/NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

As described in Section 2.0, plant extent and plant cover were the primary measures used to document changes in distribution and abundance. Plant extent was the spatial limits of a vegetation patch that included one or more 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 of plant cover for each species (plant cover was derived from the cover class recorded during field surveys (Table 2-1)).

From 2014 to 2016, the seasonal pattern (*i.e.*, changes from early to late summer) generally included an increase in the number of invasive species recorded, and a large increase in both invasive/non-native plant extent and cover as a percentage of area surveyed (see Appendix 2 for detailed results). This was the case for all the footprint types surveyed.

For example, the total number of invasive species recorded in 2016 increased from 13 in early summer surveys to 20 in late summer surveys (Appendix 2). Overall invasive/non-native plant extent increased from 0.7% to 2.4% of the surveyed area, and actual cover increased from 0.06% to 0.31% of the surveyed area.

The remaining results will focus on the late summer survey data, since these data reflect invasive/non-native plant status near the end of the growing season. The early summer results were used when evaluating the need for and nature of invasive/non-native plant control measures.

Since the purpose of the early summer survey is to detect and respond quickly to invasive plant colonization of new areas, Project footprint areas that are no longer expanding or experiencing major construction activity will be dropped from the early summer survey starting in 2017.

3.3 OVERALL CHANGES TO INVASIVE/NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

As of late summer, 2016, the overall invasive/non-native plant extent had increased to 14.8 ha, or 2.4% of the total area surveyed (Table 3-3). This was an increase of 5.6 ha from 2015. Invasive/non-native plants were most widespread in the Project camp and work areas, along the NAR, and in the borrow areas, with plants distributed on between 2.1% and 4.0% of the surveyed areas for these footprint types.

The overall invasive/non-native plant cover increased to 1.9 ha by late summer, 2016, or 0.31% of the total surveyed area (Table 3-4), which was a 0.4 ha increase from 2015. Invasive/non-native plant cover was highest (0.58%) in the camp and work areas footprint types, followed by the NAR and borrow areas.

Table 3-3: Total late summer invasive/non-native plant extent as a percentage of total area surveyed by year and Project footprint type

Footprint Type	2014	2015	2016
North Access Road	0.3	0.9	3.5
South Access Road	-	-	0.2
Camp and Work Areas	3.2	4.7	4.0
Borrow Areas	0.3	3.1	2.1
North Dyke	-	-	0.1
South Dyke[1]	-	-	0.0
Generating Station Area	-	-	0.5
Reservoir Clearing	-	-	-
All surveyed area	1.8	3.7	2.4
Total invasive/non-native plant extent (ha)	*4.9*	*9.3*	*14.8*
Total area surveyed (ha)	*269*	*251*	*620*

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

[1] Proportion of invasive/non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.

Table 3-4: Total late summer invasive/non-native plant cover as a percentage of total area surveyed by year and Project footprint type

Footprint Type	2014	2015	2016
North Access Road	0.01	0.07	0.25
South Access Road	-	-	0.01
Camp and Work Areas	0.34	0.77	0.58
Borrow Areas	0.05	0.48	0.24
North Dyke	-	-	0.00
South Dyke[1]	-	-	0.00
Generating Station Area	-	-	0.03
Reservoir Clearing	-	-	-
All surveyed area	0.20	0.59	0.31
Total invasive/non-native plant cover (ha)	*0.5*	*1.5*	*1.9*
Total area surveyed (ha)	*269*	*251*	*620*

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

[1] Proportion of invasive/non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.

Invasive/non-native plant distribution and abundance were highest (7.5% and 1.1%, respectively) in footprints that were cleared and utilized for the KIP, but have not been further used by the Project (Appendix 2). Footprints that were more recently cleared, and used only for the Project, had substantially lower invasive/non-native plant distribution and abundance (0.3% and 0.06%, respectively).

In 2016, the distribution of invasive/non-native plants on the north side of the Nelson River (Map 3-1 and Map 3-2) was broadly similar to that of 2015 (ECOSTEM 2016). Since 2015, invasive/non-native plants expanded in the ditches surrounding the Manitoba Hydro and contractor offices in Work Area B, and have established in the ditches around the work area between the NAR and the north dyke.

Invasive/non-native plants had established in excavated material placement areas (EMPA) D16 and D17, which could not be accessed in 2015. Plants were also establishing in EMPA D12, adjacent to the north dyke.

Several plants were also found establishing in the excavated and recently cleared portions of Borrow Area N-5. In the recently cleared area, the plants appeared to be associated with old cutlines, and may have been present prior to the Project.

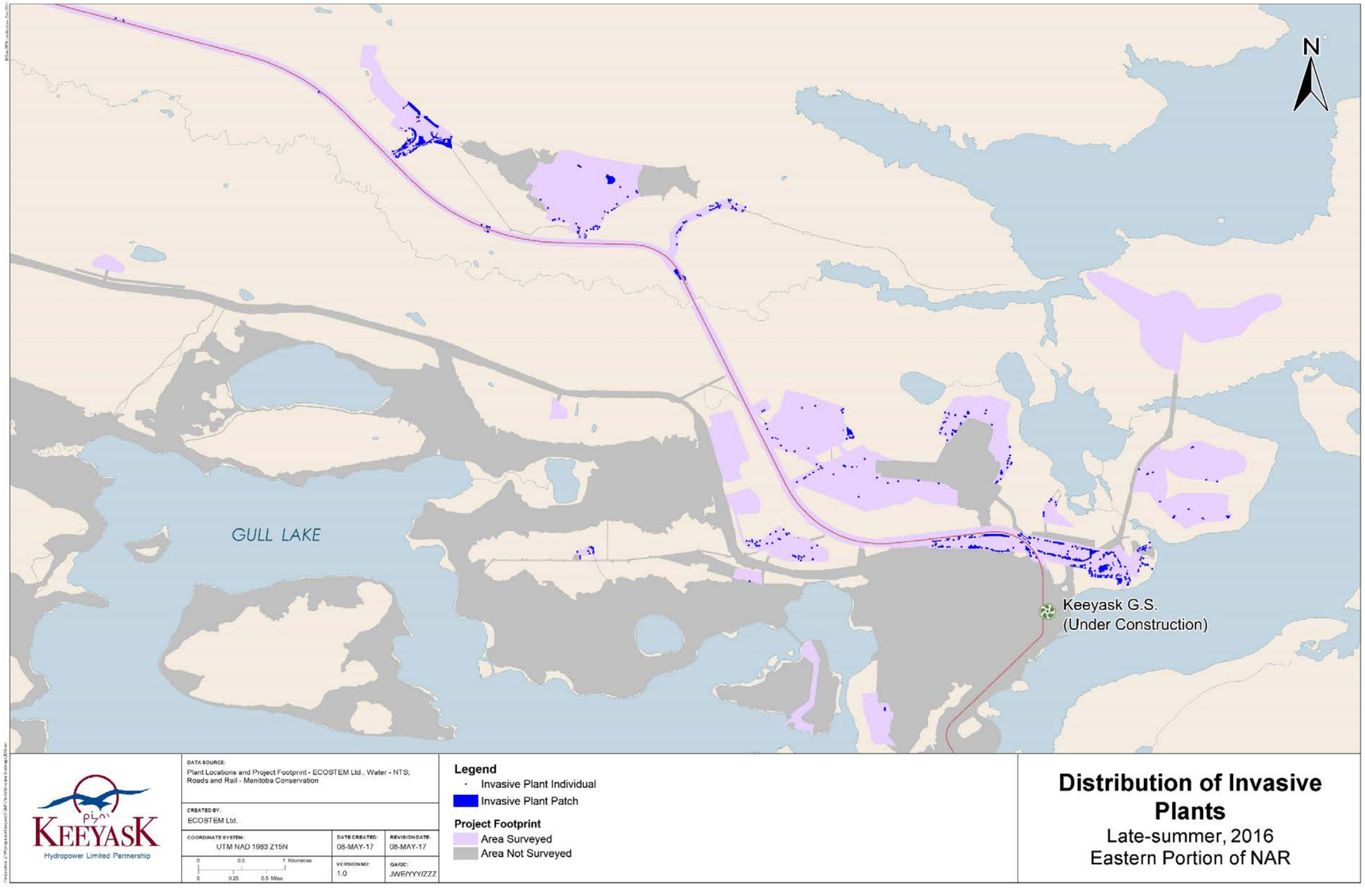
Active construction activity in portions of Work Area A, particularly around the rock crusher, and in the GS area, prevented ground searches within those areas.

Invasive/non-native plant distribution also expanded in the start-up camp and all borrow areas adjacent to the NAR.

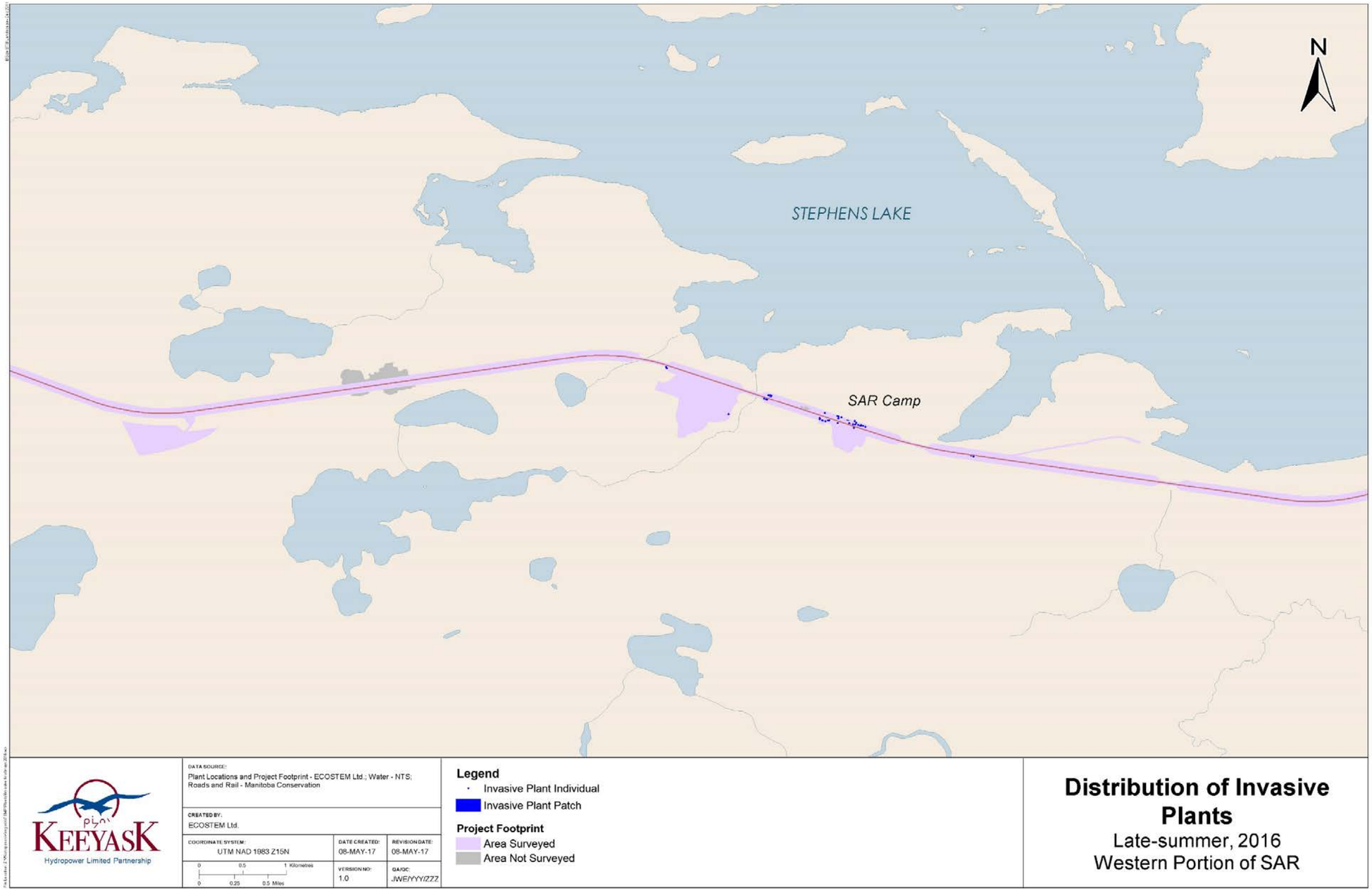
Completion of most of the south access road (SAR) allowed that portion of the Project footprint to be surveyed for the first time in summer 2016. Along reaches west of the Butnau Road, invasive/non-native plants had established around the offices and the SAR camp, and a few individuals were found in the access road ditches near the camp and in the Q-9 borrow area (Map 3-3). No invasive/non-native plants were found along the remainder of the road, or in the borrow areas that had been newly developed for the SAR construction. Along reaches adjacent to the Butnau Road, invasive/non-native plants were establishing within existing borrow areas that were redeveloped for the SAR construction (Map 3-4).

