Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Habitat Rehabilitation Implementation and Success Monitoring Report

TEMP-2023-07

KEEYASK

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KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2023-07

HABITAT REHABILITATION
IMPLEMENTATION AND SUCCESS MONITORING

YEAR 1 OPERATION

2022

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 vast majority of construction activities were completed by fall 2021, and all seven units were in operation by March 2022. The first year of operation monitoring began in the summer of 2022.

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 the terrestrial habitat rehabilitation monitoring conducted during the first summer of Project operation.

Why is the study being done?

Terrestrial habitat rehabilitation reduces adverse Project effects on terrestrial habitat and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits.

The Project's Vegetation Rehabilitation Plan, which is part of the overall Environmental Protection Program, provides the framework for rehabilitating terrestrial habitat in areas impacted by the Project, and the Keeyask Infrastructure Project (KIP). Terrestrial habitat is being rehabilitated in areas not required for Project operation (i.e., temporary Project areas) and in some permanent Project areas (e.g., along access roads).

What was done?

Terrestrial habitat rehabilitation monitoring verifies that the rehabilitation measures are being completed in accordance with the Environmental Impact Statement commitments and the Vegetation Rehabilitation Plan. This monitoring also verifies that the target habitat types are expected to be achieved.

Monitoring in 2022 focused on documenting the:

- Extent to which pre-existing access trails that meet up with the Construction Footprint had been blocked and were revegetating;
- Degree of vegetation regeneration in the temporary Project areas; and,
- Rehabilitation in areas that are planned to become a woodland or a forest.

The KHLP seeded the side slopes of the North Access Road (NAR) and South Access road (SAR) at various times since the start of Project construction, and seeded two borrow areas underneath a transmission line with native grass along the SAR.

The KHLP carried out the first efforts to rehabilitate forest or woodland habitats in 2016 at five locations, including three borrow areas developed by the KIP along the NAR, one cleared area near the Start-Up Camp and one cleared area near the Main Camp. Additional rehabilitation efforts were carried out in 2020 and 2021 at eight locations, including the remainder of one borrow area adjacent to the NAR, three excavated material placement areas along the South Dike, two large borrow areas, an excavated material placement area and a haul road on the islands north of the main work areas. Rehabilitation measures included grading to reduce steep slopes in the borrow areas, using a discer to loosen compacted mineral substrates and planting trees. A total of 131.3 ha were planted in 2020 and 2021.

In 2021, 47 trails were surveyed for measures implemented to block access, vegetation regeneration, and for evidence of recent human use of the trails.

Vegetation regeneration mapping was updated for 1,138 ha of the Construction Footprint, including the borrow areas seeded with grass in 2020.

Tree regeneration implementation success surveys were conducted in areas that were planted with tree seedlings in 2020 and 2021.

What was found?

Trail monitoring in 2022 found that there was no change in vegetation regeneration status or trail blocking measures since 2017. There was no additional Project-related disturbance or clearing in any of the monitored trails.

The evaluations of vegetation regeneration as of 2022 in the temporary portions of the Construction Footprint (i.e., the temporary Project areas) found that vegetation cover and/or structure changed for approximately 0.2% of the mapped areas since 2021. Most of the change was an increase in vegetation cover for several areas. In one case, vegetation cover was removed due to site preparation for planned rehabilitation activities.

Updated mapping of the borrow areas seeded with native grasses in 2020 found no substantial change between 2020 and 2021, with a slight overall increase in vegetation cover for one borrow area.

Rehabilitation implementation surveys for areas planted in 2021 found that four of the seven locations met or exceeded the target density for a woodland habitat type (2,500 stems/ha) at the 95% confidence level. The estimated planting density at one location was significantly lower than the target density.

As of 2022, the estimated live stem density at one of the eight rehabilitation locations planted in 2020 and 2021 (Borrow Area G-3) met or exceeded the target density for a woodland. This area exceeded the target density due to the contribution of natural regeneration.

What does it mean?

Monitoring has found that all the trails intersecting with the Construction Footprint are effectively blocked and showed no signs of recent use. In cases where trails were not physically blocked, natural regeneration following the 2013 wildfire (which was not caused by the Project) has obscured the trails and removed the need for these trails to be blocked by other means.

As expected, very minor changes in vegetation cover and/or structure type occurred in the short period of time between the 2021 and 2022 surveys. Most of the change that occurred was due to an increase in vegetation cover in previously barren areas. It is expected that natural plant regeneration will continue to increase vegetation cover in many portions of the temporary Project Footprint.

Monitoring found that patches of barren vegetation still made up a large portion of the two rehabilitation locations seeded with native grasses in 2020. However, one of the locations appeared to have an overall increase in vegetated cover since 2021. Monitoring of vegetation cover for seeded areas will continue during operation.

In 2020 and 2021, eight areas targeted to become forest or woodland habitat were planted with trees. Monitoring in 2022 found that four of these eight areas had a live stem density that was too low for it to regenerate to a woodland habitat type. At least one location will require supplemental planting in the future to meet the revegetation target. Future mapping and field surveys for the Vegetation Rehabilitation Plan will determine if any other areas require additional planting to achieve the rehabilitation targets.

What will be done next?

Rehabilitation monitoring in 2023 will include surveys of the areas tree planted in 2020, 2021 and 2022. It will also be the first year of field surveys for the habitat recovery success study, which is focused on long-term habitat recovery and will be conducted in the 2016 tree planting areas.

Detailed target habitat type and rehabilitation prescriptions will be outlined for areas impacted by construction and not required for Project operation (i.e., the temporary Project areas). This information will be used for future evaluations of rehabilitation implementation and habitat recovery success.

ACKNOWLEDGEMENTS

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STUDY TEAM

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

Fieldwork in 2022 was conducted by Brock Epp, Alanna Sutton, Owen Romanchuk, Sofia Sparby, Candice Collette, Isaac Manness, Ryan Sheffield, Saul Mayham (TCN), Grant Connell (TCN), Patrick Connell (TCN) and Alex Snitowski.

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt hydroelectric generating station (GS) and the associated facilities. The Project is located at the former 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.

Project construction began in July 2014. The vast majority of construction activities had been completed by fall 2021. The reservoir was first brought to full supply level in September 2020 and the final generating unit went into service on March 9, 2022.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project (KHLP 2012a). Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TE SV; KHLP 2012b).

The *Keeyask Generation Project Terrestrial Effects Monitoring Plan* (TEMP; KHLP 2015a) was subsequently 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, habitat rehabilitation, during the construction and operation phases.

EIS predictions for all of the key topics were directly and/or indirectly based on assumptions regarding the effectiveness of habitat rehabilitation efforts and natural regeneration processes. These key topics included intactness, ecosystem diversity, terrestrial habitat, and priority plants.

Terrestrial habitat rehabilitation mitigates adverse Project effects on terrestrial habitat and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits. Terrestrial habitat will be rehabilitated in areas not required for Project operation and in some areas that are required for Project operation (e.g., along access roads). Some of the planned rehabilitation addresses potential adverse Project effects on intactness by blocking or hindering access from Project areas to surrounding areas.

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan for rehabilitating terrestrial habitat. The *Keeyask Generation Project Vegetation Rehabilitation Plan* (the VRP; KHLP 2015b), which is part of the overall Environmental Protection Program, provides the framework for rehabilitating terrestrial habitat in areas impacted by Keeyask Infrastructure Project (KIP) and the Project. The VRP provides the framework for how the areas that were temporarily required for construction but are not required for operation of the generating station or long-term maintenance of the associated infrastructure (e.g., borrow areas) will be rehabilitated. Best efforts will be made to re-establish the habitat types that existed prior to construction. Preference will be given to rehabilitating the most affected priority habitat types. Plant species that are important to the partner First Nations will be incorporated into habitat restoration, where feasible. Permanent Project features that require sight lines for safety purposes will be revegetated with plant species that are appropriate for the site.

Monitoring is needed to verify the implementation and effectiveness of terrestrial habitat rehabilitation measures. The terrestrial habitat rehabilitation monitoring program (TEMP, Section 2.2) includes a single study, Habitat Rehabilitation Implementation and Success, that periodically evaluates the implementation and effectiveness of terrestrial habitat rehabilitation measures.

The goal of this study (Habitat Rehabilitation Implementation and Success) is to verify whether each site has achieved, or is on a pathway to achieving, its rehabilitation targets. However, it will take many years for habitat to regenerate in highly disturbed areas (e.g., borrow areas), and decades for a forest to regenerate where this is the target habitat type. Consequently, this monitoring study is divided into two components:

1. The Habitat Rehabilitation Implementation component initially focuses on verifying adequate implementation of rehabilitation efforts, and documenting the survival of plantings and seedings as well as natural plant colonization and expansion.

2. The Habitat Rehabilitaon Success component begins two to three years after successful implementation, and focuses on evaluating successful achievement of the rehabilitation targets.

The objectives of this study are to:

- Confirm that trails intersecting the Construction Footprint (except for existing resource-use trails and those required for operation) are blocked and initial revegetation efforts are adequate;
- Verify the implementation of rehabilitation prescriptions set out in the Vegetation Rehabilitation Plan;
- Confirm that the revegetated portions of the blocked trails are regenerating successfully and are expected to restore a habitat type similar to adjacent areas; and,
- Verify the effectiveness of rehabilitation efforts at restoring native habitat where this is the target prescription, and at restoring ecologically appropriate vegetation in the remaining areas.

Monitoring for the Terrestrial Habitat Rehabilitation study was conducted in 2017, 2021, and 2022. Results for the monitoring conducted in 2017 and 2021 are provided in previous reports by ECOSTEM (2018, 2022c). The following presents the monitoring conducted in 2022.

2.0 HABITAT REHABILITATION

2.1 TARGET HABITAT TYPES

A target habitat type will be determined for all areas within the Construction Footprint that are not required for Project operation. These target habitat types are established as:

1. The areas not required for Project operation are identified;
2. For treed habitat types, after it is determined:
   a. Which of the priority habitat types were most highly affected by Project construction;
   b. Substrate conditions in areas targeted for a treed habitat type are mapped, which cannot happen until Project activity in the area has ceased.

Manitoba Hydro is currently determining which areas within the Construction Footprint will not be required for Project operation.

For item 2a above, the Terrestrial Habitat Loss and Disturbance study mapped the Construction Footprint, as well as the amount and composition of terrestrial habitat affected by the Project during construction (ECOSTEM 2022a). The Priority Habitats study identified the priority habitat types that were most highly affected by construction (ECOSTEM 2022b).

Substrate conditions have been partially documented through past monitoring. Additional information to determine target habitat type will be gathered in future years.

2.2 TRAILS AND CUTLINES

The Project EIS includes a commitment to block access to select cutlines and trails that intersect the Construction Footprint. Two trails were blocked in 2017 with piled soil and vegetation, as planned. The remaining cutlines and trails were not blocked as originally planned. Dense natural revegetation following the 2013 wildfire effectively blocked the cutlines and remaining trails, making many of them nearly indistinguishable from the surrounding area (ECOSTEM 2018).

2.3 FOREST AND WOODLAND HABITATS

Each winter, Manitoba Hydro provides information on the actual rehabilitation treatments carried out to date. This information is used to plan monitoring for the next growing season. The following summarizes treatments carried out since Project construction began.

2.3.1 BACKGROUND

To develop forest or woodland habitat types in Project disturbed areas, site preparation is often implemented prior to trees being planted. Site preparation may include grading to reduce steep slopes and/or loosening compacted substrates. Site preparation and other effects (e.g., eradicate invasive plants) are followed by tree planting.

Tree planting densities differ for the forest or woodland habitat types as the typical stem density of a mature forest is much higher than a mature woodland. Tree seedlings are planted at a density of 10,000 stems/ha to achieve a forest habitat type, and at 2,500 stems/ha to achieve a woodland habitat type. Using these targets, the final spacing for tree planting is 1 m x 1 m for the rehabilitation locations where a forest is the target, and 2 m x 2 m for the rehabilitation locations where a woodland is the target.

The target tree spacing can be achieved over more than one year, if needed (i.e., two-stage initial planting). This is desirable in some situations as it reduces the risk that a high proportion of the planted seedlings will be eliminated by extreme conditions or events (e.g., a drought, excessive winter browsing). For example, the 1 m x 1 m spacing for a forest can be achieved by planting at 2 m x 2 m in one year, and then completing a second offset 2 m x 2 m planting in a subsequent year.

A consideration when setting the spacing for tree planting is that natural tree regeneration may also contribute to the total target stem density. Natural regeneration may offset some of the planted seedling mortality. Natural tree regeneration includes seedlings that establish from seeds, or pre-existing seedlings and saplings that survived vegetation clearing. For some tree species, vegetation clearing can stimulate stems to sprout from roots (e.g., trembling aspen) or root collars (e.g., white birch).

Planted seedling mortality can be high during the first few years after planting. Mortality can arise from a number of sources, such as the seedlings drying out while being stored prior to planting, hot and dry conditions following planting, particularly harsh winter conditions, or winter browsing by snowshoe hare.

2.3.2 EFFORTS TO DATE

The first efforts to rehabilitate forest or woodland habitat in selected borrow areas and excavated material placement areas (EMPAs) occurred in 2016. These were areas that had been developed as part of the KIP. Additional efforts in these areas, and in areas developed as part of the KGP, occurred in 2020 and 2021. Rehabilitation efforts in other KGP areas continued in 2022.

In 2020, rehabilitation treatments consisted of tree planting at two locations, and seeding with native grass species at two other locations (Table 2-1; Map 2-1). Tree seedlings were planted in a total of 37 ha, including EMPA D27(4)-E adjacent to the South Dike, and a portion (approximately 28%) of Borrow Area G-3. Grass seeding occurred in Borrow Areas Q-9 and B-3 along the South Access Road.

In 2021, seven locations were planted, including the remaining area of Borrow Area G-3 and Borrow Area KM-9 (most of this area was planted in 2016), Borrow Area N-5, Haul Roads 3-4, EMPA D35(1), EMPA D23(1)-E, and a portion of EMPA D23(2)-E (Table 2-1; Map 2-1). Tree seedlings were planted over a total of 83.6 ha, increasing the overall treated area in 2020 and 2021 to 131.3 ha (Table 2-1).

Table 2-1: Rehabilitation efforts including area, year, and treatment type, by location

Location	Area Treated (ha)	Year	Site Treatment	Vegetation Treatment	Planned Tree Spacing (m)
Borrow Area G-3	16.6	2020	Partially Disced	Tree planting	2x2
EMPA D27(4)-E	20.3	2020	None	Tree planting	2x2
Borrow Area Q-9	4.9	2020	Harrow	Grass seeding	n/a
Borrow Area B-3	7.6	2020	Harrow	Grass seeding	n/a
Borrow Area KM-9	1.8	2021	Disced	Tree planting	2x2
Borrow Area G-3	43.4	2021	Partially Disced	Tree planting	2x2
Borrow Area N-5	18.6	2021	Ripped	Tree planting	2x2
Haul Road 3-4	4.7	2021	Ripped	Tree planting	2x2
EMPA D35(1)	6.5	2021	None	Tree planting	2x2
EMPA D23(2)-E	1.4	2021	Disced	Tree planting	2x2
EMPA D23(1)-E	5.5	2021	Ripped	Tree planting	2x2
All	131.3				

In the tree planted locations, slope grading was carried out where needed. In Borrow Areas G-3 and KM-9, some additional substrate preparation with a discer was carried out where required.

In 2021 and 2022, jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*) were planted at a spacing of 2 m x 2 m in each planting area, equating to an initial density of 2,500 stems/ha.

Table 2-2 provides the estimated number of jack pine and black spruce seedlings planted within each rehabilitation location in 2020. A larger proportion of the black spruce seedlings were planted in EMPA D27(4)-E. That location was characterized as having a mixture of wet, peaty substrates in lower areas (which are more suitable to black spruce than jack pine) and dry, sandy substrates in higher areas. Borrow Area G-3 was characterized with predominantly dry, sandy and clayey substrates. Within each of the locations, the two species were planted as a mixture.

In 2020, overall planting density ranged from 313 to 1,282 stems/ha for black spruce, and 1,720 to 2,542 for jack pine. Planting density for the two species combined was greater than 2,500 stems/ha within both locations.

Table 2-2: Approximate area planted, number of seedlings planted and planting density in 2020, by location

Location	Species	Number of Seedlings[1]	Area Planted[2] (ha)	Overall Density (stems/ha)
Borrow Area G-3	Black spruce	2,100	6.7	313
	Jack pine	41,800	16.4	2,542
EMPA D27(4)-E	Black spruce	26,000	20.3	1,282
	Jack pine	35,600	20.7	1,720
Total	Black spruce	28,100	27.0	1,041
	Jack pine	77,400	37.1	2,084

Notes: [1]Number of seedlings planted provided by Manitoba Hydro. [2]The area planted for Borrow Area G-3 and Excavated Material Placement Area D27(4)-E is based on field data because this information was not available prior to the 2021 surveys.

Data for the number of seedlings planted for each species at locations in 2021 was not available. Based on surveys in 2022, jack pine was planted in all areas except for EMPA D23(1)-E, where only black spruce was planted. The substrate in the areas where jack pine was planted were predominantly dry sandy and clayey mineral. In EMPA D23(1)-E, where black spruce seedlings were planted, the substrate was prepared by spreading a layer of organic material over the surface.

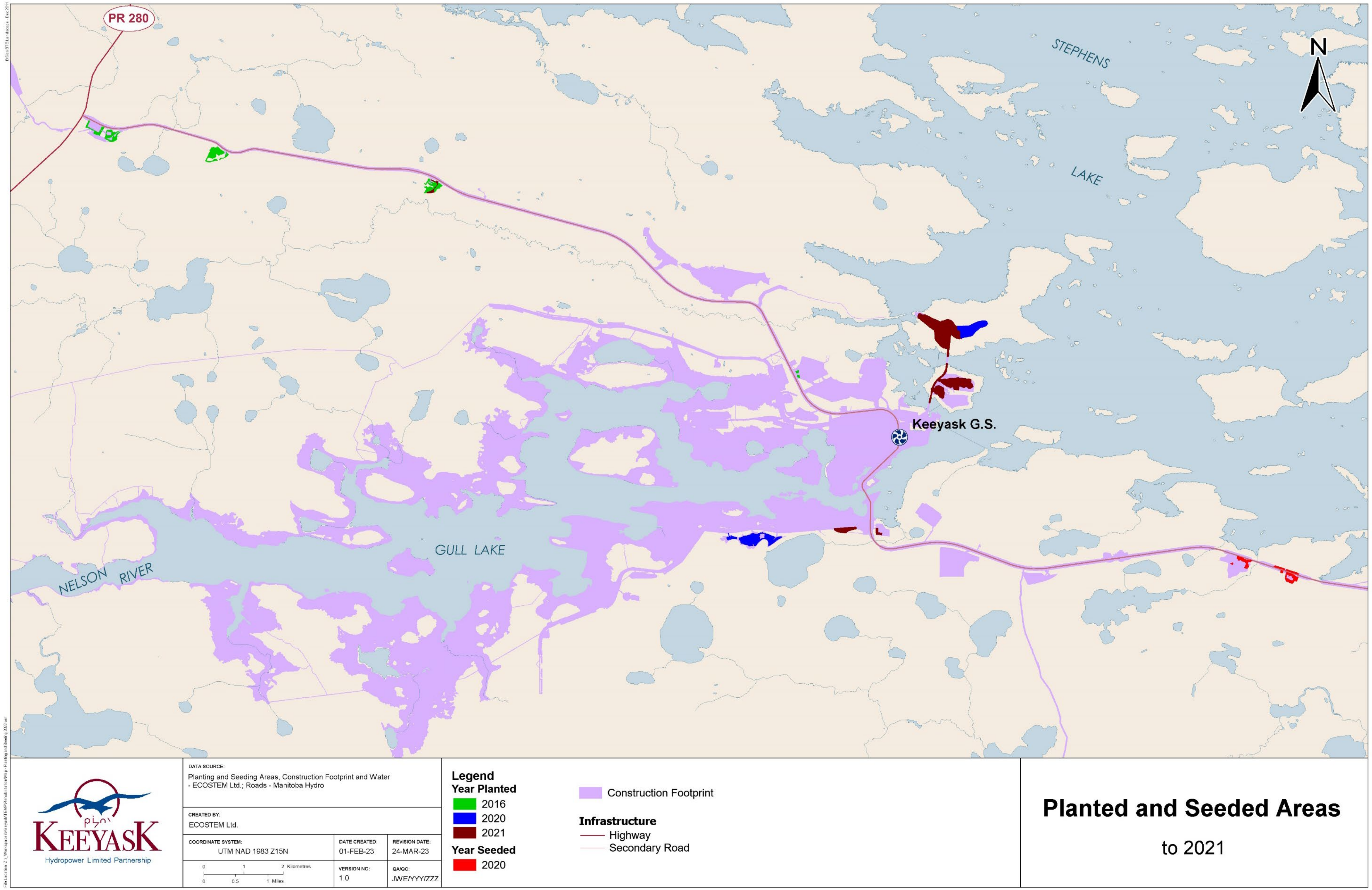
2.4 REMAINING AREAS

In areas not targeted to become a forest or woodland, vegetation regeneration efforts consisted of applying a native grass seed mixture. Some areas along the North Access Road cleared right-of-way (i.e., the road side slopes) were initially hydroseeded in 2013. A large portion of these areas were also broadcast seeded in 2019 and 2020. Portions of the cleared areas along the South Access Road were broadcast seeded in 2016. In 2020, portions of Borrow Areas B-3 and Q-9 were seeded to establish low vegetation under the transmission lines.

In the seeded locations of Borrow Areas B-3 and Q-9, areas were prepared using a harrow attached to a quad. The preparation loosened the surface substrate and created furrows for the seed. Grass species included in the native seed mix are provided in Table 2-3.

Table 2-3: Native grass species included in seed mix for 2020 seeded locations

Species	Common name
Koeleria macrantha	Prairie junegrass
Festuca saximontana	Rocky mountain fescue
Bromus anomalus	Nodding bromegrass
Elymus lanceolatus	Thick-spike wildrye
Elymus canadensis	Canada wildrye
Poa alpina	Alpine bluegrass



Map 2-1: Locations where rehabilitation measures were implemented in 2016, 2020 and 2021.

3.0 METHODS

Section 2.2.2 of the TEMP details the methods for the Habitat Rehabilitation Implementation and Success monitoring study, which commenced in 2017.

The following summarizes the monitoring activities conducted in 2022.

3.1 MONITORING SCHEDULE

The TEMP (Section 2.2.2.3.8; KHLP 2015a) provides the schedule for rehabilitation monitoring. In general, the rehabilitation implementation surveys to confirm survival of plantings and revegetation success start in the year following rehabilitation efforts and continue annually for at least five years. Habitat recovery success surveys generally start two years after rehabilitation of a broad area is complete (e.g., a borrow area).

The frequency and timing of rehabilitation monitoring are fine tuned based on the target habitat type. For example, the monitoring timing for a shrubland and peatland forest habitat are different because the shrubland habitat is expected to regenerate more rapidly. The frequency and timing of rehabilitation monitoring are also determined based on what monitoring has shown to date. For treed habitat types, if several years of monitoring has demonstrated that tree regeneration is much better than the target, then one or two years in the general schedule may be skipped. Alternatively, the starting year for recovery success surveys for a treed habitat type may be deferred if tree regeneration to date has been poor.

3.2 TRAIL BLOCKING AND REHABILITATION

The trails monitored for blocking and rehabilitation were reassessed for evidence of use in 2022 using helicopter photography acquired on August 26 and 31, 2022 to determine if any of the trails should continue to be monitored.

3.3 VEGETATION REGENERATION

3.3.1 ALL TEMPORARY PROJECT AREAS

Vegetation cover in the temporary, terrestrial portions of the Construction Footprint was mapped as of September 2021. A previous monitoring report (ECOSTEM 2022c) details the methods.

Vegetation cover mapping was updated for changes that occurred between September of 2021 and 2022. The data used for these updates included helicopter photography acquired on August

26 and 31, 2022, and ground-level photography collected on September 16, 2022. This mapping focuses on areas where the data indicate substantive changes in vegetation cover or structure, because one year is too short for any major structural changes to occur naturally.

The temporary Project areas along the North and South Access Roads, were subdivided into polygons based on total vegetation cover using the cover classes provided in Table 3-1. Vegetation structure was mapped in the remaining temporary areas using the classes provided in Table 3-2.

Table 3-1: Classes and codes for vegetation structure cover

Cover Class	Code	Cover Range	Interpretation Notes
Barren	B	<10%	Little to no discernable vegetation
Sparse	S	11 - 25%	Discernable vegetation covers less than 25% of the polygon overall
Moderate	M	26 – 75%	Discernable vegetation >25% cover, obvious gaps in cover and bare patches too small to map
High	H	76 – 100%	Very few gaps in cover to apparently continuous cover

Table 3-2: Classes and codes for vegetation structure

Vegetation Structure Type	Code	Description
Forest	F	61% - 100% trees
Forest/ Tall Shrub	F/ TS	61% - 100% trees in upper canopy/ > 25% tall shrubs in lower canopy
Woodland	D	26% - 60% trees
Woodland/ Tall Shrub	D/ TS	26% - 60% trees in upper canopy / > 25% tall shrubs in lower canopy
Sparsely Treed	S	10% - 25% trees
Sparsely Treed/ Tall Shrub	S/ TS	10% - 25% trees in upper canopy / > 25% tall shrubs in lower canopy
Heterogeneous mixture of woodland and sparsely treed	M	Mixture of woodland and sparsely treed
Heterogeneous mixture of woodland and sparsely treed/ Tall Shrub	M/ TS	Mixture of woodland and sparsely treed with TS lower canopy
Tall Shrub	TS	<10% tree cover and > 25% tall shrub cover
Low Shrub and/or Graminoid and/ or Bryoid	L	<10% trees and < 25% tall shrub and > 10% ground cover
Emergent	E	> 25% emergent vegetation cover
Barren	B	< 10% vegetation cover
Unclassified Young Regeneration	R	Burned after 1992, insufficient information to classify into vegetation structure type

3.3.2 SEEDING AREAS

The locations seeded with native grasses in 2020 were initially mapped in late 2021. A previous monitoring report (ECOSTEM 2022c) details the methods.

In 2022, the boundaries mapped in 2021 were confirmed and updated as needed with ground surveys and photography collected on September 16, 2022. Each polygon was assigned a cover class based on the overall percent foliage cover of vegetation (Table 3-3), and a cover type based on the dominant type of vegetation in the polygon (Table 3-4).

Table 3-3: Classes and codes for seeding area vegetation cover

Cover Class	Code	Cover Range	Interpretation Notes
Barren	B	~0%	No discernable vegetation
Sparse	S	<25%	Discernable vegetation covers less than 25% of the polygon overall
Moderate	M	26 – 75%	Discernable vegetation >25% cover, obvious gaps in cover and bare patches too small to map
High	H	76 – 100%	Very few gaps in cover to apparently continuous cover

Table 3-4: Cover type classes and codes

Cover Type	Code	Description
Graminoid	G	Dominant vegetation cover are grasses or sedges
Forb	F	Dominant vegetation cover are broadleaf herbs
Low shrub	LS	Dominant vegetation cover are low shrub species
Tall shrub	TS	Dominant vegetation cover are tall shrub species
Treed	T	Dominant vegetation cover are tree species
Unknown	U	Unknown vegetation cover

3.4 TREE PLANTING AREAS

Monitoring of tree planting areas in 2022 focused on areas planted in 2020 and 2021 (Table 3-5). The previous year's monitoring report (ECOSTEM 2022c) provides the five-year results for areas planted in 2016.

The locations where tree planting occurred were subdivided into planting areas. The planting areas were mapped based on having relatively homogeneous conditions for tree species planted, site preparation, substrate and topographic conditions.