Almost all of the invasive/non-native plants found at the sampled south dyke clearings were on or near pre-existing cutlines, and may have been present prior to the Project (Map 3-5). Overall, invasive/non-native plant extent and cover were very low in footprints south of the Nelson River.

Map 3-1: Distribution of invasive / non-native plants during late summer, 2016, in footprints along the western portion of the north access road

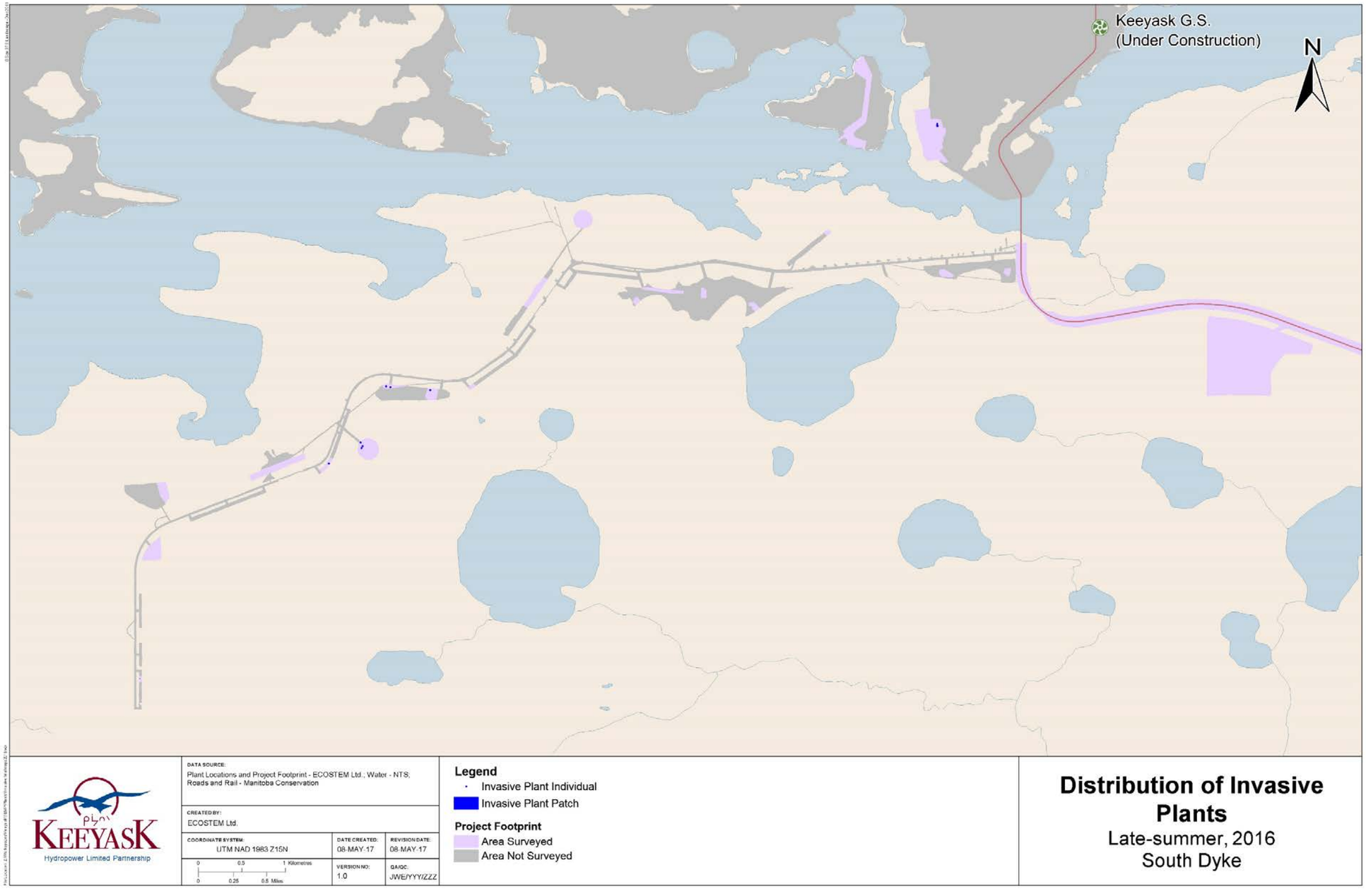


Map 3-2: Distribution of invasive/non-native plants during late summer, 2016, in footprints along the eastern portion of north access road



Map 3-3: Distribution of invasive/non-native plants during late summer, 2016, in footprints along the western portion of the south access road

Map 3-4: Distribution of invasive/non-native plants during late summer, 2016, in footprints along the eastern portion of the south access road



Map 3-5: Distribution of invasive / non-native plants during late summer, 2016, in footprints along the south dyke

3.4 CHANGES TO SPECIES DISTRIBUTION AND ABUNDANCE

A total of 21 invasive/non-native plant species were observed during the late summer 2016 surveys, which was five more than in 2015 (Table 3-5). This was the highest number of invasive/non-native species observed in the surveys conducted since the beginning of the KIP construction monitoring (see ECOSTEM 2015a). Seven of these species had not been recorded in previous years. Three species found in previous years were not found in 2016.

The increasingly large survey area, and the amount of time since construction activity first initiated, were thought to be the primary factors contributing to the increasing number of locations over time.

Map 3-6 to Map 3-13 illustrate the distribution and cover class for the five most abundant invasive or non-native species recorded in 2016 in Project footprints north of the Nelson River, where they are most abundant.

The two most abundant invasive/non-native species were lamb's quarters (*Chenopodium album*), and common dandelion (*Taraxacum officinale*), with 34% and 28% of the total invasive cover in 2016, respectively (Table 3-6). Other abundant species included white and yellow sweet clover (26% combined), and perennial sow-thistle. All of these species, with the exception of lamb's quarters, increased in cover since 2015. Three species that were found in previous surveys but not in late summer 2016 were black medick (*Medicago lupilina*), rye (*Secale cereal*) and red clover (*Trifolium pratense*).

Table 3-5: Total approximate invasive and non-native species cover (m^2) in the Project footprint, by year

Common Name[1,2]	Species	2014	2015	2016
Common Burdock	*Arctium minus*	-	-	0
Wormwood	*Artemisia absinthium*	-	0	1
Lamb's-quarters	*Chenopodium album*	2,903	8,844	6,342
Canada Thistle	*Cirsium arvense*	-	0	0
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	586
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0
Pineappleweed	*Matricaria discoidea*	-	18	29
Black Medick	*Medicago lupulina*	0	1	-
Alfalfa	*Medicago sativa*	124	11	14
White Sweet Clover	*Melilotus albus*	532	2,252	3,015
Yellow Sweet Clover	*Melilotus officinalis*	0	2	109
Unidentified Sweet Clover	*Melilotus spp.*	72	-	1,838
Common Timothy	*Phleum pratense*	-	-	0
Common Plantain	*Plantago major*	80	121	268
Yellow or Curled Dock	*Rumex crispus*	-	-	100
Rye	*Secale cereale*	0	-	-
Smooth Catchfly	*Silene csereii*	-	5	26
Perennial Sow-thistle	*Sonchus arvensis*	252	972	1,111
Common Dandelion	*Taraxacum officinale*	1,291	2,422	5,268
Alsike Clover	*Trifolium hybridum*	25	242	190
Red Clover	*Trifolium pratense*	0	0	-
White Clover	*Trifolium repens*	0	0	0
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0
Wheat	*Triticum aestivum*	-	-	30
Tufted Vetch	*Vicia cracca*	-	-	0
All species		5,280	14,890	18,927

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 2016). Underlined species are noxious weeds in Manitoba (Government of Manitoba 1988). Remaining species are non-native species that may become problematic in some locations and/or conditions (CDC personal communication).

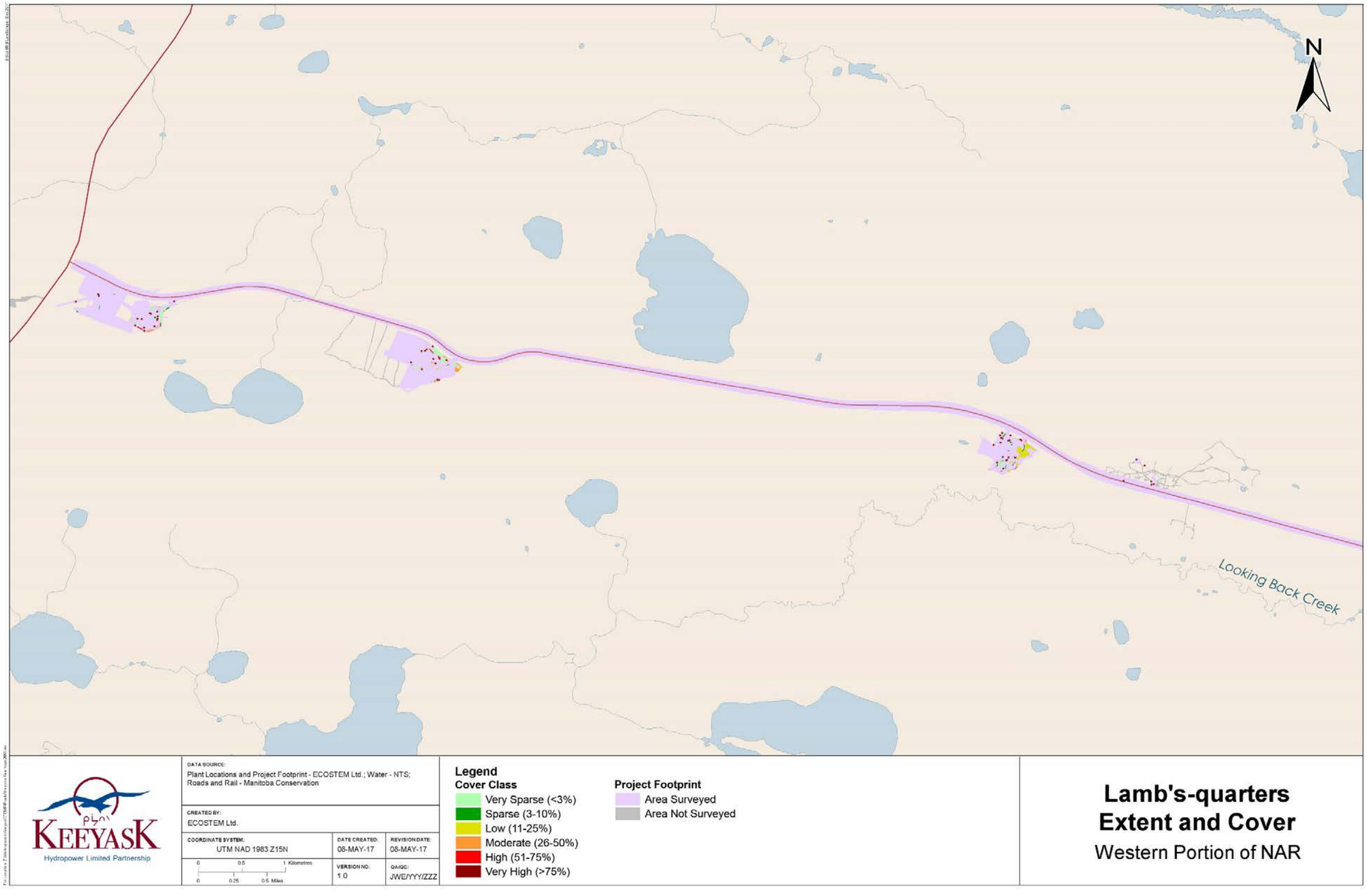
[2] Species difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