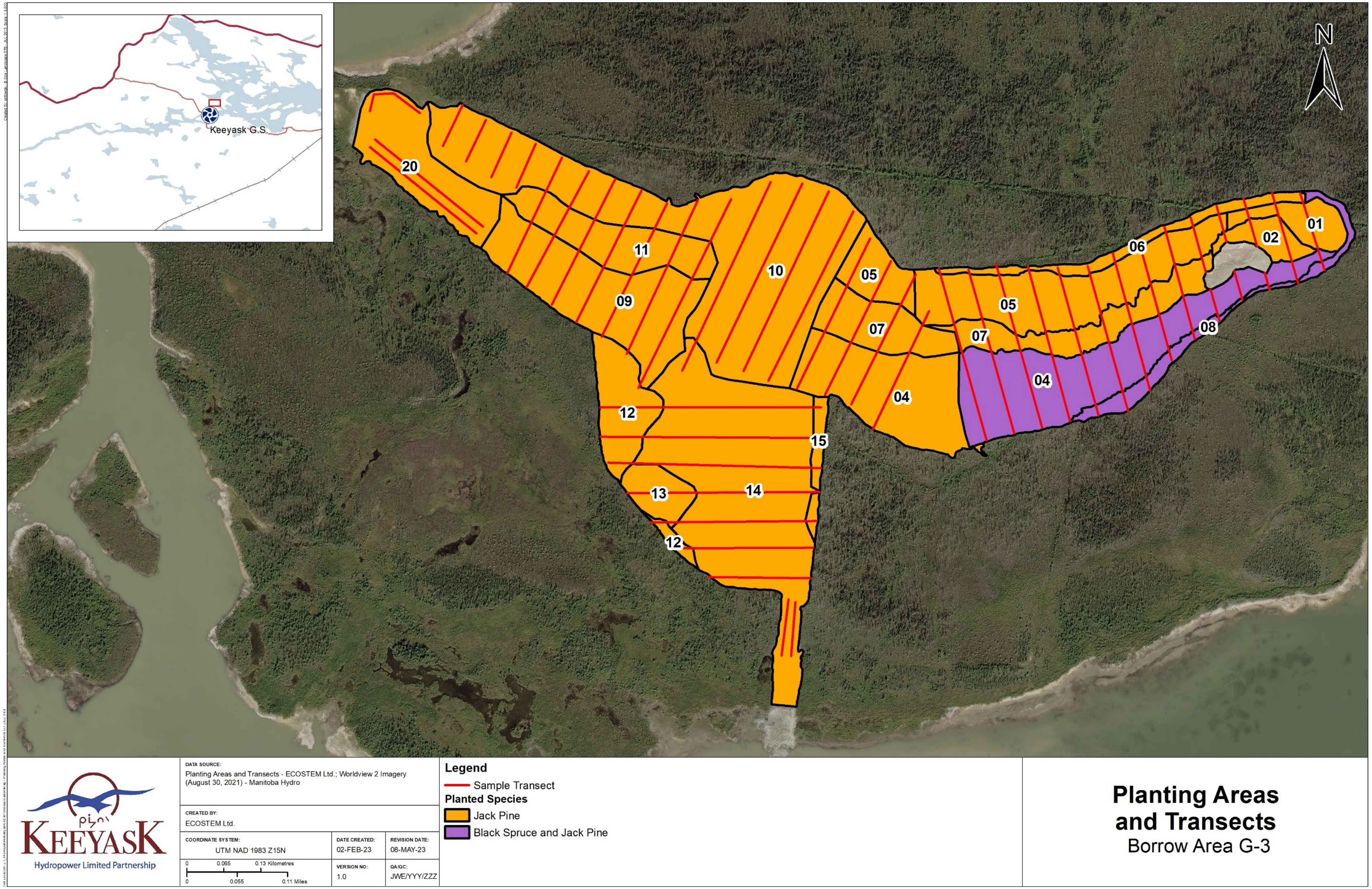
Maps provided by Manitoba Hydro showed the overall extent of planting in the eight rehabilitation locations (i.e., Borrow Area G-3, EMPA D27(4)-E, EMPA D23(1)-E, EMPA D23(2)-E, EMPA D35(1)-E, Borrow Area KM-9, Borrow Area N-5, Haul Road 3-4). To establish planting areas, a botanist conducted a preliminary foot survey of the rehabilitation location and delineated the planting areas on a paper map. Planting areas were delineated based on a combination of surface substrate material, topography (e.g., level, slope, basin), and the species planted. The planting areas were mapped after the 2021 and 2022 field surveys.

Map 3-1 to Map 3-5 show the planting areas for the 2020 and 2021 rehabilitation locations.

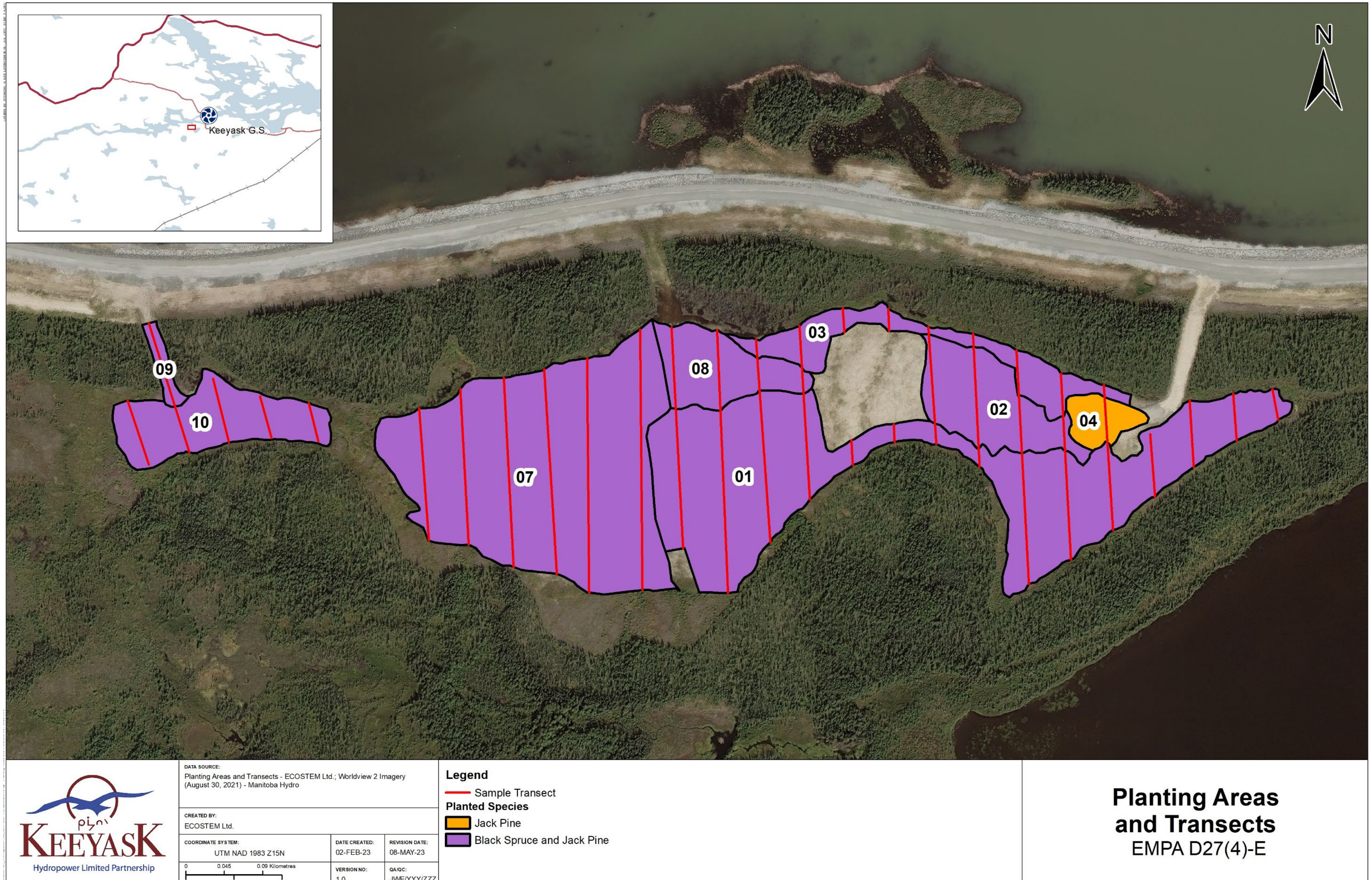
Table 3-5: Species planted, area planted, and number and length of transects surveyed by planting area in 2022 for the 2020 and 2021 rehabilitation locations

Location	Planting Area	Planted Species	Area Planted	Transects Sampled	
				Number	Length (km)
Borrow Area KM-9	22	Jack pine	1.8	5	0.59
Borrow Area G-3	1	Jack pine	1.0	3	0.13
	2	Jack pine	0.8	2	0.13
	4	Both	9.8	18	1.58
	5	Jack pine	5.8	15	1.08
	6	Jack pine	1.1	14	0.19
	7	Jack pine	4.1	14	0.84
	8	Both	1.2	9	0.15
	9	Jack pine	5.0	7	0.91
	10	Both	12.2	15	2.17
	11	Jack pine	2.5	7	0.49
	12	Jack pine	2.1	6	0.30
	13	Jack pine	0.9	2	0.14
	14	Jack pine	10.1	10	1.97
	15	Jack pine	0.5	4	0.06
	20	Jack pine	3.0	3	0.61
Borrow Area N-5	1	Jack pine	13.6	17	1.47
	3	Jack pine	2.8	5	0.11
	4	Jack pine	1.5	3	0.37
Haul Road 3-4	5	Jack pine	4.7	1	0.30
EMPA D35(1)-E	6	Jack pine	6.2	5	1.06
	7	Jack pine	0.3	1	1.02
EMPA D23(2)-E	1	Jack pine	1.4	3	0.07
EMPA D23(1)-E	1	Black spruce	5.5	11	1.02
EMPA D27(4)-E	1	Both	7.1	15	1.41
	2	Both	1.5	4	0.33
	3	Both	1.3	9	0.27
	4	Jack pine	0.4	1	0.05
	7	Both	7.1	6	1.38
	8	Both	1.2	4	0.26
	9	Both	0.2	1	0.11
	10	Both	1.6	5	0.31
All			**118.1**	**225**	**20.86**

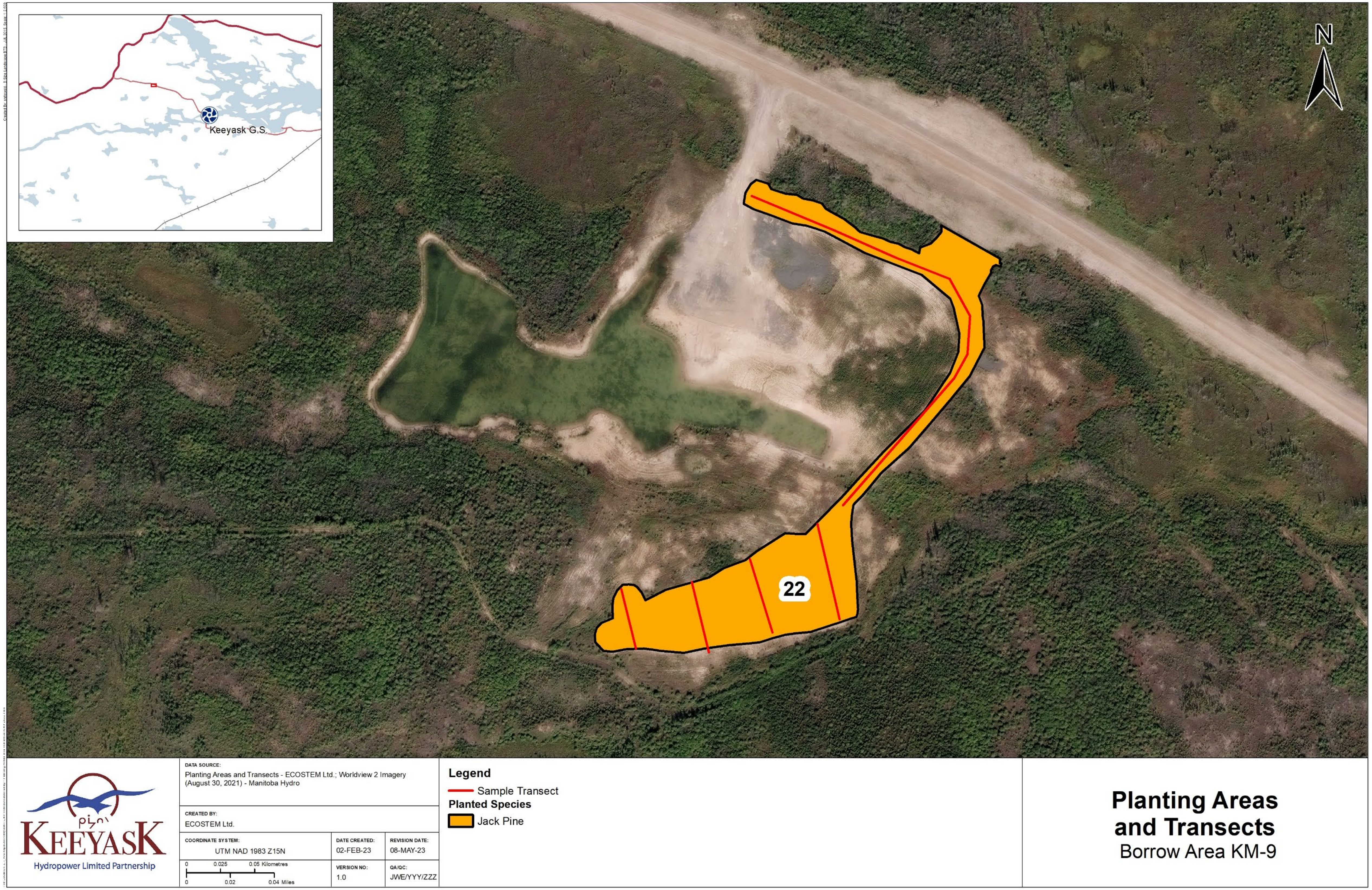
Notes: [1] Actual planted species based on species identified during field surveys not including natural regeneration.
[2] Numbers in a column may not add to the total shown due to rounding.



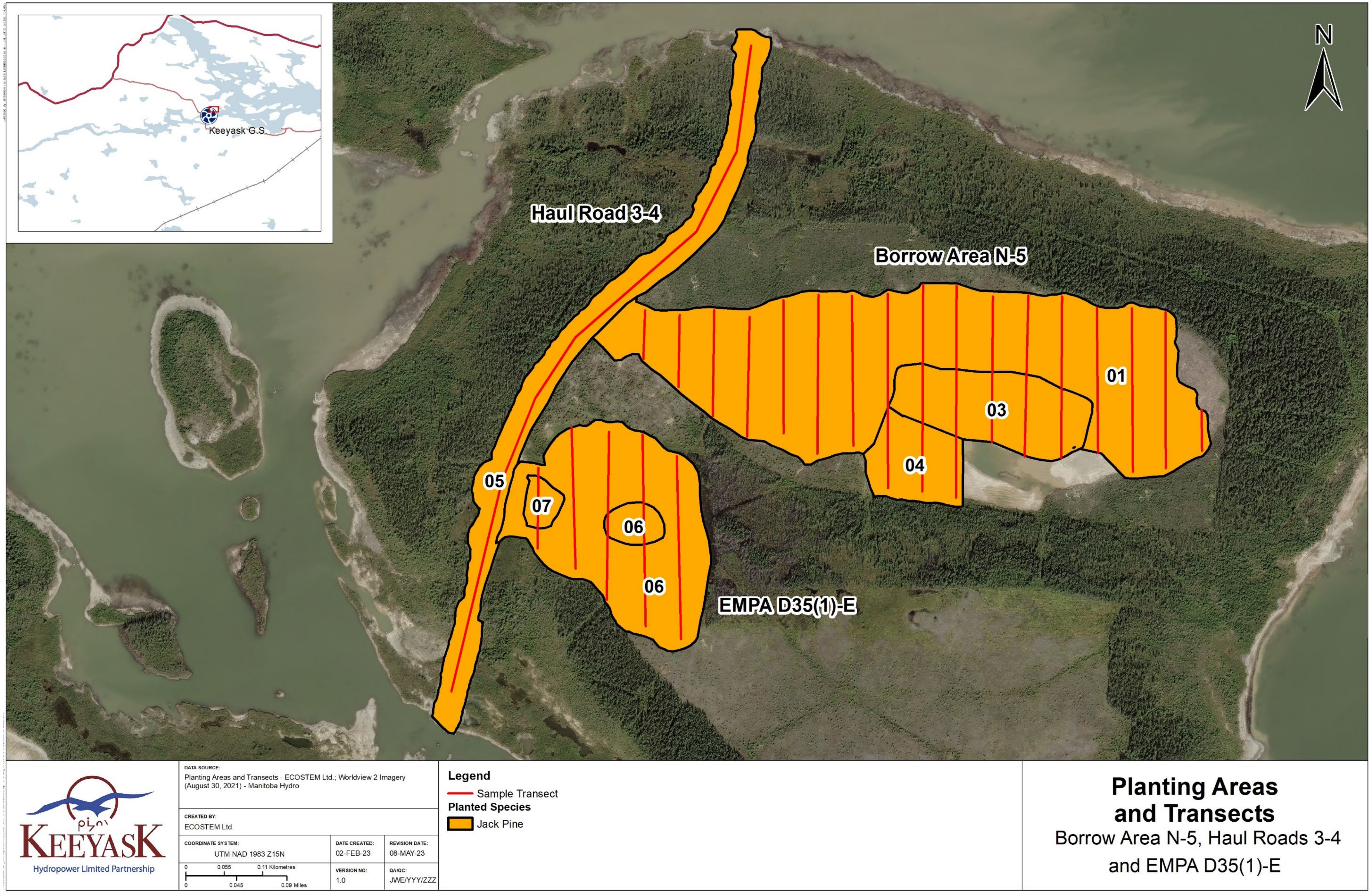
Map 3-1: Locations of the tree planting areas and rehabilitation transects for 2022 sampling in Borrow Area G-3



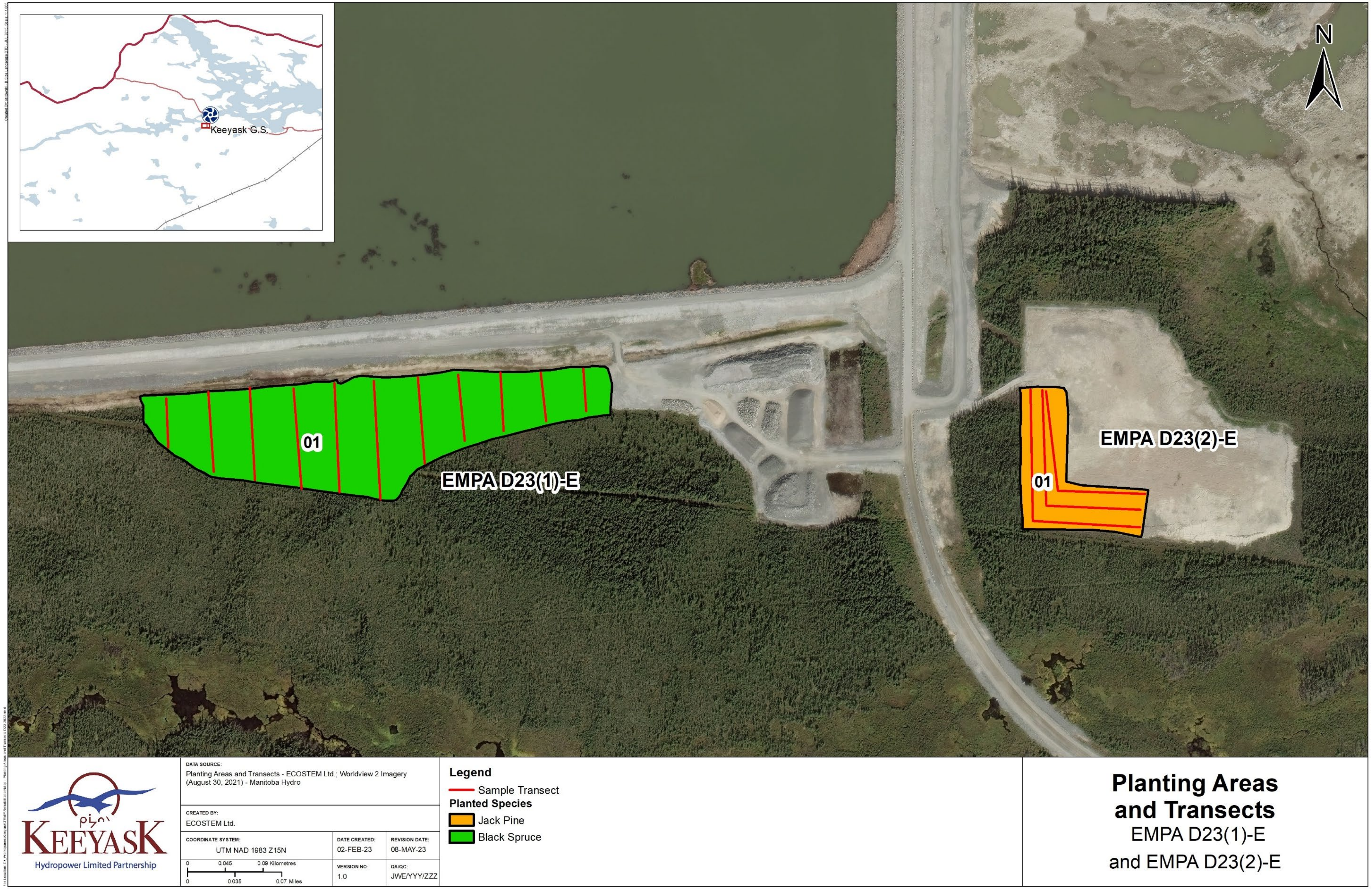
Map 3-2: **Locations of tree planting areas and rehabilitation transects for 2022 sampling in EMPA D27(4)-E**



Map 3-3: Locations of tree planting areas and rehabilitation transects for 2022 sampling at Borrow Area KM-9



Map 3-4: Locations of tree planting areas and rehabilitation transects for 2022 sampling at Borrow Area N-5, Haul Road 3-4 and EMPA D35(1)-E



Map 3-5: Locations of tree planting areas and rehabilitation transects for 2022 sampling at EMPA D23(1)-E and EMPA D23(2)-E

3.5 DATA COLLECTION

Belt transects were established in the general planting areas provided by Manitoba Hydro. All the rehabilitation locations except Borrow Area KM-9, EMPA D23(2)-E, and Haul Roads 3-4 were large and relatively continuous. The transects were spaced approximately 50 meters apart and extended across the narrower axis of the planted areas in both locations. In narrow planting areas (<50 m wide), where 2 or more parallel transects were required, a formula ([mean area width in meters minus 4]/2) was used to determine the spacing. In very narrow planted strips (<16 m wide), a single transect was sampled along the middle of the area. Map 3-1 to Map 3-5 shows the transect locations sampled on September 13 to 16, 2022 in the 2020 and 2021 rehabilitation locations.

Along each transect, the boundaries of the field-mapped planting areas were marked with flagging tape and a GPS waypoint. After the field surveys, transects were subdivided at the mapped planting area boundaries.

In the field, surveyors navigated to each of the pre-determined transects using a handheld GPS (Garmin Map 62 or Map 78). Plastic (PVC) pipes and pin flags were inserted into the ground as markers at the beginning, end, and inflection points of each transect, and at the planting area boundaries, so the same locations could be re-sampled in the future. A waypoint was also recorded at each marker, and at each location that a transect crossed into a new planting area.

Tree regeneration surveys were conducted along a total of 225 belt transects, in 32 distinct planting areas across the eight 2020 to 2021 tree planting rehabilitation locations (Table 3-5).

Live and dead tree species stems were counted within a 1 m wide belt centered on the transect line (Figure 3-1). Information recorded for each stem included species, height class (Table 3-6), vigour class (Table 3-7), natural regeneration class (Table 3-8; Figure 3-2), and damage class (Table 3-9). Vigour class is a semi-quantitative variable, with overall tree condition and health increasing from 0 to 6. Additional notes regarding transect environmental conditions (other regenerating vegetation, and general comments) were recorded. Reference photos were taken at the beginning and end points of each transect, including the start and end of each transect segment within the planting areas.

Table 3-6: Tree height class

Class	Description
Seedling	Trees ≤ 50 cm tall
Sapling	Trees > 50 cm and ≤ 1.3 m tall
Tree	Trees > 1.3 m tall

Table 3-7: Tree vigour class

Class Code	Class Name	Description
0	Older dead	Appears to have been dead for at least one year
1	Dead	Appears to have died within the past year
2	Almost dead	Appears dead except a few needles still green
3	Dead leader	The top of the main stem appears dead
4	Dead lower branches	Most of the lower branches appear dead, but rest of plant appears healthy
5	Mostly living	Mostly healthy; a few dead needles
6	Alive	No signs of mortality

Table 3-8: Natural regeneration class

Class code	Class name
D	Definitely natural regeneration
P	Possibly natural regeneration
N	Not natural regeneration (planted)
U	Could not be determined due to herbivory or some other form of damage

Table 3-9: Damage class

Class code	Class name
M	Mechanical damage
H	Herbivory
E	Undermined or washed over by erosion and/or sediment deposition (Photo 3-1)
N	None

Flagged sampling transect in Borrow Area G-3

Sampling a transect in EMPA 27-4

Figure 3-1: Tree regeneration sampling in 2022

 Naturally regenerating (front) and planted (back) jack pine in Borrow Area G-3	 Mixture of naturally regenerating black spruce and planted jack pine in Borrow Area G-3
 Jack pine planting area in Borrow Area G-3	 Naturally regenerating black spruce in Borrow Area G-3

Figure 3-2: Examples of different types of regeneration observed in planting areas in 2022

Photo 3-1: Recently dead jack pine with erosion damage

3.6 DATA ANALYSIS

3.6.1.1 REHABILITATION IMPLEMENTATION

The estimated actual stem densities from the transect data were compared with the planned planting densities to assess whether the planting was carried out as planned. For each rehabilitation location, transect data were pooled. If trees were planted for more than one planned density in a rehabilitation location, then transects planted at the same density were pooled. Transect data collected the year after planting is used for assessing rehabilitation implementation. Only the planted seedlings, whether living or dead, were considered (i.e., natural regeneration was ignored).

A t-test or a Wilcoxon signed rank test was used to determine if the planned planting stem density was achieved. A one-tailed t-test in R (R Core Team 2022) was used to compare the mean total planted stem densities to the planned stem densities, where the mean was calculated across all transects in the rehab location planted at a specific target density (some locations may be divided into areas with different target densities). To consider the rehabilitation as meeting the planned density, the mean stem density must be significantly greater than the planned stem density minus one (e.g., 10,000 – 1 = 9,999 stems/ha), at $\alpha = 0.05$. A Shapiro-Wilk test was used to check for violations of normality in the transect data. If the assumption of normality was violated, the t-test result was still considered interpretable provided the number of samples (transects) was at least

30. If that criterion was not met, the non-parametric one-sample Wilcoxon signed rank test was used.

3.6.1.2 CHANGES BETWEEN 2021 AND 2022

Live stem density in areas where planting occurred at least two years prior to the current survey year, and with more than one year of data, were analyzed to determine if there was a significant change in live stem density compared to the previous year.

Because slight, unavoidable differences in the transect position can impact the number of stems tallied on a transect, stem density was considered to have changed significantly only if the 95% confidence interval of the current year sample mean stem density differed significantly from that of the previous year. A one-way analysis of variance (ANOVA) in R (R Core Team 2022) was used to compare the transect mean total live stem densities between years for each planting area with at least three transects. Qualitative assessments were made for planting areas with only one or two transects.

4.0 RESULTS

4.1 TRAIL BLOCKING AND REHABILITATION

Monitoring of the 47 trails found no change in vegetation regeneration status or trail blocking measures since 2017. Also, there was no additional Project-related disturbance or clearing in any of the monitored trails.

4.2 VEGETATION REGENERATION

4.2.1 ALL TEMPORARY PROJECT AREAS

The 2022 vegetation cover mapping recorded a small total area of change (2.4 ha) distributed over numerous areas (Table 4-1 and Table 4-2). This represented approximately 0.2% of the 1,138 ha of temporary Project areas mapped for 2021.

In all but one case, the area changes were due to increased vegetation cover that resulted in the vegetation structure changing from Barren cover with no structure type, to either Sparse or Moderate cover with a Low vegetation structure type (Table 4-1 and Table 4-2). These changes occurred at several locations, including the west slopes of EMPA D16, in a portion of Borrow Area B-6, and at several locations in the ditches along the South Access Road (Map 4-1 and Map 4-2).

At one location in Borrow Area G-1 at KM-15, approximately 50 m^2 of vegetation cover changed from Moderate with a Low structure type to Barren (Map 4-1). This was due to low regenerating vegetation being removed during site preparation for habitat rehabilitation activities (Photo 4-1).