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

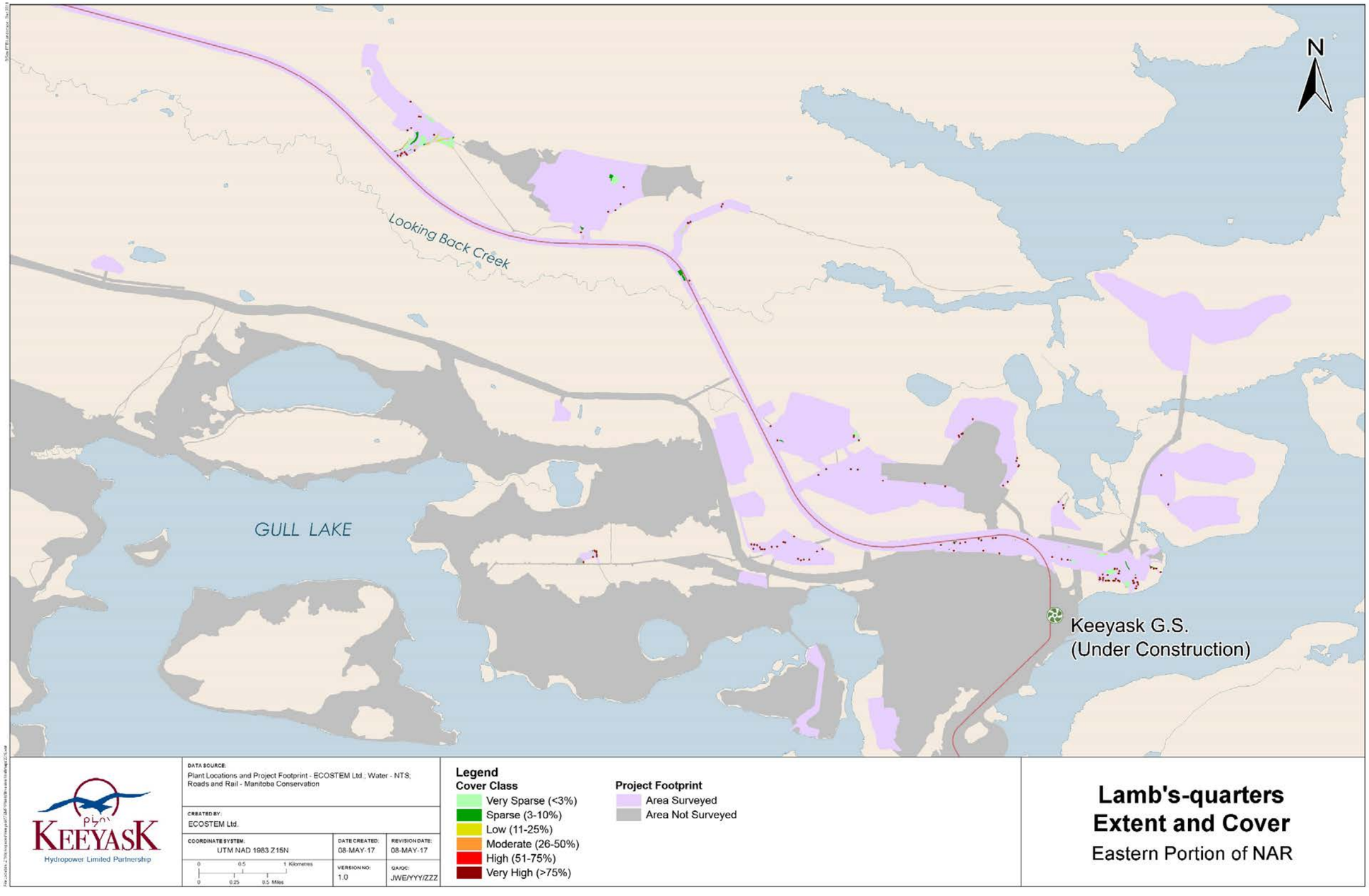
Common Name[1,2]	Species	2014	2015	2016
Common Burdock	*Arctium minus*	-	-	0
Wormwood	*Artemisia absinthium*	-	0	0
Lamb's-quarters	*Chenopodium album*	55	59	34
Canada Thistle	*Cirsium arvense*	-	0	0
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	3
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0
Pineappleweed	*Matricaria discoidea*	-	0	0
Black Medick	*Medicago lupulina*	0	0	-
Alfalfa	*Medicago sativa*	2	0	0
White Sweet Clover	*Melilotus albus*	10	15	16
Yellow Sweet Clover	*Melilotus officinalis*	0	0	1
Unidentified Sweet Clover	*Melilotus* spp.	1	-	10
Common Timothy	*Phleum pratense*	-	-	0
Common Plantain	*Plantago major*	2	1	1
Yellow or Curled Dock	*Rumex crispus*	-	-	1
Rye	*Secale cereale*	0	-	-
Smooth Catchfly	*Silene csereii*	-	0	0
Perennial Sow-thistle	*Sonchus arvensis*	5	7	6
Common Dandelion	*Taraxacum officinale*	24	16	28
Alsike Clover	*Trifolium hybridum*	0	2	1
Red Clover	*Trifolium pratense*	0	0	-
White Clover	*Trifolium repens*	0	0	0
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0
Wheat	*Triticum aestivum*	-	-	0
Tufted Vetch	*Vicia cracca*	-	-	0
All species		5,280	14,890	18,927

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 2016). Underlined species are noxious weeds in Manitoba (Government of Manitoba 1988). Remaining species are non-native species that may become problematic in some locations and/or conditions (CDC personal communication).

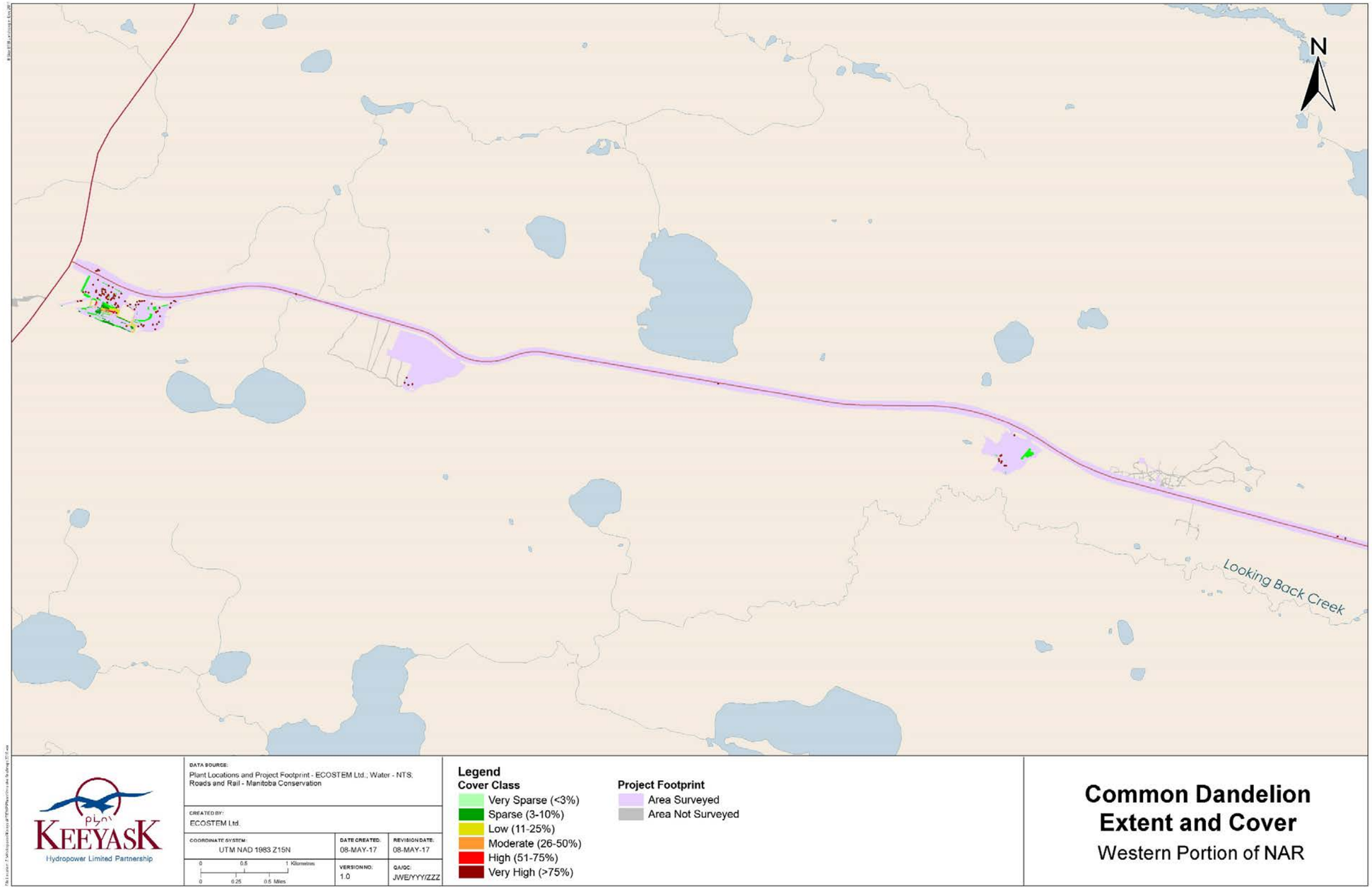
[2] Species difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.