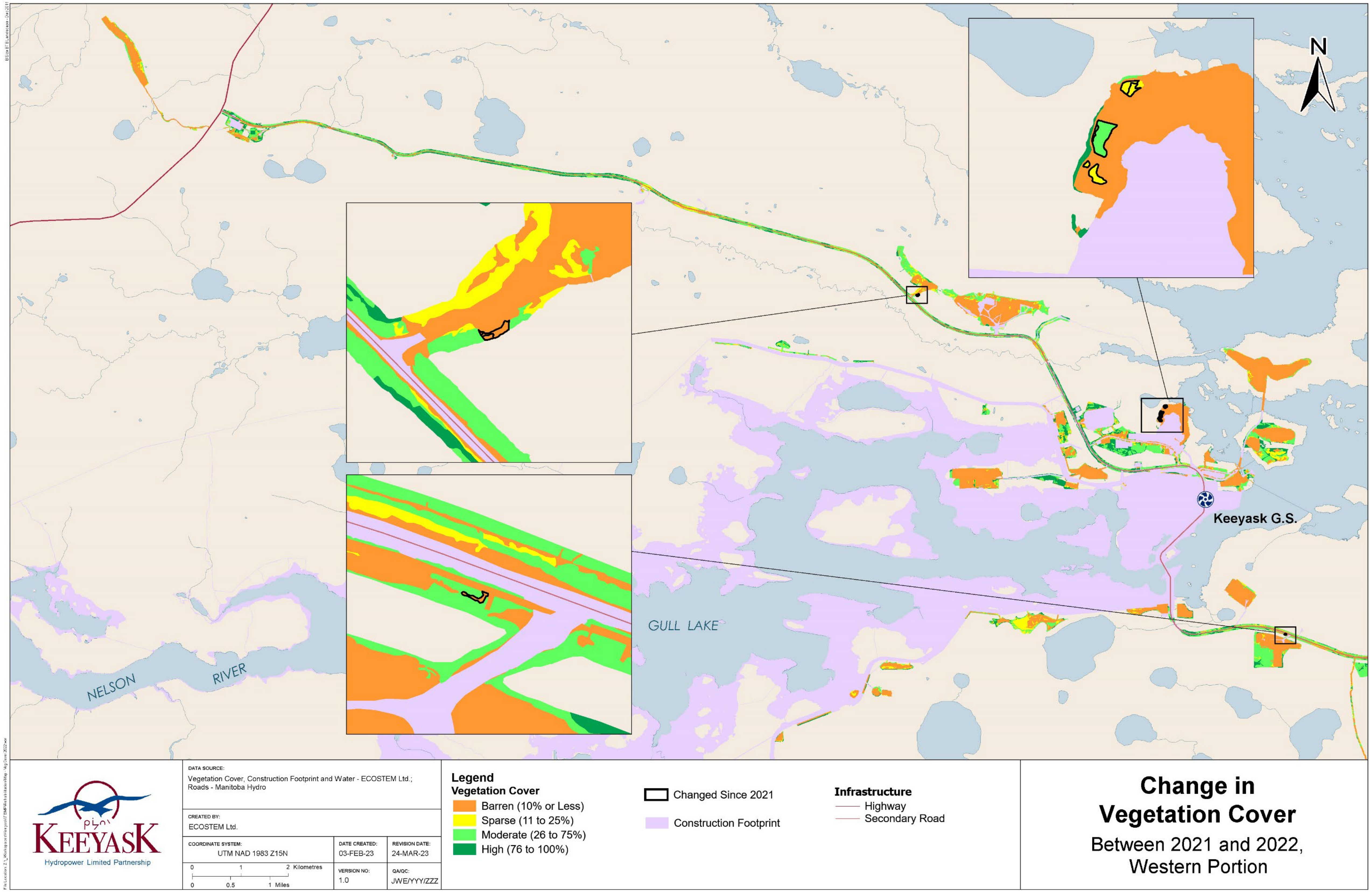
Table 4-1: Vegetation cover in areas where there was a change in vegetation cover since 2021

Footprint Type	Vegetation Cover Class (ha)			Total Area (ha)
	Barren	Sparse	Moderate	
Borrow Area	0.1	0.4	-	0.5
EMPA	-	0.4	0.5	0.8
South Access Road	-	1.1	-	1.1
Total	*0.1*	*1.9*	*0.5*	*2.4*

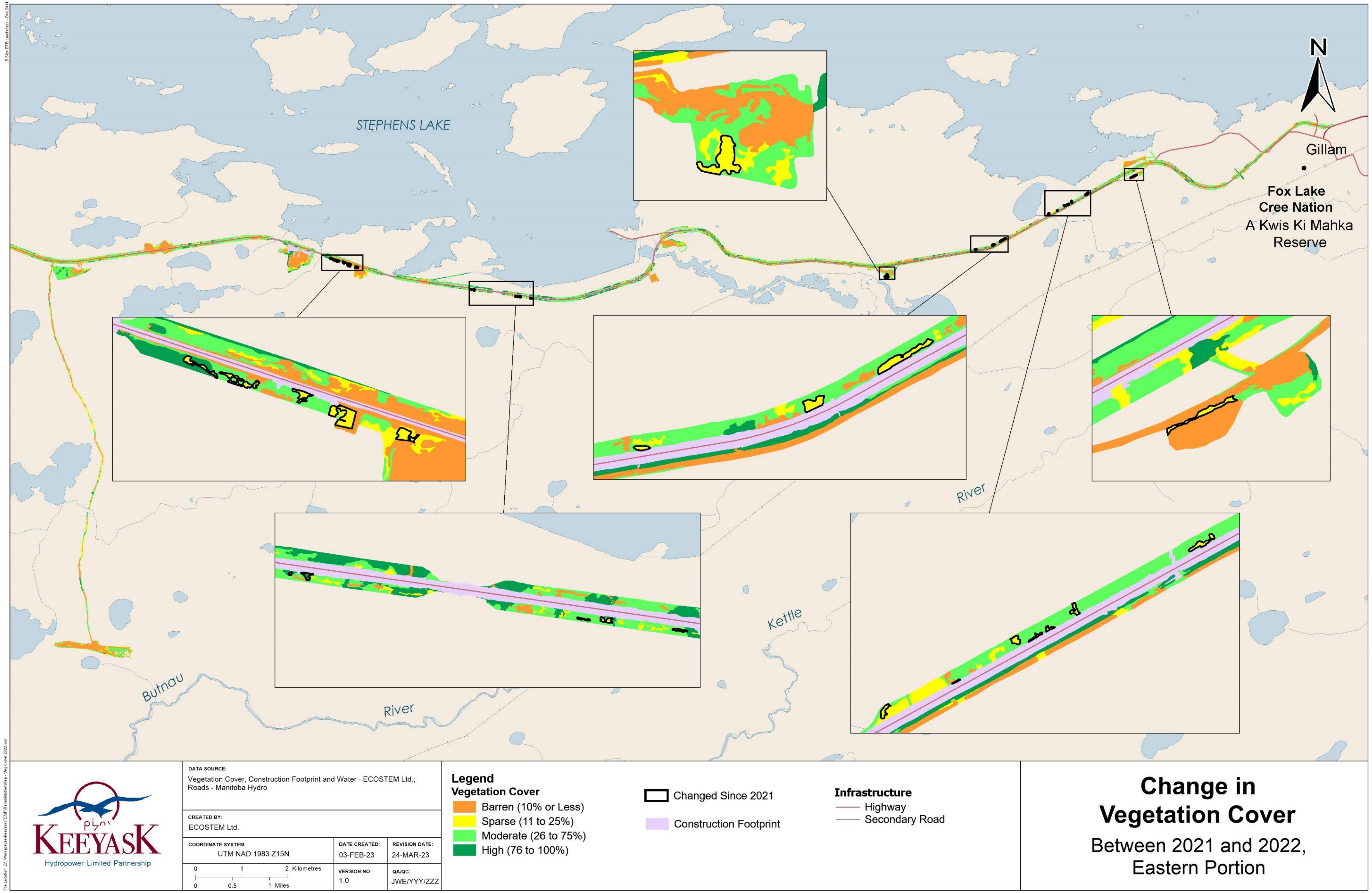
Table 4-2: Vegetation structure type in areas where there was a change in vegetation structure since 2021

Footprint Type	Vegetation Structure Type (ha)		Total Area (ha)
	None	Low	
Borrow Area	0.1	0.4	0.5
EMPA	-	0.8	0.8
South Access Road	-	1.1	1.1
Total	*0.1*	*2.3*	*2.4*

Photo 4-1: Area in Borrow Area G-1 at KM-15 where rehabilitation activities changed vegetation cover and structure



Map 4-1: **Locations where vegetation cover and structure changed between 2021 and 2022 in the western portions of the Construction Footprint as of September 2022**



Map 4-2: Locations where vegetation cover and structure changed between 2021 and 2022 in the eastern portions of the Construction Footprint as of September 2022

4.2.2 SEEDING AREAS

Ground surveys of the areas seeded with native grasses in 2020 found no change in the overall spatial limits of the seeded area (Table 4-3). However, the total vegetated area within these limits increased by 0.07 ha. The increase was entirely in Borrow Area B-3 (Photo 4-2), where vegetation cover increased from 3.88 ha to 3.95 ha (Table 4-3). There was a slight decrease in total vegetated cover in Borrow Area Q-9, from 2.46 to 2.45 ha. Overall, as of September 2022 approximately 55.5% and 63.4% of the seeded area in Borrow Areas B-3 and Q-9 supported sparse to high vegetation cover (Table 4-3).

Table 4-3: Total difference in vegetation cover in the seeding areas after revised mapping for 2022.

Location	Cover Class	Area (ha)		Difference
		2021	2022	
Borrow Area B-3	Barren	3.25	3.17	-0.08
	Sparse	1.38	1.47	0.10
	Moderate	2.50	2.48	-0.02
	Vegetated subtotal	3.88	3.95	0.08
	Location total area	7.12	7.12	0.00
Borrow Area Q-9	Barren	1.40	1.41	0.01
	Sparse	1.17	1.16	-0.01
	Moderate	1.13	1.07	-0.05
	High	0.16	0.22	0.06
	Vegetated subtotal	2.46	2.45	-0.01
	Location total area	3.86	3.86	0.00
All seeded areas		10.99	10.99	0.00

Photo 4-2: Seeded area regeneration in B-3 in September 2022

Vegetation cover class and cover type by seeding area are provided in Table 4-4 and Table 4-5. The overall proportion of types across the seeding areas did not change substantially between 2021 and 2022. Similarly, the cover type did not change in any of the seeding areas. Graminoid-dominated vegetation still formed all the cover in Borrow Area B-3, SA-1, and most of SA-2 in Borrow Area Q-9, with the balance of that area made up of low shrub cover (Table 4-5).

Table 4-4: Vegetation cover class as a percentage of total area in the seeded portions of the 2020 rehabilitation locations as of September, 2022

Location	Seeding Area	Area Seeded (ha)	Percent in Vegetation Cover Class			
			High	Moderate	Sparse	Barren
Borrow Area B-3	1	0.38	-	8.5	34.9	56.6
	2	0.99	-	33.2	24.1	42.6
	3	1.22	-	24.3	17.1	58.6
	4	4.54	-	40.3	19.7	40.1
	Total	7.12	-	34.9	20.7	44.5
Borrow Area Q-9	1	0.21	-	18.1	38.5	43.5
	2	3.66	5.9	28.3	29.6	36.2
	Total	3.86	5.6	27.8	30.0	36.6
All areas		10.99	2.0	32.4	24.0	41.7

Table 4-5: Vegetation cover type as a percentage of total area in the seeded portions of the 2020 rehabilitation locations as of September, 2022

Location	Seeding Area	Vegetated Area (ha)	Percent in Vegetation Cover Type	
			Graminoid	Low Shrub
Borrow Area B-3	1	0.17	100.0	-
	2	0.57	100.0	-
	3	0.50	100.0	-
	4	2.72	100.0	-
	Total	3.95	100.0	-
Borrow Area Q-9	1	0.12	100.0	-
	2	2.33	97.8	2.2
	Total	2.45	97.9	2.1
All Areas		6.40	99.2	0.8

4.3 TREE PLANTING AREAS

4.3.1 PRESCRIPTION IMPLEMENTATION

A Shapiro-Wilk test found that the planted stem densities met the assumption for normality in three of the rehabilitation locations where planting was completed in 2021 (all these locations had fewer than 30 transects) but did not in both Borrow Areas G-3 and N-5 (Table 4-6). For Borrow Area G-3, the t-test results were still used as the total number of transects exceeded 30. For Borrow Area N-5, the nonparametric Wilcoxon signed rank test was used.

Results from the 2022 transect data indicated that at a 95% confidence level, plantings in Borrow Areas G-3 and N-5, and in EMPAs D35(1)-E and D23(2)-E met or exceeded the target density of 2,500 stems/ha (Table 4-6). At 1,117 stems/ha, the estimated planted stem density in EMPA D23(1)-E was significantly lower than the target density. The mean density of stems in the remaining two areas were both above 3,100 stems/ha, but neither was significantly higher than 2,499 stems/ha at $\alpha = 0.05$ (Table 4-6).

Table 4-6: Estimated actual planted stem densities in the rehabilitation locations one year after planting was completed in 2021

Location	Number of Transects[1]	Mean Density (stems/ha)[2]	Standard Deviation
Borrow Area KM-9	**5**	3,145	996
Borrow Area G-3[3]	129	**2,907**	2,189
Borrow Area N-5	25	**3,013**[4]	920
Haul Roads 3-4	1	3,116	-
EMPA D35(1)-E	**6**	**3,186**	553
EMPA D23(2)-E	**3**	**3,812**	448
EMPA D23(1)-E	**11**	*1,117*	559

Notes: [1] Bolded values indicate the data associated with the transects met the assumption of normality. [2] Bolded values indicate mean is significantly greater than 2,499 stems/ha at α = 0.05 using a one-tailed t-test; *Italicized* values indicate mean is significantly less than 2,500 stems/ha at α = 0.05. [3] A portion of Borrow Area G-3 that was planted in 2020 is included in these results to obtain a density for the entire location. [4] Wilcoxon signed rank test used because assumption of normality not met, and number of samples is <30.

4.3.2 TREE REGENERATION STATUS IN 2022

Based on the combined living stem density (includes natural regeneration), Borrow Area G-3 was the only rehabilitation location planted in 2020 and 2021 that had an estimated live stem density in 2022 that was significantly greater than 2,499 stems/ha (Figure 4-1; Table 4-7). Four of the remaining seven rehabilitation locations, including Borrow Areas KM-9 and N-5, and EMPAs D35(1)-E and D23(2)-E, had overall estimated live stem densities higher than 2,500 stems/ha, but the difference was not significant. The live stem density for EMPA D23(1)-E was significantly lower than the target stem density, with an average live stem density of just over 900 stems/ha.

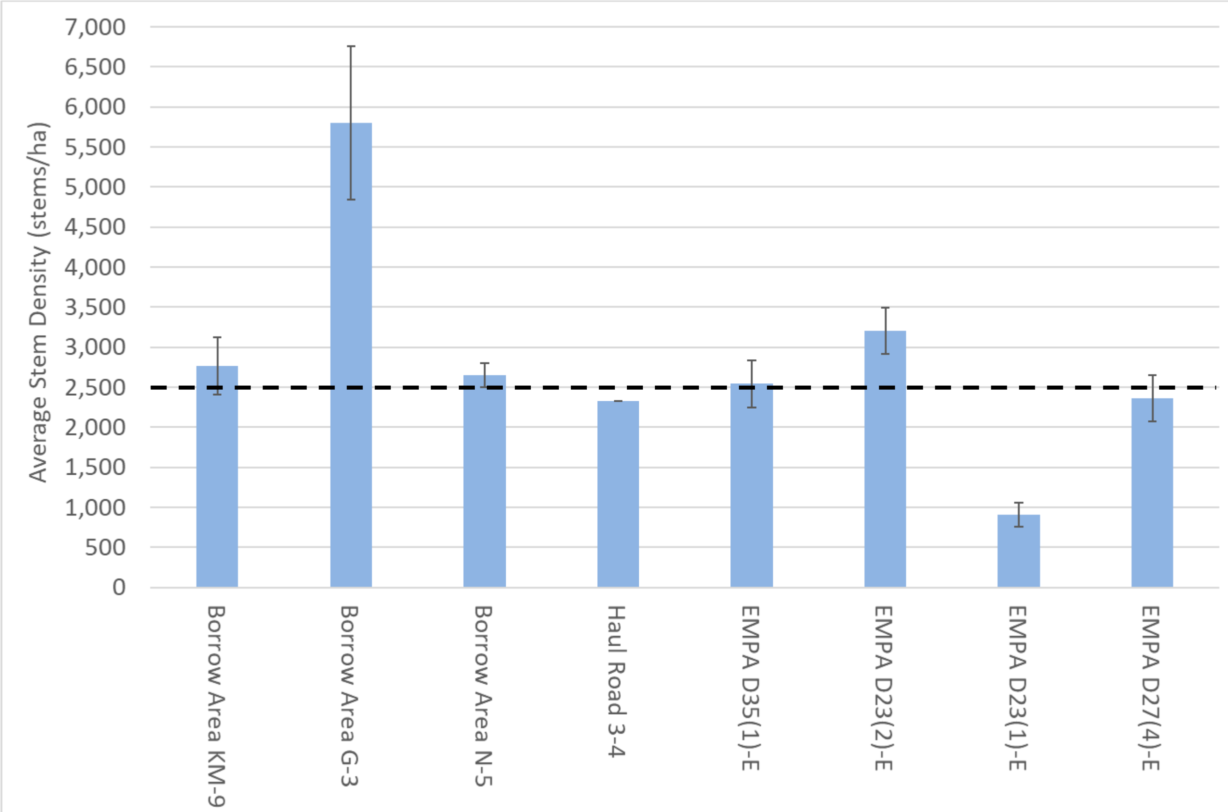


Figure 4-1: Overall live stem density as of 2022 for the rehabilitation locations planted in 2020 and 2021. Error bars represent standard error of the mean, and the dashed line represents the target stem density for a woodland (2,500 stems/ha)

Table 4-7: Estimated live stem densities in the rehabilitation locations planted in 2020 and 2021 as of September 2022

Location	Number of Transects[1]	Mean Density (stems/ha)[2]	Standard Deviation
Borrow Area KM-9	**5**	2,762	804
Borrow Area G-3	129	**5,803**	10,855
Borrow Area N-5	**25**	2,652	753
Haul Road 3-4	1	2,330	-
EMPA D35(1)-E	**6**	2,544	719
EMPA D23(2)-E	**3**	3,204	503
EMPA D23(1)-E	**11**	*907*	490
EMPA D27(4)-E	45	2,362	1,933

Notes: [1] Bolded values indicate the data associated with the transects met the assumption of normality. [2] Bolded values indicate mean is significantly greater than 2,499 stems/ha at α = 0.05 using a one-tailed t-test; *Italicized* values indicate mean is significantly less than 2,500 stems/ha at α = 0.05.

Nineteen of the 32 planting areas treated in 2020 and 2021 had a combined live jack pine and black spruce stem density below 2,500 stems/ha as of September 2022. These planting areas were distributed through all rehabilitation locations except for Borrow Area KM-9 and EMPA D23(2)-E (Table 4-8; Map 4-3).

As of September 2022, live planted and/or naturally regenerating jack pine was present in 31 of the 32 areas planted in 2020 and 2021 (Figure 4-2). The average live stem density for planted and naturally regenerating jack pine in these areas ranged from 41 to 4,425 stems/ha (Table 4-8). The planting areas that had the highest average live jack pine stem densities occurred in Borrow Area G-3 (PA-6, PA-8, and PA-11; Photo 4-3; Table 4-8). The planting areas with the lowest jack pine live stem densities were mostly in EMPA D27(4)-E. Six of the eight planting areas in that location had live jack pine stem densities below 1,000 stems/ha, with only one planting area exceeding 2,500 stems/ha.

Photo 4-3: Jack pine regeneration in a planting area with advanced regeneration in PA-5 in Borrow Area G-3 in 2022

Live planted and/or naturally regenerating black spruce was present in 21 of the 32 areas planted in 2020 and 2021. Live stem densities ranged from 9 to 16,417 stems/ha across the planting areas where black spruce was present (Table 4-8). The highest densities of live black spruce stems occurred in Borrow Area G-3 (PA-6, PA-8, and PA-12), and was almost entirely comprised of natural regeneration. In Borrow Area G-3, planted black spruce was limited to PA-4, PA-8, and PA-10. Planted black spruce was present in all but one of the eight planting areas in EMPA D27(4)-E. The black spruce planting area that had the lowest average live stem density was PA-2 in EMPA D27-4, with a density of 58 stems/ha. In EMPA D23(1)-E, where black spruce was the only species planted, live stem density was 907 stems/ha (Table 4-8).

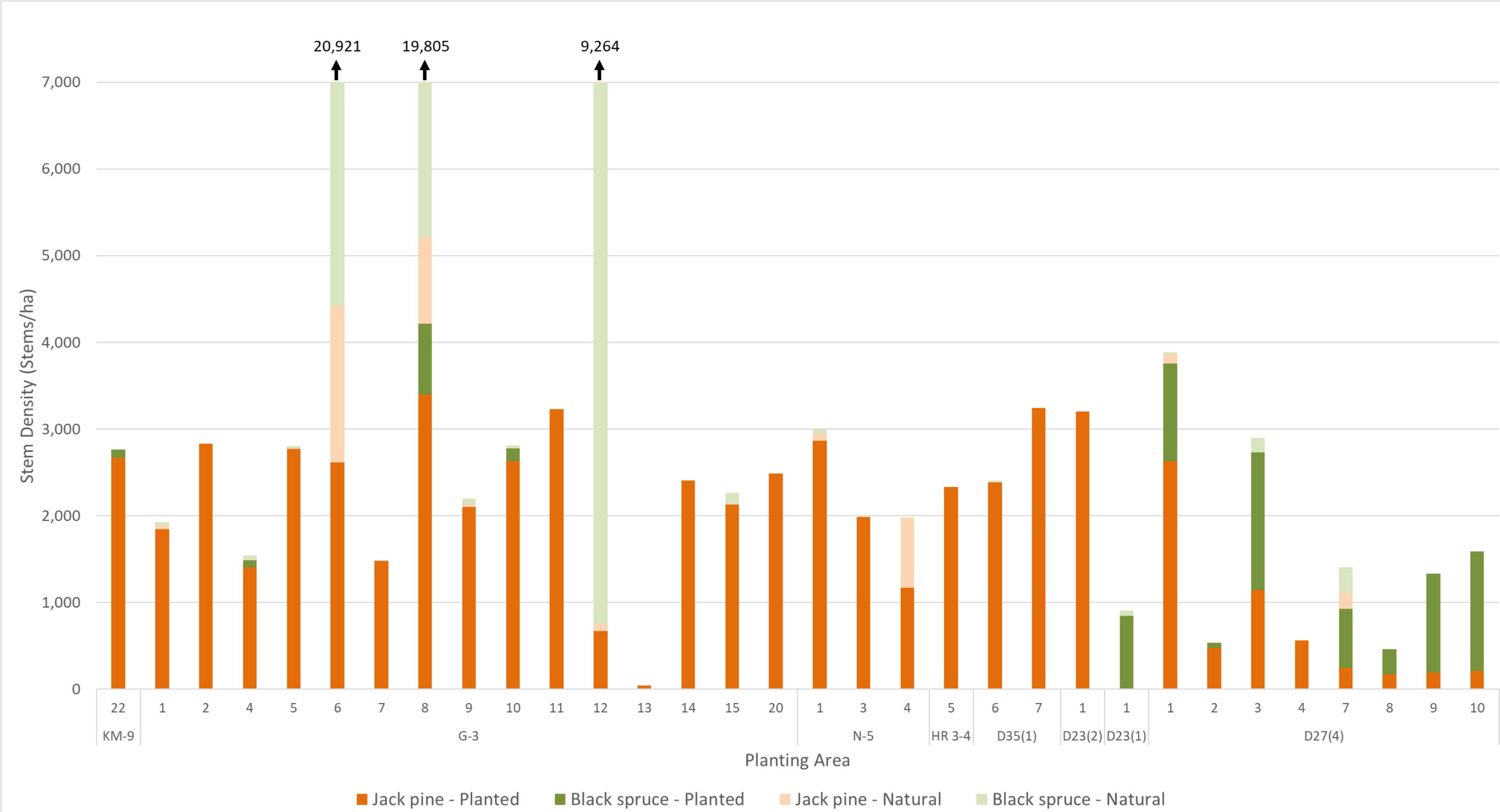


Figure 4-2: Composition of jack pine and black spruce regeneration in the 2020 and 2021 planting areas

Table 4-8: Jack pine and black spruce live stem average density and standard deviation (shown in brackets) as of September 2022 for locations planted in 2020 and 2021, by planting area

Location	Planting Area	Year Planted	Number of Transects	Average Density (stems/ha)	
				Black Spruce	Jack Pine
Borrow Area KM-9	22	2021	5	91 (130)	2,670 (758)
Borrow Area G-3	1	2020	3	39 (67)	1,885 (1,688)
	2	2020	2	-	2,834 (429)
	4	2020, 2021	18	134 (174)	1,412 (574)
	5	2020, 2021	15	26 (102)	2,780 (1,418)
	6	2020	14	16,417 (18,703)	4,425 (4,693)
	7	2020, 2021	14	-	1,482 (1,313)
	8	2020	9	15,416 (15,586)	4,389 (2,908)
	9	2021	7	67 (177)	2,128 (929)
	10	2021	15	183 (614)	2,629 (786)
	11	2021	7	-	3,227 (903)
	12	2021	6	8,507 (11,079)	758 (1,296)
	13	2021	2	-	41 (57)
	14	2021	10	9 (29)	2,407 (488)
	15	2021	4	132 (263)	2,131 (1,801)
	20	2021	3	-	2,487 (1,419)
Borrow Area N-5	1	2021	17	45 (163)	2,932 (573)
	3	2021	5	-	1,986 (605)
	4	2021	3	-	1,922 (488)
Haul Road 3-4	5	2021	1	-	2,330
EMPA D35(1)-E	6	2021	5	16 (22)	2,388 (687)
	7	2021	1	-	3,243
EMPA D23(2)-E	1	2021	3	-	3,204 (503)
EMPA D23(1)-E	1	2021	11	907 (490)	-
EMPA D27(4)-E	1	2020	15	1,151 (1,212)	2,735 (1,999)
	2	2020	4	58 (71)	478 (355)
	3	2020	9	1,755 (1,603)	1,142 (855)
	4	2020	1	-	566
	7	2020	6	967 (256)	383 (170)
	8	2020	4	290 (261)	172 (147)
	9	2020	1	1,143	190
	10	2020	5	1,374 (827)	216 (208)

Natural black spruce and/or jack pine regeneration was present in 16 of the 32 planting areas surveyed (Figure 4-2). Overall, jack pine made up a smaller portion of the naturally regenerating stems than black spruce and occurred in fewer planting areas (11 of the 32) than naturally regenerating black spruce (Table 4-9). Where present, naturally regenerating jack pine comprised from 0.3% to 43.5% of the average live stem density in a planting area. The planting areas with the highest percent of jack pine regeneration were PA-6 and PA-8 in Borrow Area G-3, and PA-7 in EMPA D27(4)-E where naturally regenerated jack pine stems accounted for 43.0%, 24.4% and 33.3% of the live stems, respectively.

Black spruce natural regeneration was present in 15 of the 32 planting areas, and in all rehabilitation locations except Haul Roads 3-4, and EMPAs D35(1)-E and D23(1)-E (Table 4-9). Naturally regenerating black spruce made up most of the black spruce stem density in the Borrow Area G-3 planting areas (Photo 4-4), including those where black spruce was planted. The exception was PA-4, where natural regeneration made up just over one-third of the tallied black spruce stems.

Photo 4-4: Naturally regenerating black spruce growing in Borrow Area G-3 (PA-12) in 2022

Table 4-9: Average percent of live stem density that is from naturally regenerating jack pine and black spruce stems as of September 2022 for areas planted in 2020 and 2021, by species

Location	Planting Area	Year Planted	Number of Transects	Average Percent of Stem Density from Natural Regeneration	
				Black Spruce	Jack Pine
Borrow Area KM-9	22	2021	5	0.0	0.0
Borrow Area G-3	1	2020	3	100.0	1.8
	2	2020	2	-	0.0
	4	2020, 2021	18	36.7	0.3
	5	2020, 2021	15	100.0	0.4
	6	2020	14	100.0	50.2
	7	2020, 2021	14	-	0.0
	8	2020	9	95.2	24.4
	9	2021	7	100.0	0.7
	10	2021	15	52.6	0.0
	11	2021	7	-	0.0
	12	2021	6	100.0	16.7
	13	2021	2	-	0.0
	14	2021	10	100.0	0.0
	15	2021	4	100.0	0.0
	20	2021	3	-	0.0
Borrow Area N-5	1	2021	17	100.0	3.1
	3	2021	5	-	0.0
	4	2021	3	-	33.3
Haul Road 3-4	5	2021	1	-	0.0
EMPA D35(1)-E	6	2021	5	100.0	0.0
	7	2021	1	-	0.0
EMPA D23(2)-E	1	2021	3	-	0.0
EMPA D23(1)-E	1	2021	11	3.9	-
EMPA D27(4)-E	1	2021	15	0.5	3.3
	2	2020	4	0.0	0.0
	3	2020	9	10.7	0.0
	4	2020	1	-	0.0
	7	2020	6	38.5	33.3
	8	2020	4	0.0	0.0
	9	2020	1	0.0	0.0
	10	2020	5	0.0	0.0

Notes: "-" indicates that the species was not tallied in the planting area, values of "0" indicate the species was present, but none were naturally regenerating.

Pooling all planted stems tallied in 2022 for each rehabilitation location, overall mortality (Photo 4-5) was highest in Borrow Area G-3, with 30.0% of tallied stems dead (Figure 4-3). This was followed by Haul Roads 3-4 (25.2%) and EMPA 27(4)-E (23.2%). Mortality was lowest overall in EMPA D23(2)-E (14.9%).