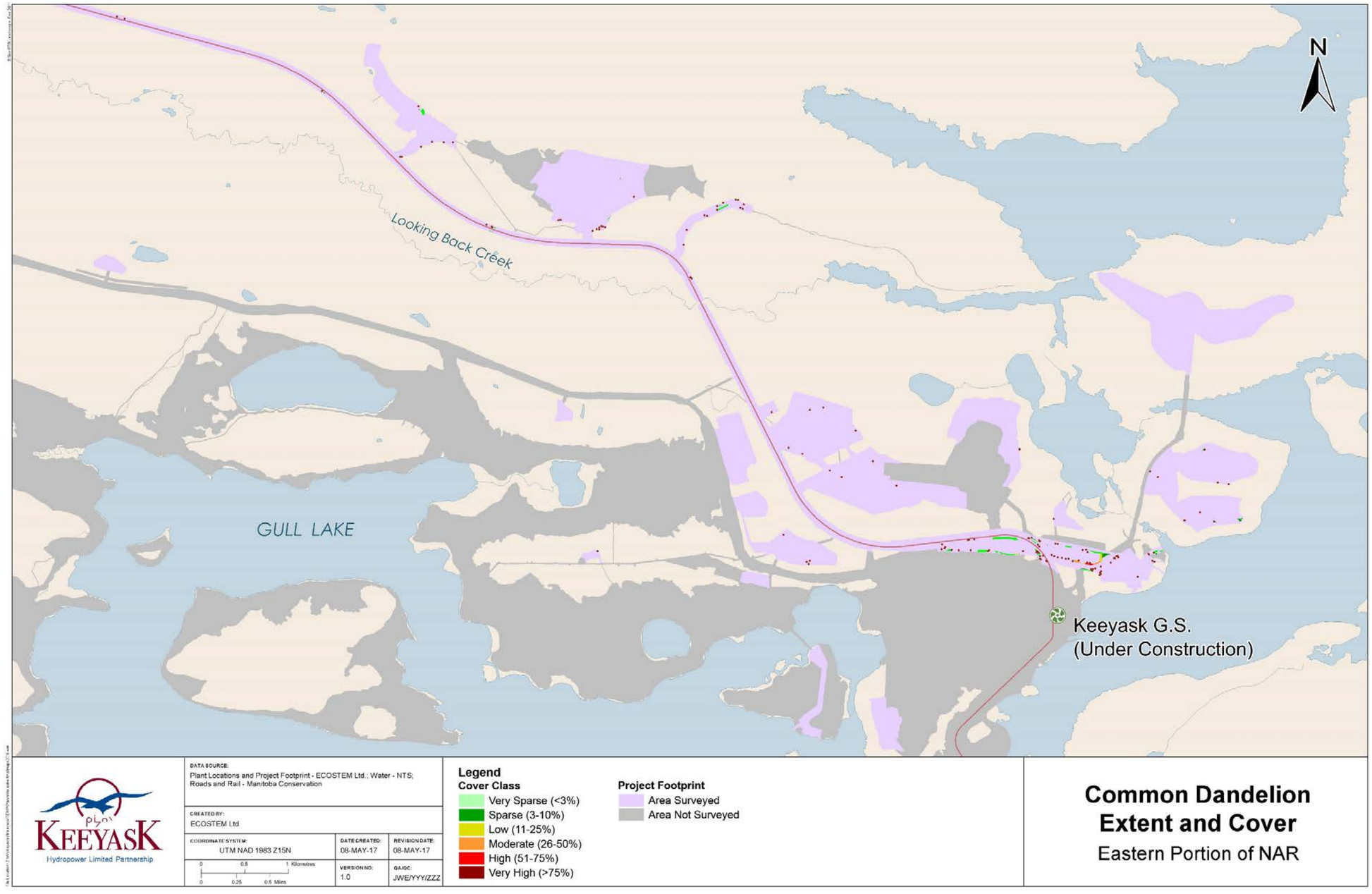
Map 3-6: The distribution and cover of lamb's quarters in footprints along the western portion of the north access road



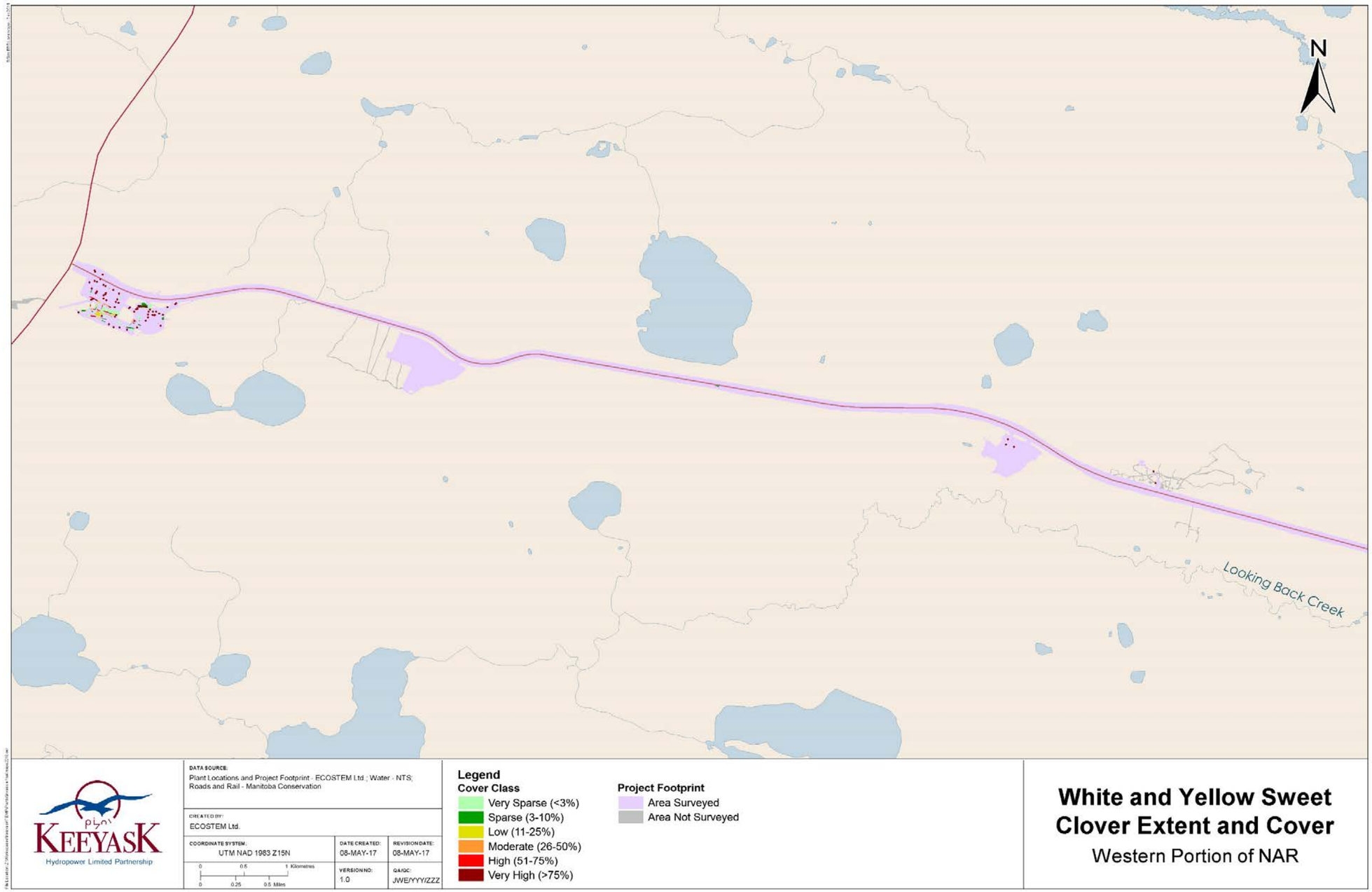
Map 3-7: The distribution and cover of lamb's quarters in footprints along the eastern portion of the north access road



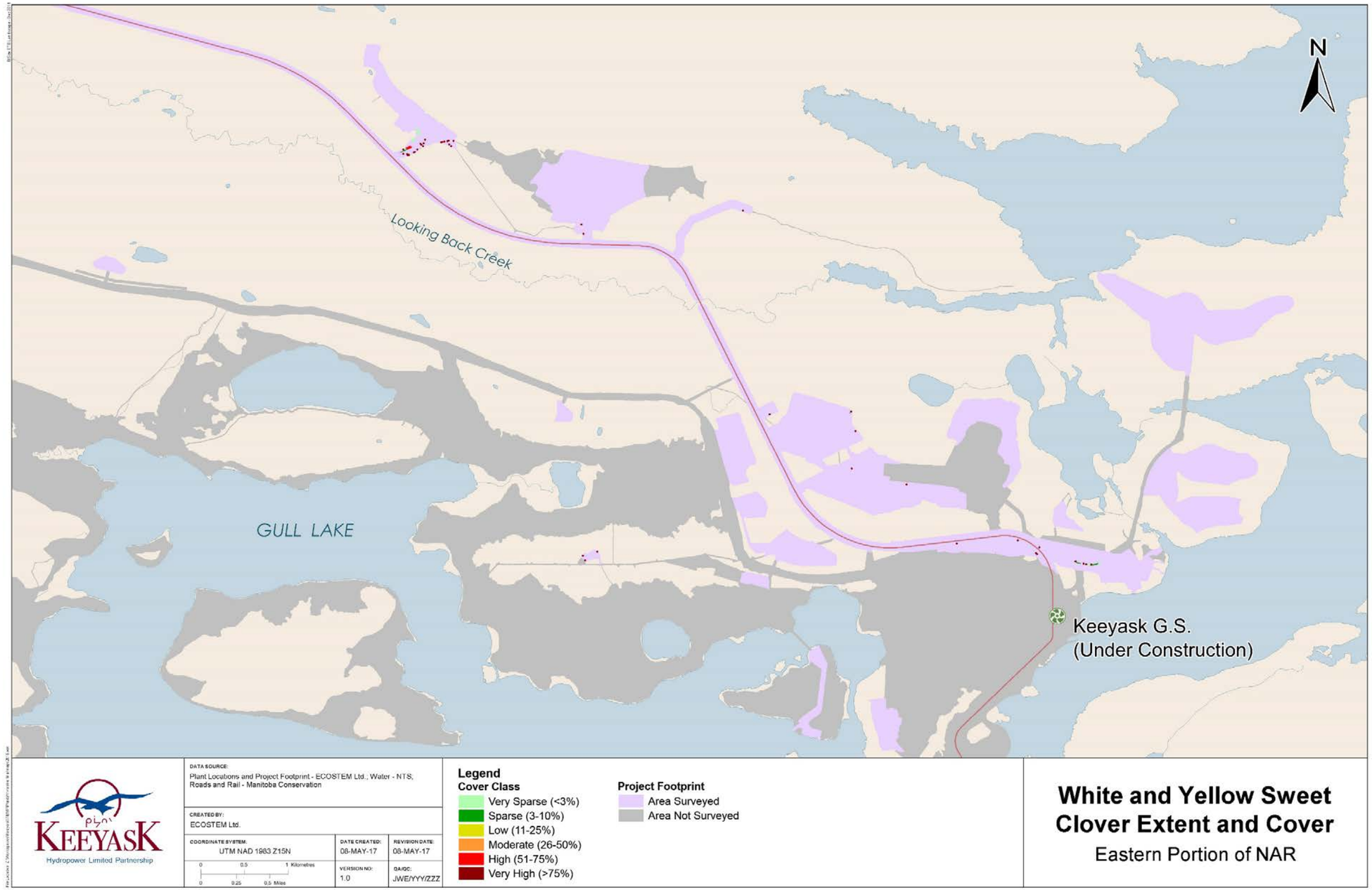
Map 3-8: The distribution and cover of common dandelion in footprints along the western portion of the north access road