Photo 4-5: Recently dead jack pine (vigour 1) in Borrow Area G-3 in 2022

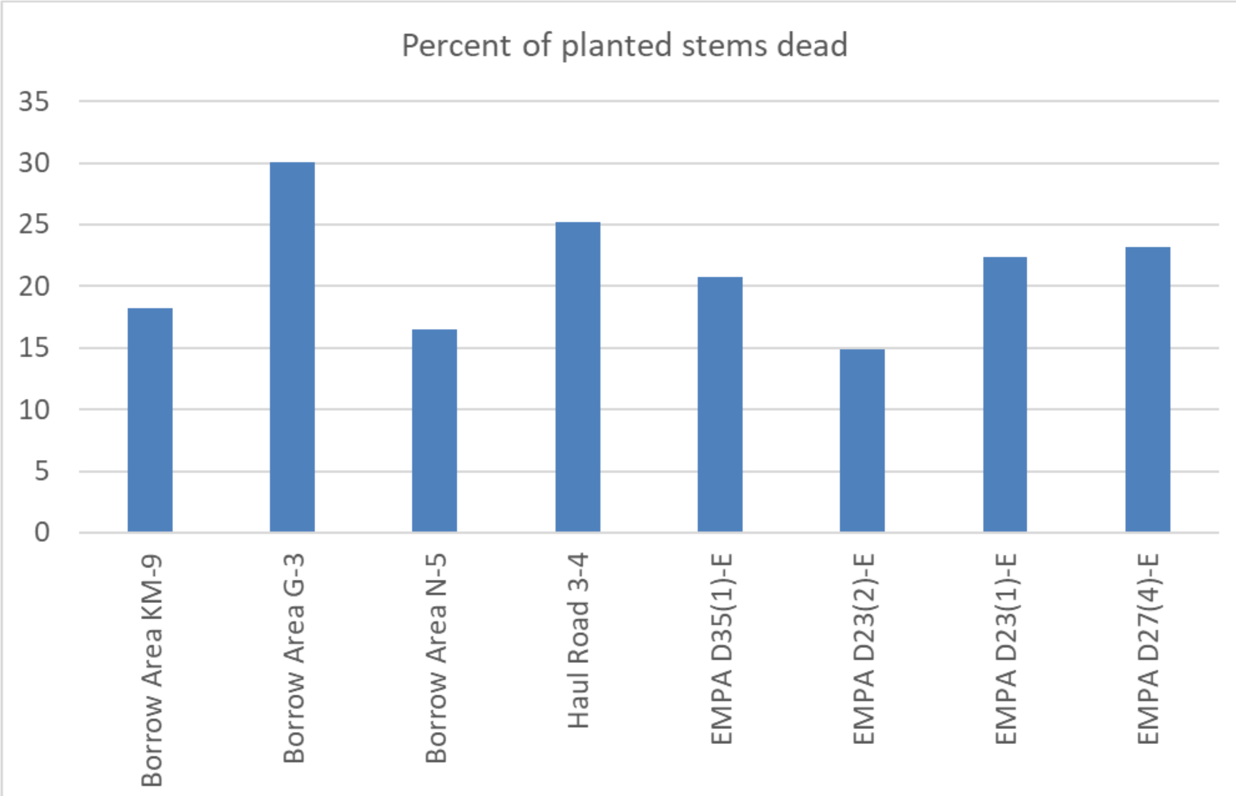


Figure 4-3: Percent of tallied planted jack pine and black spruce stems that were dead in 2022, for all planting areas pooled by rehabilitation location

Planted jack pine mortality by planting area ranged from 0% to 80% (Table 4-10; Map 4-4). While Planting Area 13 in Borrow Area G-3 had the highest percent mortality, this was based on only five tallied jack pine stems for the planting area. Planting Area 2 in EMPA D27(4)-E had the next highest mortality at 72.7%, followed by PA-12, PA-4, PA-20 and PA-9 in Borrow Area G-3, and PA-7 and PA-10 in EMPA D27(4)-E, all of which had more than 40% planted stem mortality for jack pine. The planting areas with the lowest planted jack pine stem mortality were in PA-5, PA-11 and PA-15 of Borrow Area G-3, and PA-4 and PA-8 of EMPA D27(4)-E, all of which had less than 10% mortality (Table 4-10).

For planted black spruce, the highest stem mortality occurred in PA-2 of EMPA D27(4)-E (50%), but this was based on only 4 tallied stems (Table 4-10). The single planting area in EMPA D23(1)-E had 22.3% stem mortality overall. The planting areas with the lowest mortality were PA-4 and PA-8 in Borrow Area G-3, and PA-8 in EMPA D27(4)-E, where all tallied stems were alive.

Table 4-10: Planted black spruce and jack pine percent stem mortality by planting area for 2020 and 2021 rehabilitation locations as of September 2022

Location	Planting Area	Percent of Planted Stem Mortality	
		Black Spruce	Jack Pine
Borrow Area KM-9	22	-	18.5
Borrow Area G-3	1	-	0.0
	2	-	15.9
	4	0.0	48.3
	5	-	10.0
	6	-	0.0
	7	-	16.1
	8	0.0	0.0
	9	-	42.6
	10	25.0	35.4
	12	-	9.2
	13	-	65.0
	15	-	80.0
	11	-	25.4
	14	-	9.1
	20	-	45.0
Borrow Area N-5	1	-	11.9
	3	-	37.7
	4	-	17.5
Haul Road 3-4	5	-	25.2
EMPA D35(1)-E	6	-	22.4
	7	-	0.0
EMPA D23(2)-E	1	-	14.9
EMPA D23(1)-E	1	22.3	-
EMPA D27(4)-E	1	9.3	17.5
	2	50.0	72.7
	3	16.3	22.5
	4	-	0.0
	7	16.1	41.1
	8	0.0	0.0
	9	14.3	60.0
	10	22.0	46.2

Notes: "-" indicates that the species was not tallied in the planting area, values of "0" indicate the species was present, but no stems were dead.

Vigour class was variable for live jack pine stems in the planting areas (Map 4-5). In general, planting areas where average vigour was less than 4 was dominated by stems with poorer condition and health (Photo 4-6), more often having a dead leader (Photo 4-7), or only a few living branches or needles (Photo 4-8). The lowest average vigour class for living stems was 3.5, in Haul Road 3-4 (Table 4-11). Average jack pine vigour was less than 4 in the single planting area in EMPA D35(2)-E, and all the remaining rehabilitation locations had at least one planting area with an average living jack pine vigour below 4.

Average vigour class for live black spruce stems was at least 4 in all planting areas, except for the one planting area in EMPA D23(1)-E (Table 4-11). For black spruce, average vigour was above 5 (mostly healthy) in 15 of the 21 planting areas where live stems were present (Photo 4-9).

Photo 4-6: Area with poor jack pine condition (red leaves, vigour 0-4) in Borrow Area N-5 (PA-1) in 2022

Photo 4-7: Jack pine with dead leader and few living leaves (vigour 3, close to 2) in Borrow Area G-3 in 2022

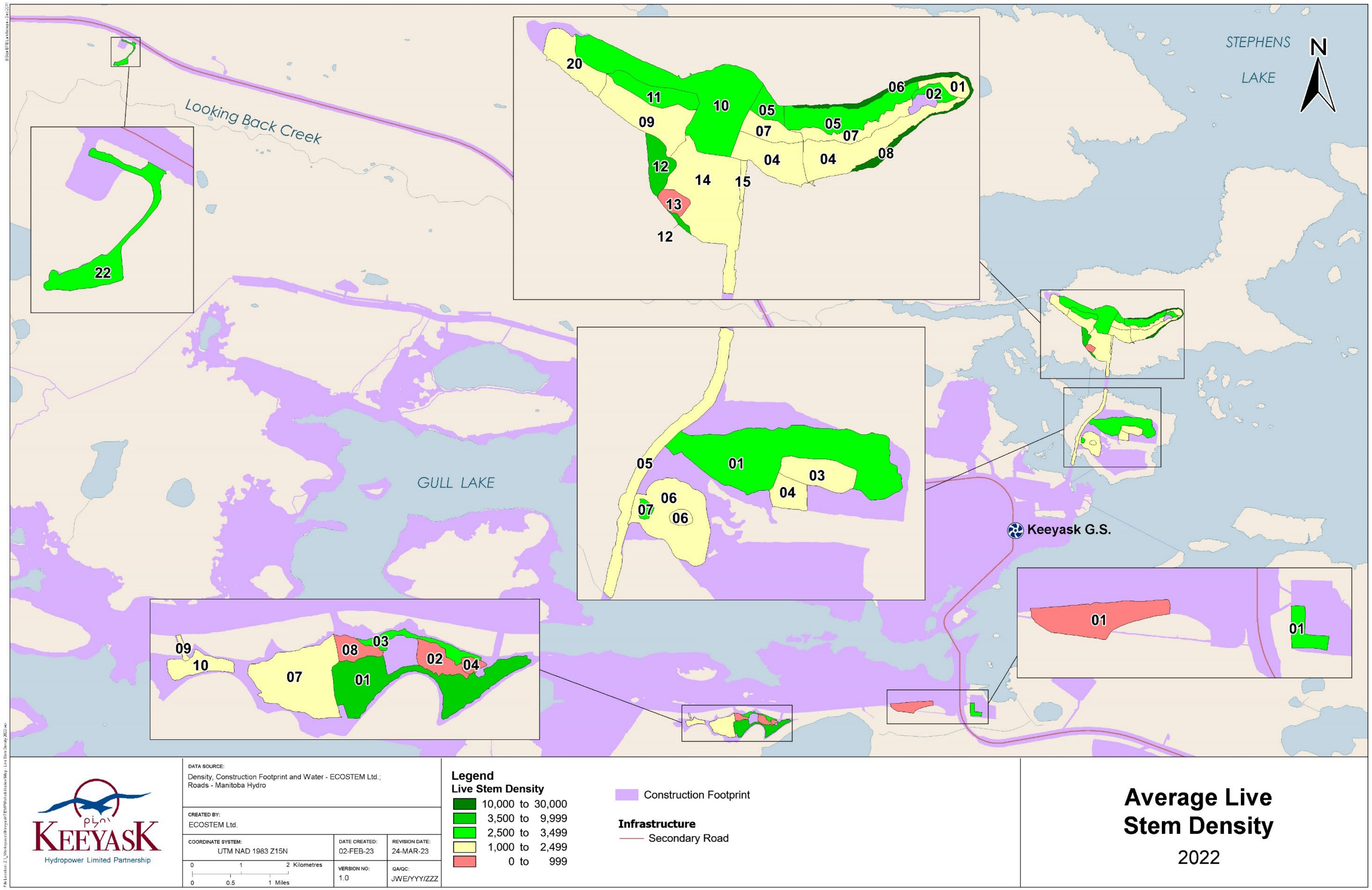
Photo 4-8: Jack pine, vigour 2, only 2 or 3 leaves still green in Borrow Area G-3 in 2022

Photo 4-9: Black spruce vigour 5 or 6 (yellow arrow) and dead jack pine (vigour 1) in 2022

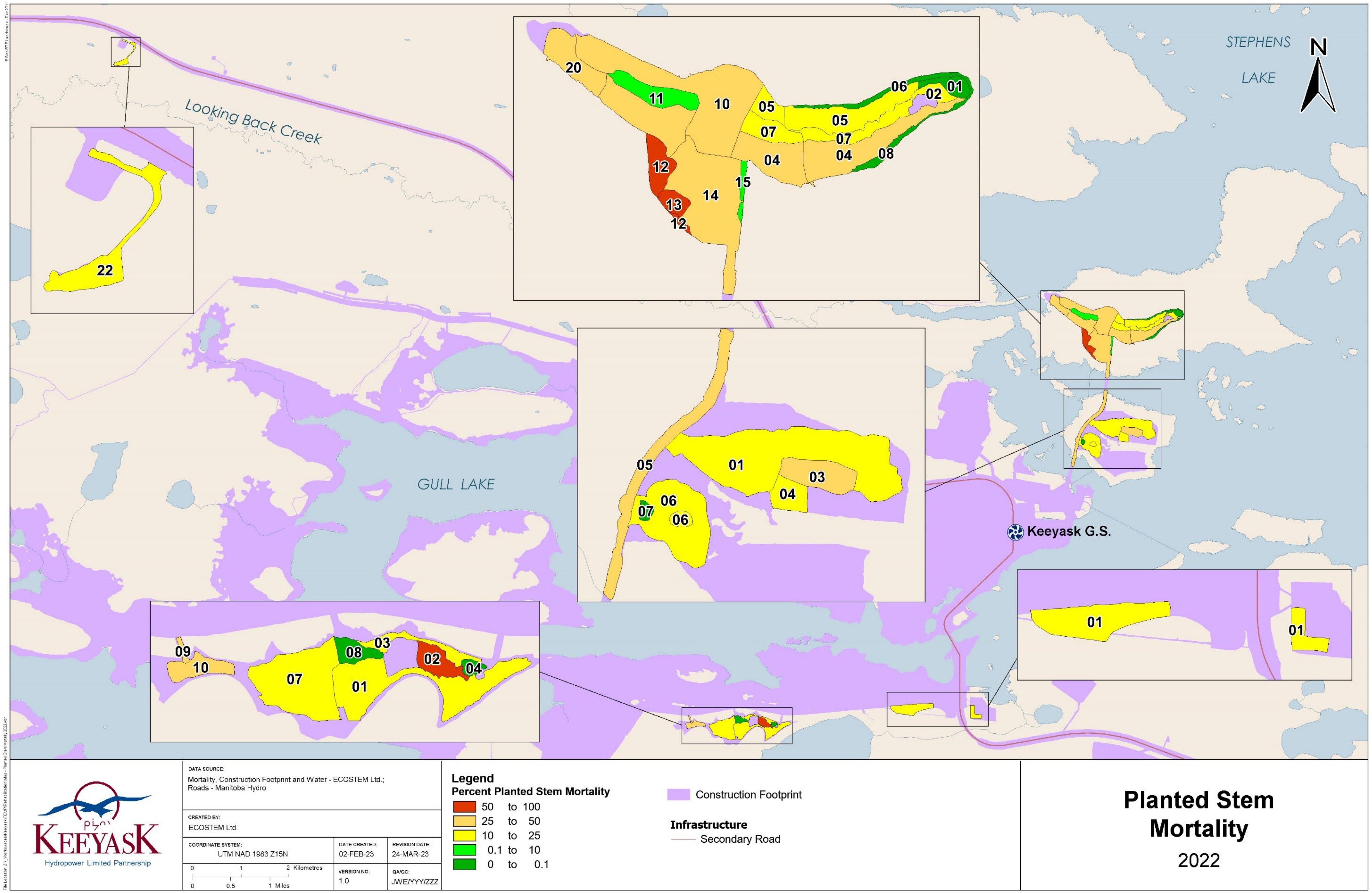
Table 4-11: Average vigour class of living stems by planting area for 2020 and 2021 rehabilitation locations as of September 2022