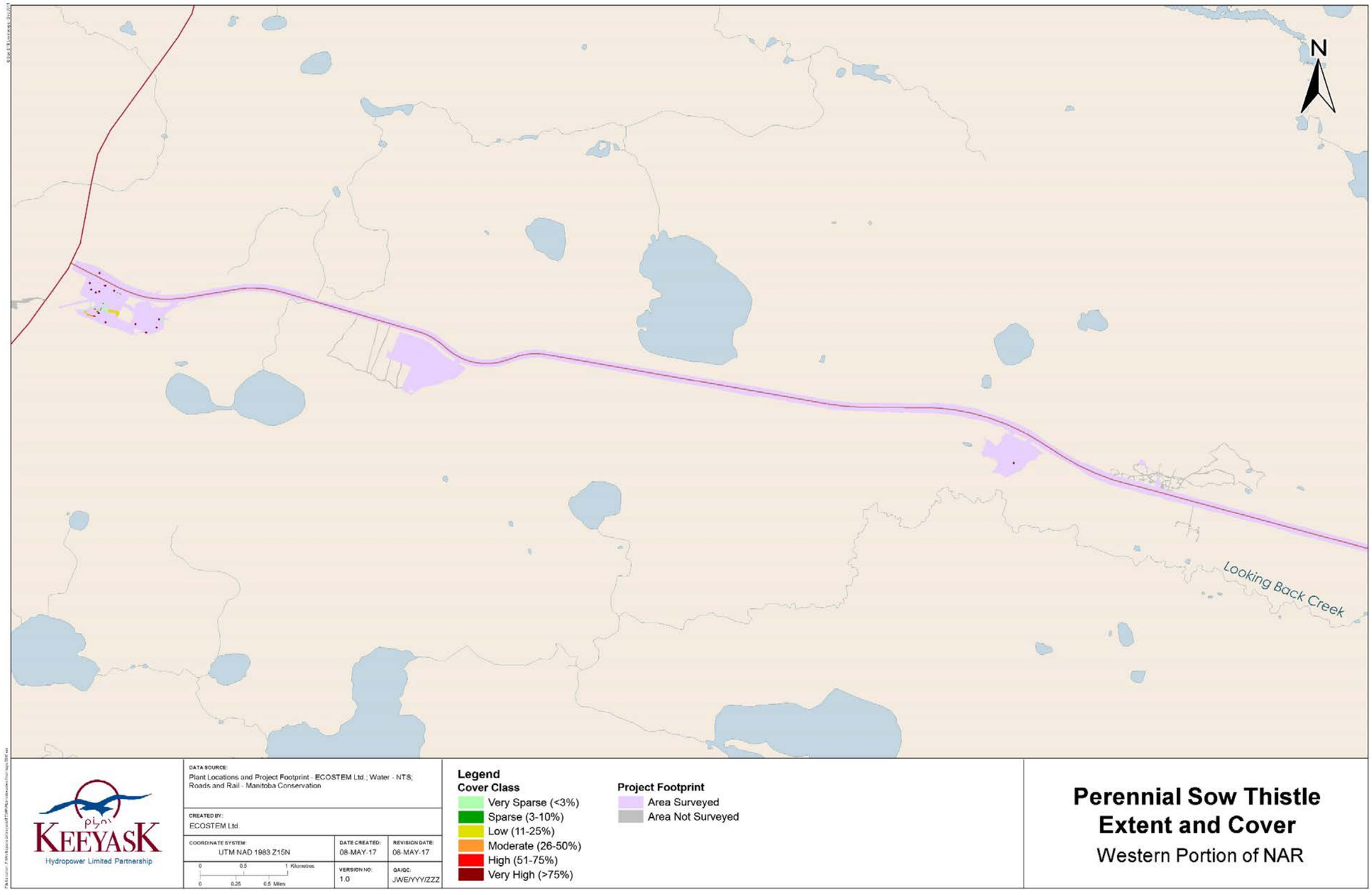
Map 3-9: The distribution and cover of common dandelion in footprints along the eastern portion of the north access road



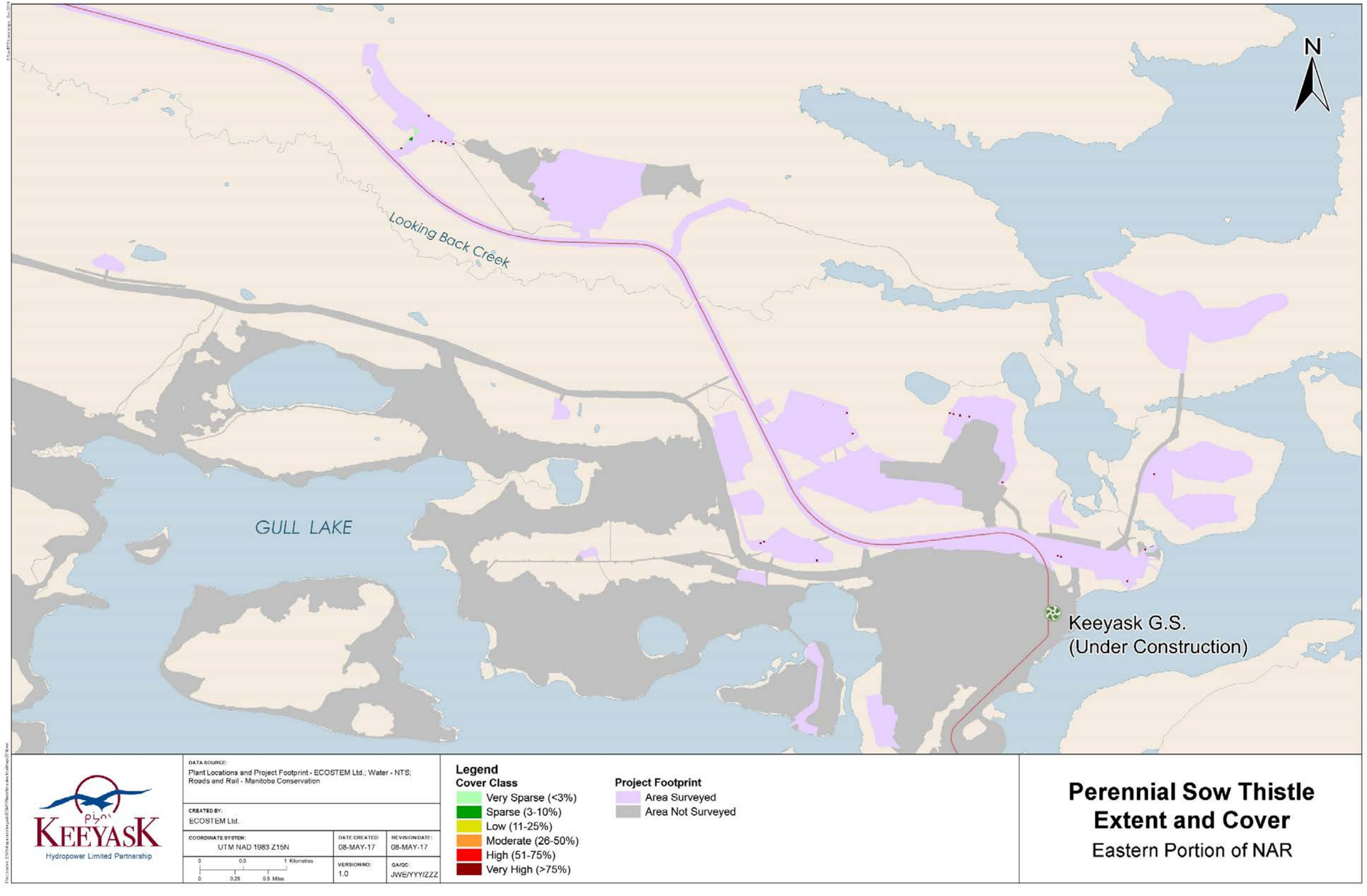
Map 3-10: The distribution and cover of white and yellow sweet clover in footprints along the western portion of the north access road



Map 3-11: The distribution and cover of white and yellow sweet clover in footprints along the eastern portion of the north access road



Map 3-12: The distribution and cover of perennial sow thistle in footprints along the western portion of the north access road



Map 3-13: The distribution and cover of perennial sow thistle in footprints along the eastern portion of the north access road

3.5 CONTROL OR ERADICATION MEASURES

Key control or eradication measures included in the EIS and EnvPPs are:

- 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.
- Weed control will be applied to material stockpiles to prevent introduction of invasive species.

Additional control or eradication recommendations provided during monitoring focused on the plant species of highest invasive concern, and on the situations where there are practical ways to prevent further spreading. Many of the invasive 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 vectors. Based on surveys conducted in the summers of 2011 to 2013 under the KIP monitoring, at least three invasive 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).

Sources used to classify the potential for a plant species to create adverse effects for native ecosystems or other situations in Manitoba and Canada include the Invasive Species Council of Manitoba (ISCM; 2017), White et al. (1993), the Provincial Noxious Weeds Act (Government of Manitoba 1988) and the Federal Weed Seeds Order (Government of Canada 2005).

ISCM (2017) and White et al. (1993) were considered the most relevant sources for this study. The weed seed regulations include some native boreal plants (*e.g.*, spreading dogbane) because originate from agricultural concerns. At a minimum, the agricultural based sources identify species that can substantially reduce the performance of desired plant species.

The invasive species considered to be of highest concern for the Project area were those that the ISCM classifies as “Category 1” or “Category 2” species, followed by ISCM “other” species and those that White et al. (1993) classify as “high” or “moderate” invasives. ISCM Category 2 species are those which are present in Manitoba, capable of further spread and have an established pathway for spread (ISCM 2017). 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.

Almost half (nine) of the 21 non-native species recorded in 2016 are considered to be invasive plants (Table 3-7). Of these, only one is an ISCM Category 2 species (scentless chamomile).

Scentless chamomile is a fast growing, prolific seed producer that can form dense monocultures (Leafy Spurge Stakeholders Group (LSSG) 2010). Field surveys during 2015 identified one scentless chamomile plant within the road ROW between the start-up camp and the camp well (Map 3-14), while 2016 surveys identified a second location. In both cases, it was recommended shortly after the species was found that Manitoba Hydro site staff carefully: hand-pull the plant; remove the soil from around the base of the plant; place all material into a double layer of garbage bags prior to disposal; and, if feasible, burn all of the collected material. Manitoba Hydro site staff carried out the scentless chamomile plant removal shortly thereafter.

At the next level of invasive concern, four species are on ISCM's "other" list (common burdock, Canada thistle, perennial sow thistle and tufted vetch). White *et al.* (1993) classify three of the nine species as moderately invasive in Canada (Canada thistle, white clover, yellow sweet clover) and two as minor invasives (wormwood, alfalfa).

Canada thistle is classified as an invasive of "other" concern in Manitoba, a moderate invasive in Canada and a weed seed in Canada (Table 3-7). On this basis, it was recommended that the plants identified during the fall 2015 surveys be removed when they emerge in the spring. 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 3-16). One location found in spring 2015 has not been observed since then. The remaining two locations were included in the areas treated with herbicides (see below).

Common burdock is classified as an invasive of "other" concern in Manitoba and considered to be a noxious weed in Manitoba (Table 3-7). The large basal leaves can shade out smaller plants. Its seed is spread via burrs that attach to clothing and vehicles (ISCM 2017). It is recommended that burrs on dead stems of the plant identified in late summer 2016 (Map 3-17) be removed early in the spring, and the rest of the plant when it emerges in the spring. The preferred disposal method is the same as the one described above for scentless chamomile.

Perennial sow thistle is classified as an invasive of "other" concern in Manitoba and as a weed seed in Canada (Table 3-7). This species is commonly found in disturbed areas throughout the Province, including along PR 280, and would be difficult to effectively control. Some of the areas containing perennial sow thistle were sprayed with herbicides August 2016 (see below). Additional potential control measures for the 2017 growing season are being considered.

Tufted vetch is classified as a species of some concern in Manitoba (Table 3-7). The species can spread aggressively, crowding out native vegetation. The plant was found at only three locations during late summer 2016 surveys (Map 3-18). It is recommended that the plants be removed when they emerge in the spring. The preferred disposal method is the same as the one described above for scentless chamomile.

At the next level of invasive concern, eight of the nine invasive species recorded in the Project footprint are also considered to be noxious weeds and/or weed seed species (Table 3-7). These, and the remaining non-native species, may become problematic in some locations

and/or conditions. They will be a consideration when developing revegetation plans for areas being rehabilitated to native habitat types.

It appears that control measures may not be needed for lamb's quarters. This species has spread within the current Project footprint, beginning during the KIP construction, and continuing through Project construction to late summer 2016 (particularly in the work areas and borrow areas). However, there are signs that lamb's quarters may now be in decline. Its extent decreased locally in the start-up camp and KM-4 borrow area (Map 3-6). Additionally, total cover in most footprints peaked in late summer 2015, then declined substantially by late summer 2016, indicating total cover within the patches had declined.

The remaining invasive/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. Other species that appeared to be expanding rapidly in both extent and/or cover included narrow-leaved hawks beard, common dandelion, white and yellow sweet clover and common plantain. Several of these species are commonly found in disturbed areas throughout the Province, particularly along roadsides, making it difficult to prevent spreading.

In addition to the species-specific recommendations described above, a number of control or eradication recommendations were developed following the completion of last year's annual report (ECOSTEM 2016). These recommendations focused on the areas 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. After considering available options, an herbicide application was recommended for the key sites shown in Map 3-15. All of these sites except for the single site off the SAR were sprayed on August 25, 2016. Results from the 2017 invasive plant surveys will be used to evaluate the efficacy of this herbicide application. Subsequent revegetation efforts should also contribute to reducing invasive plant distribution and abundance.

As an additional preventative measure, a training session was held with site environmental staff in August 2016. During this session, staff were taken into the field and shown how to recognize the invasive plant species of highest concern using live examples, and provided with some potential measures (such as the recommended manual removal and disposal method) to respond to their discovery in new areas. Site staff were also taken to a recently observed scentless chamomile plant, and showed how to properly remove and dispose of it.

The late summer rare plant survey reported the presence of healthy wheat plants in the spillway laydown area. These plants were growing on top of straw bales and on the ground in straw that had fallen off bales (Figure 3-1). These straw bales were brought to site to control erosion. Given the developmental stage of the plants at that time, it appeared unlikely that they could produce viable seed before a fall frost would kill the plants. These areas will be revisited during 2017 surveys to confirm this.

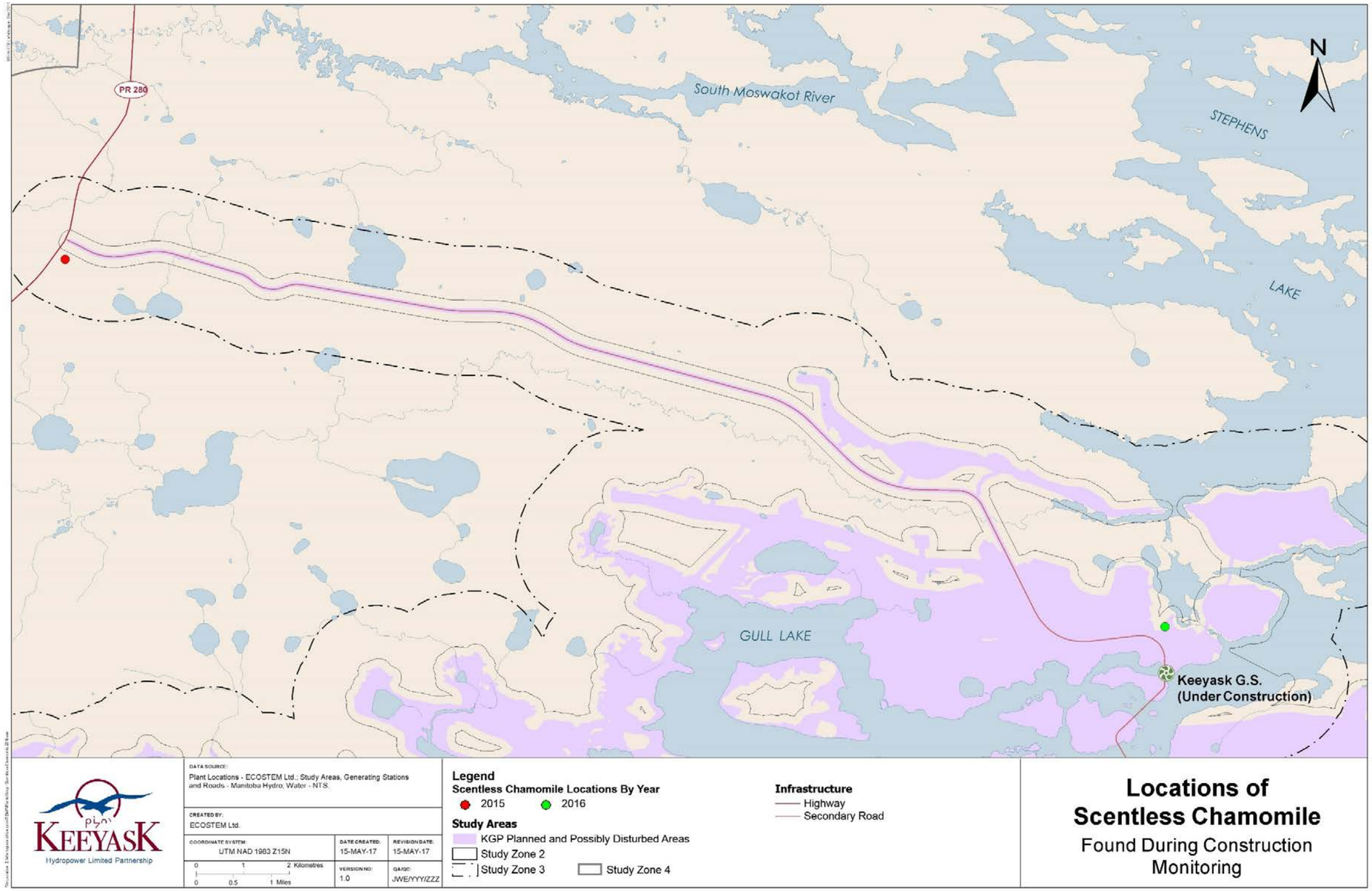
Control recommendations for the 2017 growing season are being developed based on the results to date.

Table 3-7: Invasive concern classifications and spread rate notes for non-native plant species recorded in the Project footprint

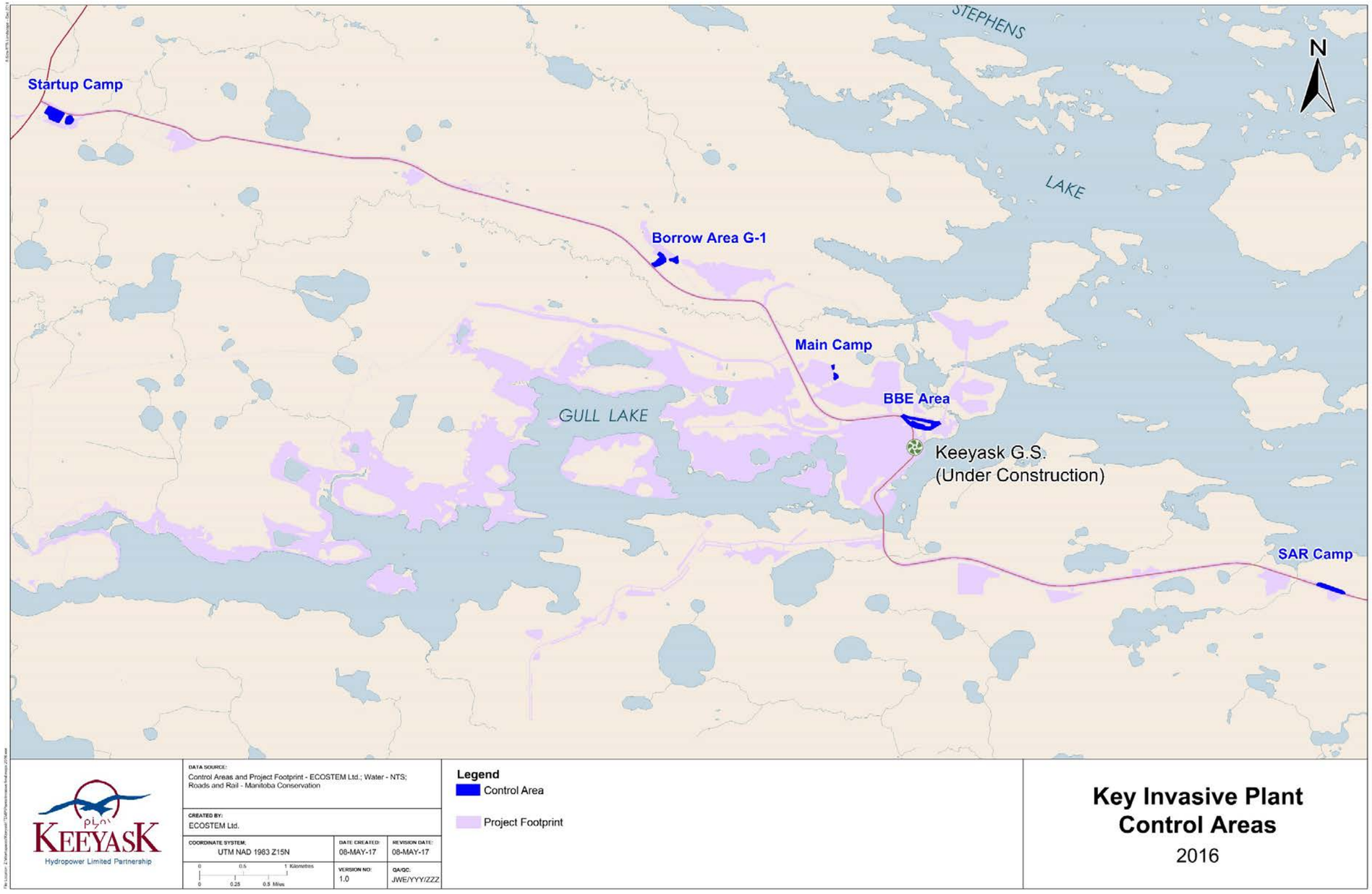
Common Name[1]	Scientific Name	ISCM Category[2]	White *et al.* Category[3]	Noxious Weed[4]	Weed Seed[5]	Spread Rate Notes[6]
Scentless chamomile	*Tripleurospermum inodorum*	Category 2		yes	secondary	Rapid and prolific spread
Canada thistle	*Cirsium arvense*	other	moderate	yes	primary	Hardy seeds
Common burdock	*Arctium minus*	other		yes		Burs attach to passing objects
Perennial sow thistle	*Sonchus arvensis*	other			primary	Spread by seeds
Tufted vetch	*Vicia cracca*	other				
White sweet clover	*Melilotus albus*		moderate			Hardy seeds
Yellow sweet clover	*Melilotus officinalis*		moderate			Hardy seeds
Wormwood	*Artemisia absinthium*		minor	yes		
Alfalfa	*Medicago sativa*		minor			
Lamb's quarters	*Chenopodium album*			yes		Spread by seeds
Smooth catchfly	*Silene csereii*			yes		
Common dandelion	*Taraxacum officinale*			yes		Seeds spread by wind
Narrow-leaved hawks-beard	*Crepis tectorum*			yes		Seeds spread by wind
Pineappleweed	*Matricaria discoidea*					Spread by seeds
Black medick	*Medicago lupulina*					Seeds; spreading stems
Common plantain	*Plantago major*					Spread by seeds
Alsike clover	*Trifolium hybridum*					
Red clover	*Trifolium pretense*					
White clover	*Trifolium repens*					

Notes: [1] In decreasing order of concern for the Project area. [1] White et al. (2003). [2] Invasive Species Council of Manitoba (2017). [4] Government of Manitoba (1988). [3] Government of Canada (2005). [6] LSSG (2010), Government of Saskatchewan (2016b).

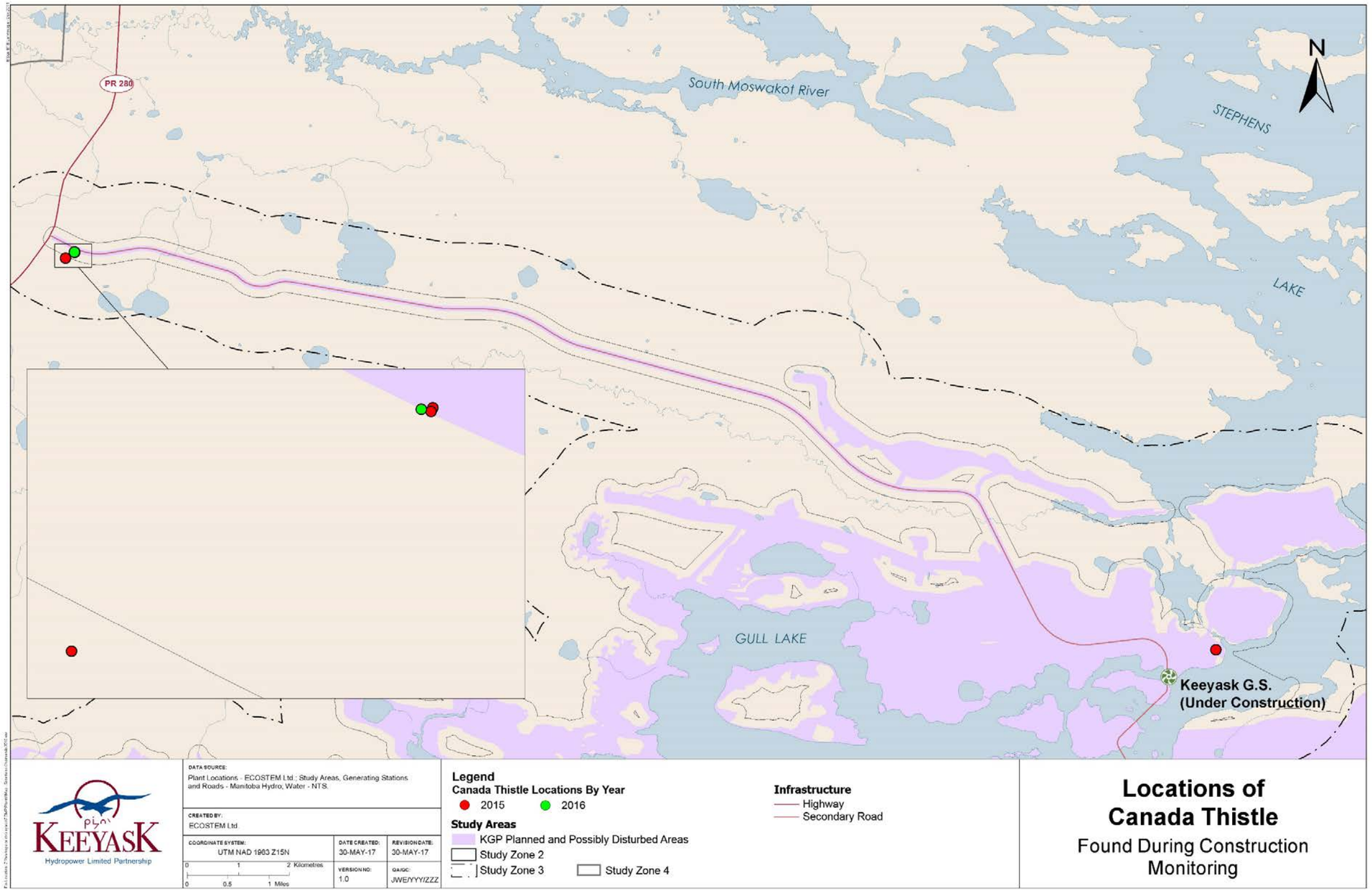
Figure 3-1: Wheat plants growing on top of straw bales and on the ground in straw



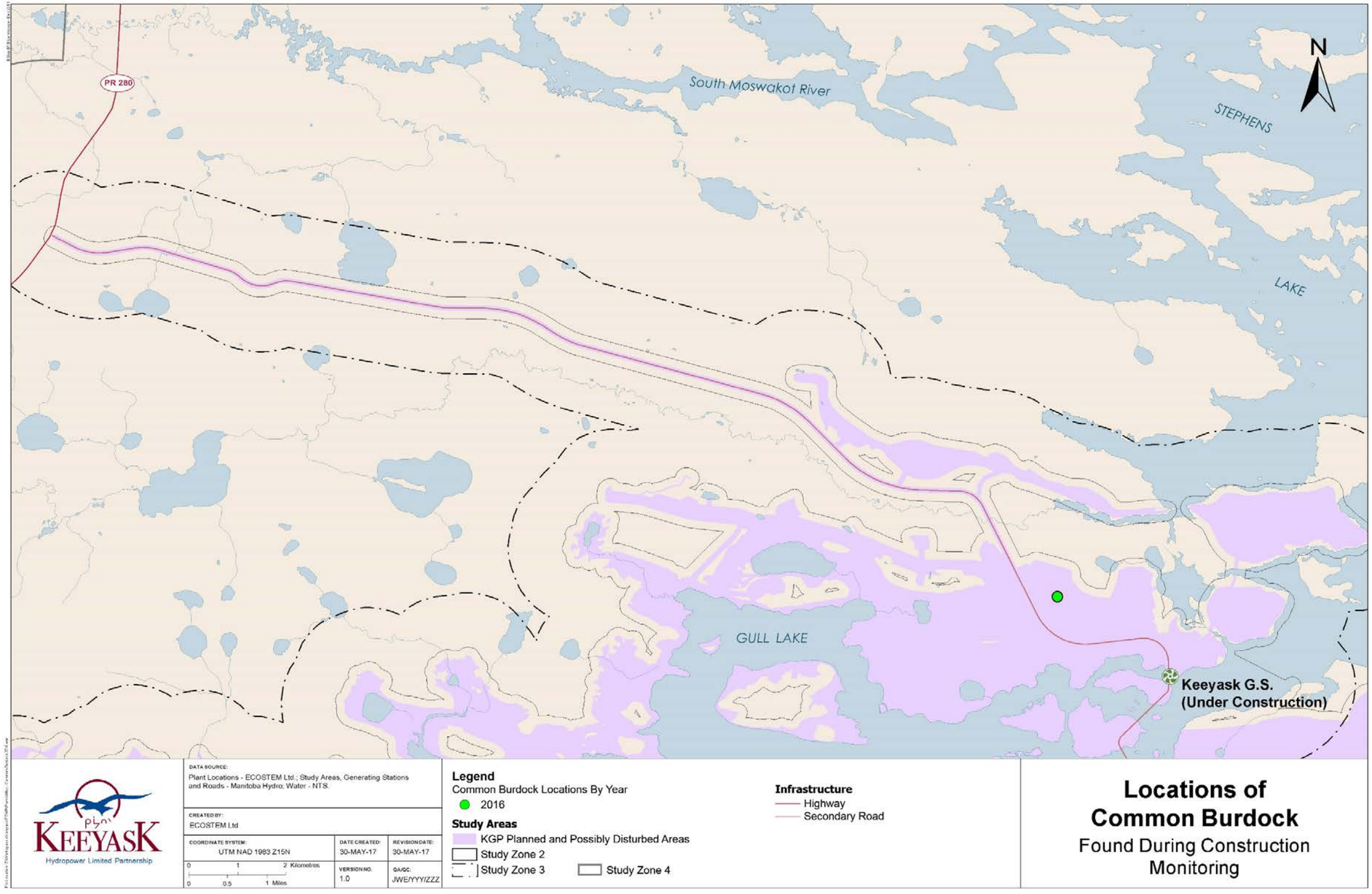
Map 3-14: Locations of scentless chamomile identified during construction monitoring



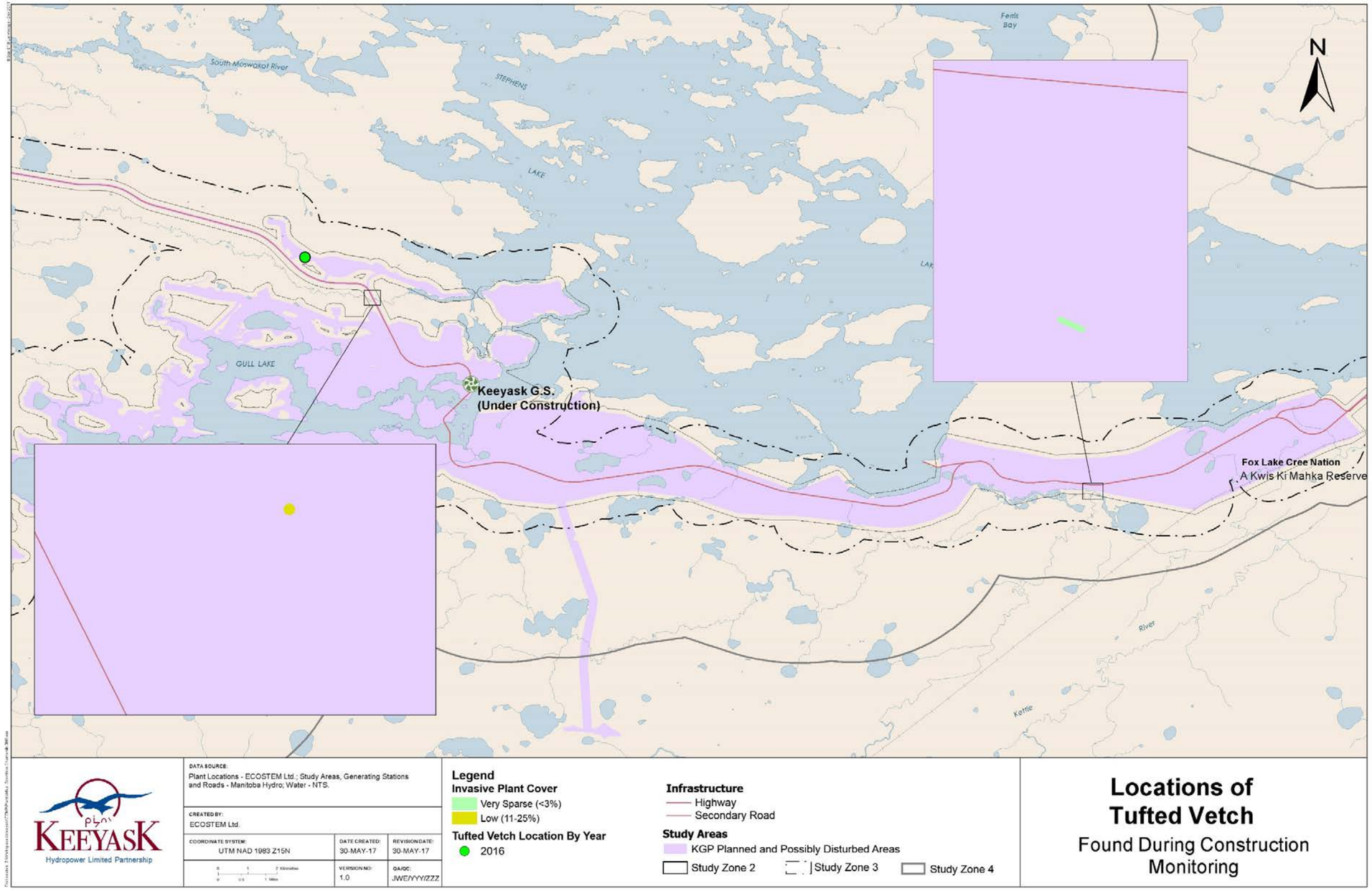
Map 3-15: Key areas selected for invasive plant control in 2016



Map 3-16: Canada thistle locations



Map 3-17: Common burdock location



Map 3-18: Tufted vetch locations

4.0 SUMMARY AND CONCLUSIONS

Non-native plants are plant species that are growing outside of their country or region of origin. Invasive plants are non-native plants that can out-compete native plants. Invasive plants are of concern because they can crowd out or even replace native plant species and, in extreme cases, adversely change vegetation composition or other ecosystem attributes. The Invasive Plant Spread and Control study is determining the degree to which the Project contributes to introducing and spreading invasive and non-native plants. This study also recommends control measures where appropriate, and evaluates the effectiveness of mitigation measures.

In general, all areas impacted by Project clearing or disturbance were surveyed for invasive and other non-native plants in 2016. The exceptions were areas that could not be accessed due to safety concerns relating to ongoing construction activities, or because they were very recently cleared and invasive/non-native plants would not yet have had time to establish. Project areas included in the 2016 surveys were the north and south access roads, borrow areas, excavated material placement areas, camp areas, work areas, portions of the north and south dykes, and a portion of the generating station area.

Monitoring surveys were conducted twice annually, in early and in late summer, during 2015 and 2016. The number of non-native species and their cover increased between these surveys in both years. This was somewhat due to plants being less detectable earlier in the summer, as they had not germinated yet and/or their stems and leaves were not sufficiently developed. The exception to higher cover in late summer was lamb's quarters, which appeared to peak in total cover in 2015, followed by a large decline in 2016.

The remainder of this summary focuses on results from the late summer surveys since these data are more representative of invasive plant conditions. The early summer surveys provided early detection of potential situations that were much easier to control if responded to quickly. In this regard, the early summer survey will be discontinued for the established Project footprints since they provide minimal added information for invasive plant monitoring and management.

A total of 21 invasive and other non-native species were found during the late summer surveys. Of these, nine were considered invasive. The majority of these non-native species were in the footprints used KIP, some of which are also being used by the Project. Non-native plants were beginning to colonize newer footprints cleared for the Project, but cover remained comparatively low in these areas.

Increases in the number of non-native species and their cover in 2016 compared to 2015 were attributed to several factors. First, the increased annual and cumulative amount of construction activity and number of vehicles likely contributed to spreading these species. This was particularly the case for footprints that already contained non-native species when Project construction began (e.g. the start-up camp). Second, many of these species are widespread in human disturbed areas within the Keeyask region, and thus easily transported to Project areas on vehicles, footwear and other materials that are brought into the Project site. Third, the longer

time since construction began provided more opportunity for natural sources, such as wind or animals, to spread seeds.

Six new invasive and other non-native species were recorded in 2016. The single new invasive species was common burdock (classified as an invasive species of "other" concern by ISCM 2017). The five new non-native species were narrow-leaved hawks-beard, bird's-foot trefoil, common timothy, curled dock, tufted vetch and wheat.

Almost half (nine) of the 21 non-native species recorded in 2016 are considered to be invasive plants. Of these, only one is an ISCM Category 2 species (scentless chamomile). At the next level of invasive concern, ISCM classifies four species as "other" species of concern in Manitoba (common burdock, Canada thistle, perennial sow thistle and tufted vetch). White *et al*. (1993) classify three of the nine species as moderately invasive in Canada (Canada thistle, white clover, yellow sweet clover) and two as minor invasives (wormwood, alfalfa).

Scentless chamomile was the only invasive plant species recorded in 2016 for which the ISCM recommends rapid response. The preferred method for removal and disposal of such plants is: hand-pull the plant; remove the soil from around the base of the plant; place all material into a double layer of garbage bags prior to disposal; and, dispose of all of the collected material, preferably by burning it.

One single scentless chamomile plant was identified within EMPA D17. After its discovery, it was recommended that the plant be carefully removed and disposed of. On the day after its discovery, Manitoba Hydro field staff removed and disposed of the scentless chamomile plant and the soil material. The other location where scentless chamomile had been found in 2015, and then removed by site staff, did not have any new plants in 2016.

For the three of the four species that ISCM classifies as "other" invasives (common burdock, Canada thistle and tufted vetch), it is recommended that the plants be removed and disposed of using the same method as for scentless chamomile. These species are of relatively high invasive concern and were found at only a few locations each.

Perennial sow thistle, the fourth ISCM" other" species, was already fairly widespread in the footprint, and in disturbed areas throughout the region, and would be difficult to effectively control using the species-specific method described for scentless chamomile. The perennial sow thistle locations were addressed with the generalized control method described below.

At the next highest level of invasive concern, eight of the nine invasive species recorded in the Project footprint are also considered to be noxious weeds in Manitoba and/or weed seed species in Canada. These, and the remaining non-native species, may become problematic in some locations and/or conditions. They will be a consideration when developing revegetation plans, particularly for areas being rehabilitated to native habitat types.

While lamb's quarters was one of the noxious weed species, it appears that control measures may not be needed for it. Lamb's quarters had the highest cover of all invasive species in 2016. However, its total cover decreased since 2015, despite a larger area surveyed. While lamb's quarters appeared to be establishing in newer footprints, its extent and cover declined within all

areas used by the KIP, and its cover declined for areas used by both the KIP and the KGP. Continued monitoring of this species will determine if this decline is a trend, or if it is an anomaly. If this is shown to be a trend in the older footprints, then it may reduce the need to implement future control measures for this species.

Many of the non-native species recorded in the Project footprint are commonly found in disturbed areas throughout the Province (e.g., dandelion, sweet clover), particularly along roadsides, making it difficult to prevent vehicles and people from inadvertently spreading these species into the Project footprint. Based on surveys conducted prior to the KIP construction, it was likely that at least three invasive species were already well established in the start-up camp area when the KIP construction began.

In addition to the species-specific recommendations described above, some general control or eradication recommendations were developed for the invasive species following the completion of last year's annual report (ECOSTEM 2016). One of these additional control measures was an herbicide application program implemented on August 25, 2016 (see the EnvPP annual report (Manitoba Hydro 2017) for information on the herbicide applications). Herbicides were applied to several key sites 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. Surveys in 2017 will evaluate the efficacy of this control measure.

As another preventative measure, site environmental staff were trained to recognize the invasive plant species of high concern so they could take steps to eradicate them before they have an opportunity to spread throughout the Project site.

Control recommendations for the 2017 growing season are being developed based on the results to date.

It becomes increasingly challenging to complete the invasive/non-native plant surveys in an efficient and consistent manner as the Project footprint grows in size, and as these plants continue to expand their distribution. Consideration is being given to an alternative field mapping method for footprint areas that are no longer expanding or are no longer being actively used.

4.1 NEXT STEPS

Consideration is being given to an alternative field method for the established footprint areas. Control recommendations for the 2017 growing season are being developed based on the results to date. Monitoring fieldwork for invasive plants will continue in 2017.

5.0 LITERATURE CITED

Alberta Invasive Plants Council. 2016. Canada Thistle Fact Sheet. http://invasivespeciesmanitoba.com/site/uploads/pdf/ISCM%20Fact%20Sheets/AB%20CanadaThistle.pdf [Accessed March 11, 2016].

ECOSTEM 2013. Keeyask Infrastructure Project: Terrestrial habitat, ecosystem and plant monitoring during construction: activities from July, 2011 to March, 2013. Monitoring Program Report #12-01.

ECOSTEM 2014. Keeyask Infrastructure Project: Terrestrial habitat, ecosystem and plant monitoring during construction: Annual report 2013 - 2014. Monitoring Program Report #13-01.

ECOSTEM 2015a. Keeyask Infrastructure Project: Terrestrial plant, habitat and ecosystem monitoring during construction: Annual report 2014 - 2015.

ECOSTEM 2015b. Keeyask Generation Project: 2014 pre-clearing rare plant surveys: Annual report 2014-2015

ECOSTEM Ltd. 2016. Terrestrial Effects Monitoring Plan Annual Report 2015 – 2016: Keeyask Generation Project: Terrestrial Plant, Habitat, and Ecosystem Monitoring: Annual Report 2015-2016. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2016.

ECOSTEM Ltd. 2017. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2017-01: Habitat Loss and Disturbance Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2017.

Government of Saskatchewan. 2016. Scentless Chamomile. https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/weeds/scentless-chamomile [Accessed March 11, 2016]

Government of Saskatchewan. 2016b. Urban Guide to Weed Control. https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/weeds/urban-guide-to-weed-control [Accessed April 11, 2016]

Government of Canada. 2005. Weed Seeds Order, 2005. Minister of Agriculture and Agri-Food, Government of Canada.

Government of Manitoba. 1988. The Noxious Weeds Act. Government of Manitoba, C.C.S.M. c. N110.

ISCM (Invasive Species Council of Manitoba). 2017. Invasive plants & animals in Manitoba. [Online] http://www.invasivespeciesmanitoba.com/site/index.php. [accessed April 11, 2017].

Keeyask Hydropower Limited Partnership (KHLP). 2012a. Keeyask Generation Project Environmental Impact Statement: Response to EIS Guidelines, Winnipeg, Manitoba. June 2012.

Keeyask Hydropower Limited Partnership (KHLP). 2012b. Keeyask Generation Project Environmental Impact Statement: Terrestrial Environment Supporting Volume, Winnipeg, Manitoba. June 2012.

Keeyask Hydropower Limited Partnership (KHLP). 2015. Keeyask Generation Project Terrestrial Effects Monitoring Plan. Winnipeg, Manitoba. December 2015.

Leafy Spurge Stakeholders Group (LSSG). 2010. Best Management Practices for Industry: Top invasive Plant Concerns for Rights-of-Way. Brandon, Mb.

Manitoba Hydro 2017. Environmental Protection Plan Annual Report April 2016 – March 2017. Keeyask Generation Project Environmental Protection Plan Report # EnvPP-2017-01. June 2017.

White, D.J., Haber, E., and Keddy, C. 1993. Invasive plants of natural habitats in Canada: an integrated review of wetland and upland species and legislation governing their control. Canadian Wildlife Service, Ottawa, Canada. 121pp.

APPENDIX 1:
INVASIVE PLANT INDIVIDUAL AREAS

Table 5-1: 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
Chrysanthemum leucanthemum	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 INVASIVE PLANT RESULTS

Table 5-2: Total early and late summer invasive plant extent as a percentage of total area surveyed by year and Project footprint type

Footprint Type	2014		2015		2016	
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer
North Access Road	0.00	0.32	0.32	0.89	0.01	3.5
South Access Road	-	-	-	-	-	0.2
Camp & Work Areas	0.56	3.24	3.59	4.66	1.26	4.0
Borrow Area	0.02	0.33	0.64	3.09	0.85	2.1
North Dyke	-	-	-	-	-	0.1
South Dyke1	-	-	-	-	0.00	0.0
Generating Station Area	-	-	-	-	-	0.5
Reservoir Clearing	-	-	-	-	-	-
All	0.30	1.83	1.98	3.70	0.72	2.4
Total invasive plant extent (ha)	*0.7*	*4.9*	*4.7*	*9.3*	*4.8*	*14.8*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*

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

[1] Proportion of invasive cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.

Table 5-3: Total early and late summer invasive plant cover as a percentage of total area surveyed by year and Project footprint type

Footprint Type	2014		2015		2016	
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer
North Access Road	0.00	0.01	0.02	0.07	0.00	0.25
South Access Road	-	-	-	-	-	0.01
Camp & Work Areas	0.06	0.34	0.46	0.77	0.18	0.58
Borrow Area	0.00	0.05	0.05	0.48	0.04	0.24
North Dyke	-	-	-	-	-	0.00
South Dyke1	-	-	-	-	0.00	0.00
Generating Station Area	-	-	-	-	-	0.03
Reservoir Clearing	-	-	-	-	-	-
All	0.03	0.20	0.24	0.59	0.06	0.31
Total invasive plant extent (ha)	*0.08*	*0.53*	*0.57*	*1.49*	*0.43*	*1.89*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*

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

[1] Proportion of invasive cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.

Table 5-4: Total approximate invasive or non-native species cover (m^2) and number of species in the Project footprint, by year and season.

Common Name	2014		2015		2016	
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer
Common Burdock	-	-	-	-	-	0
Wormwood	-	-	0	0	0	1
Lamb's-quarters	89	2,903	1,115	8,844	990	6,342
Canada Thistle	-	-	0	0	-	0
Narrow-leaved Hawks-beard	-	-	-	-	-	586
Bird's-foot Trefoil	-	-	-	-	0	0
Pineappleweed	-	-	7	18	0	29
Black Medick	-	0	-	1	-	-
Alfalfa	119	124	0	11	4	14
White Sweet Clover	-	532	1,742	2,252	900	3,015
Yellow Sweet Clover	-	0	-	2	7	109
Unidentified Sweet Clover1	387	72	-	-	565	1,838
Common Timothy	-	-	-	-	-	0
Common Plantain	27	80	56	121	68	268
Yellow or Curled Dock	-	-	-	-	-	100
Rye	-	0	-	-	-	-
Smooth Catchfly	-	-	0	5	16	26
Field Sow-thistle	38	252	301	972	52	1,111
Common Dandelion	143	1,291	2,316	2,422	1,654	5,268
Alsike Clover	-	25	145	242	43	190
Red Clover	-	0	-	0	-	-
White Clover	-	0	-	0	0	0
Scentless chamomile	-	-	-	0	-	0
Wheat	-	-	-	-	-	30
Tufted Vetch	-	-	-	-	-	0
Number of invasive species	**7**	**12**	**11**	**16**	**13**	**21**

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

[1] 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 5-5: Total late summer invasive plant extent by project footprint use and year

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

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

Table 5-6: Total late summer invasive plant cover by project footprint use and year

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

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