Location	Planting Area	Average Vigour of Living Stems		
		Jack Pine	Black Spruce	Both
Borrow Area KM-9	22	3.9	5.7	3.9
Borrow Area G-3	1	5.3	6.0	5.3
	2	3.9	-	3.9
	4	4.1	5.2	4.2
	5	4.7	6.0	4.7
	6	5.8	6.0	6.0
	7	3.8	-	3.8
	8	5.8	6.0	6.0
	9	4.1	6.0	4.2
	10	4.1	4.6	4.1
	11	4.0	-	4.0
	12	5.3	6.0	6.0
	13	5.0	-	5.0
	14	3.6	6.0	3.6
	15	5.8	6.0	5.8
	20	3.8	-	3.8
Borrow Area N-5	1	4.1	6.0	4.1
	3	3.8	-	3.8
	4	4.4	-	4.4
Haul Road 3-4	5	3.5	-	3.5
EMPA D35(1)-E	6	3.9	5.5	3.9
	7	3.9	-	3.9
EMPA D23(2)-E	1	3.8	-	3.8
EMPA D23(1)-E	1	-	3.8	3.8
EMPA D27(4)-E	1	5.4	5.2	5.3
	2	3.8	4.5	3.9
	3	4.2	5.1	4.7
	4	3.7	-	3.7
	7	4.3	4.8	4.6
	8	4.7	4.7	4.7
	9	4.5	4.6	4.6
	10	5.1	4.0	4.2

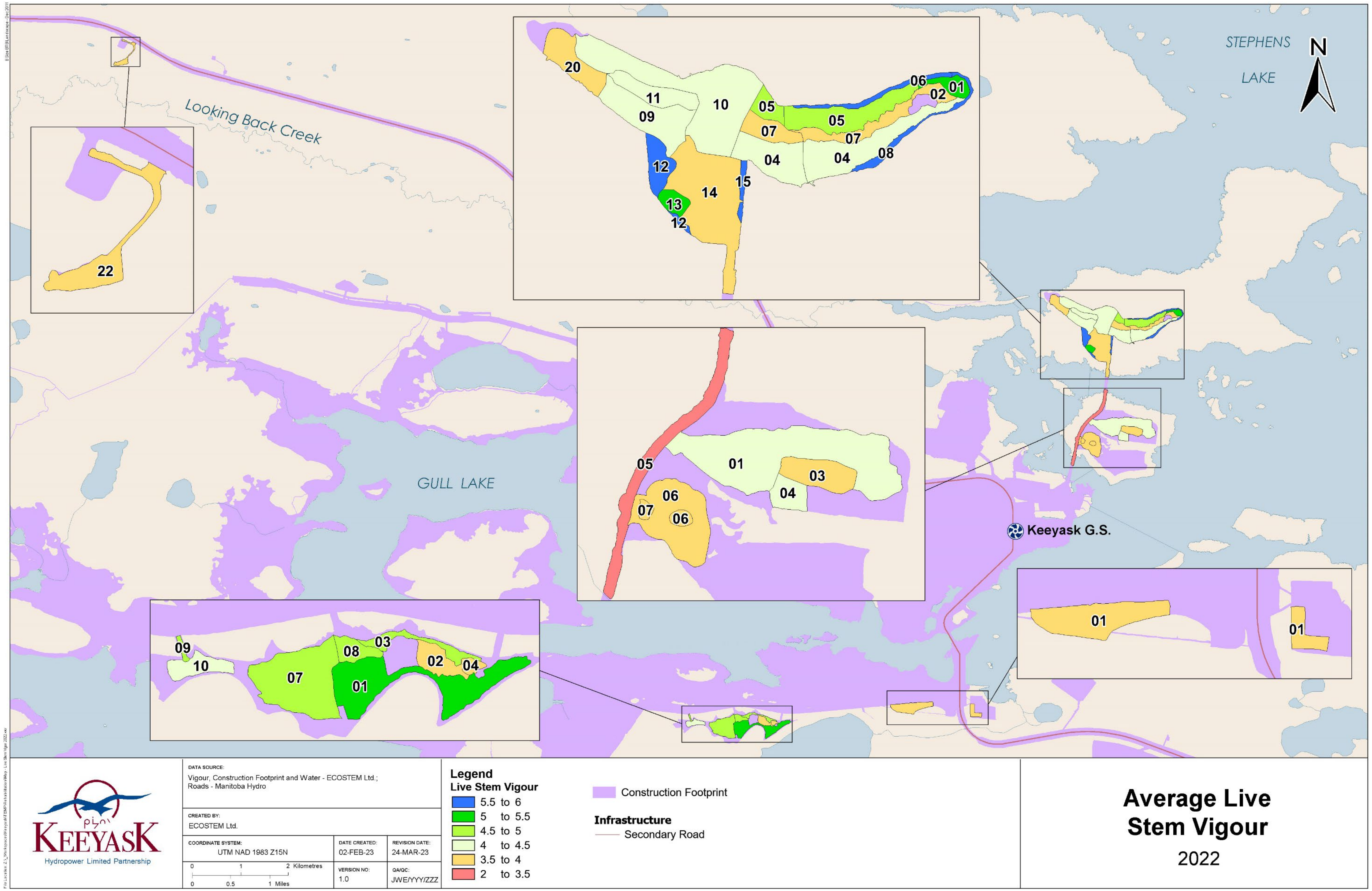
Notes: "-" indicates that the species was not tallied in the planting area.



Map 4-3: Average total live stem density for areas planted in 2020 and 2021 as of September 2022



Map 4-4: **Percent stem mortality of planted stems for areas planted in 2020 and 2021 as of September 2022**



Map 4-5: Average live stem vigour for areas planted in 2020 and 2021 as of September 2022

4.3.3 CHANGES BETWEEN 2021 AND 2022

For areas planted in 2020, average live stem density differed to varying degrees for the planting areas when comparing data from the 2021 and 2022 surveys. Based on an ANOVA, average live stem density significantly differed for a single planting area, PA-4 in Borrow Area G-3 (Figure 4-4). In this planting area there was a statistically significant 48% decrease in live stem density between 2021 and 2022.

Of the two planted species, only jack pine had a significant decrease in live stem density (in PA-4 in Borrow Area G-3; Table 4-12). There was no significant between-year difference in average live jack pine density for any of the other 2020 planting areas. Similarly, there was no significant change in average live black spruce density for any of the 2020 planting areas (Table 4-13).

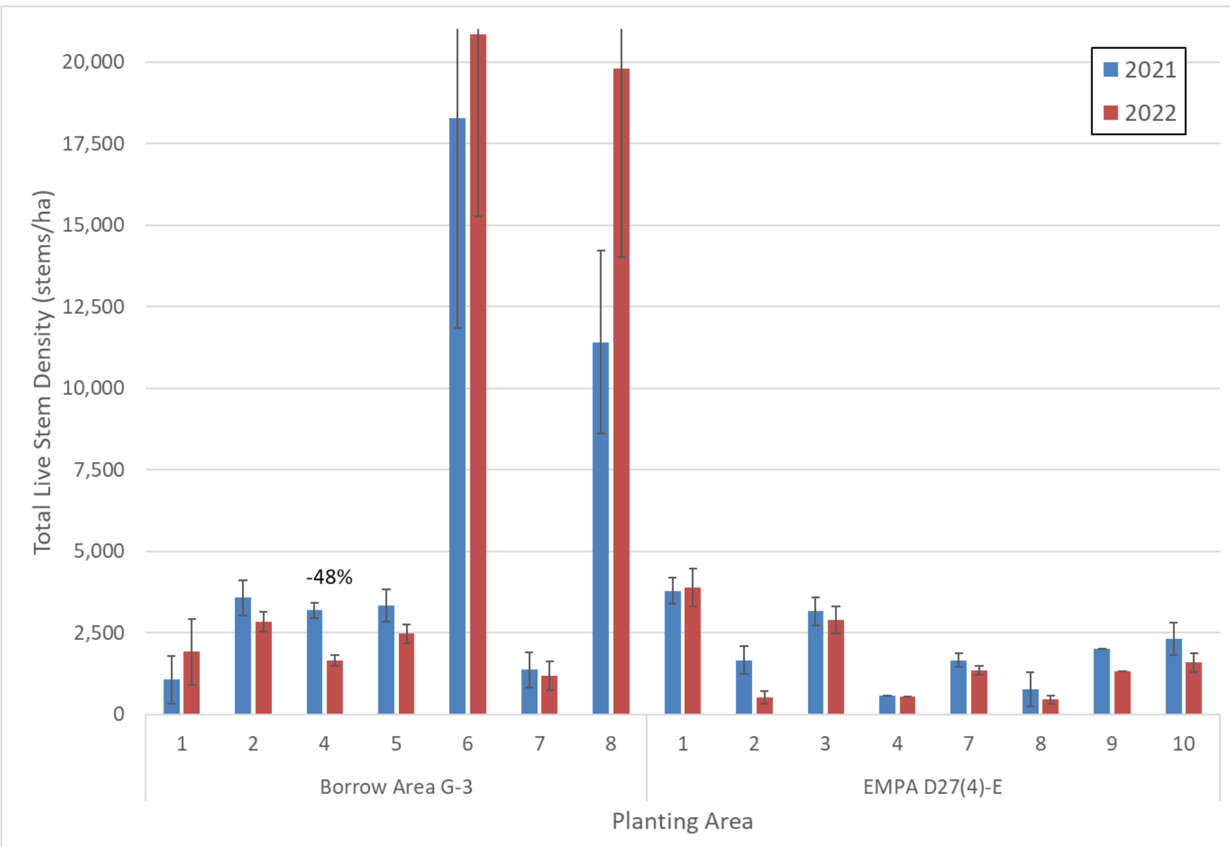


Figure 4-4: Total live stem density and standard error of the mean for 2020 planting areas in 2021 and 2022

Table 4-12: Total live jack pine stem density comparison and significant[1] percent change (shown in brackets) between 2021 and 2022 for areas planted in 2020

Location	Planting Area	Number of Transects	Average Density (stems/ha)	
			2021	2022
Borrow Area G-3	1	3	1,066	1,885
	2	2	3,583	2,834
	4	14	2,998	1,506 (-50%)
	5	11	3,267	2,444
	6	14	2,765	4,425
	7	10	1,368	1,187
	8	9	3,928	4,389
EMPA D27(4)-E	1	15	2,658	2,735
	2	4	1,581	478
	3	9	1,643	1,142
	4	1	577	566
	7	6	654	383
	8	4	323	172
	9	1	769	190
	10	5	415	216

Notes: [1] Significance of change based on analysis of variance (α = 0.05).

Table 4-13: Total live black spruce stem density comparison and significant[1] percent change (shown in brackets) between 2021 and 2022 for areas planted in 2020

Location	Planting Area	Number of Transects	Average Density (stems/ha)	
			2021	2022
Borrow Area G-3	1	3	-	39
	2	2	-	-
	4	14	193	149
	5	11	64	36
	6	14	15,509	16,417
	7	10	-	-
	8	9	7,487	15,416
EMPA D27(4)-E	1	15	1,134	1,151
	2	4	83	58
	3	9	1,522	1,755
	4	1	-	-
	7	6	1,009	967
	8	4	452	290
	9	1	1,250	1,143
	10	5	1,913	1,374

Notes: [1] Significance of change based on analysis of variance (α = 0.05).

5.0 DISCUSSION

5.1 TRAIL BLOCKING AND REHABILITATION

The 2022 trail blocking and rehabilitation monitoring found that most of the trails continued to be obscured by vegetation naturally regenerating after the 2013 wildfire (which was not caused by the Project), and showed no signs of recent use. Natural regeneration has removed the need for these trails to be blocked by other means.

5.2 VEGETATION REGENERATION

5.2.1 ALL TEMPORARY PROJECT AREAS

As expected, there were only very minor changes in vegetation cover and structure in the temporary Project areas since 2021, with 0.2% of the mapped area changing.

The single change from vegetated to non-vegetated cover was in a small, localized area that underwent site preparation for tree planting. As such, this change to non-vegetated cover is expected to be temporary, and it will eventually support a targeted vegetation cover.

It is anticipated that other portions of the temporary Project areas that have been naturally regenerating during construction may temporarily be reverted to non-vegetated cover as site preparation for habitat rehabilitation takes place.

Overall, the small increase in vegetation cover since 2021 is positive, as previously barren patches along the SAR and in other Project areas were revegetating naturally.

5.2.2 SEEDED AREAS

The 2021 and 2022 mapping for the areas seeded in 2020 are not directly comparable. The 2022 mapping was updated using an information source (foot surveys) not available in 2021. As a result, it is uncertain as to whether the differences in vegetation cover are due to actual changes in vegetation cover, or due to more accurate cover mapping in 2022. If there are actual differences, they appear to be minor. It is possible that the larger differences, particularly the decrease in barren cover and increase in sparse cover are at least partially due to actual increases in vegetation cover. This progression was observed elsewhere in the temporary Project areas (Section 5.2.1).

Importantly, there was no evidence indicating that there was a decrease in vegetation cover between 2021 and 2022.

From 36% to 59% of each of the seeding areas was still barren (i.e., cover<10%) in 2022. Substrate conditions were thought to be a contributor to the degree of revegetation to date. Monitoring for the Wuskwatim Generation Project (ECOSTEM 2017) found that grass revegetation was slow on dry, compact substrates, or coarse, rapidly drained soils. Portions of the two locations seeded in 2020 had similar substrates to these, and as such are expected to establish over several years.

Further assessment of the seeded areas and other portions of the temporary Project Footprint, including substrate conditions for the Vegetation Rehabilitation Plan, will help to understand reasons for varying revegetation success. Monitoring of seeded locations will continue in 2023.

5.3 TREE PLANTING AREAS

5.3.1 PRESCRIPTION IMPLEMENTATION

The reasons why the estimated planted stem density in EMPA D23(1)-E (1,117 stems/ha) was far below the target density of 2,500 stems/ha are uncertain. It is possible that the planted stem density was underestimated to some degree due to some stems being overlooked during the surveys. This rehabilitation area had higher cover of naturally regenerating herbaceous vegetation (Photo 5-1). If some trees died soon after planting, then their remnants may not have been visible during the following year’s survey.

In general, estimated planting densities could be underestimated for any of the rehabilitation locations. Planting density results rely on dead stems being present, or detectable one year after planting. Herbivory, or erosion may have removed a portion of the stems between planting and the time of the surveys (Photo 5-2). However, there was no evidence that this was a major factor in most of the planting areas.

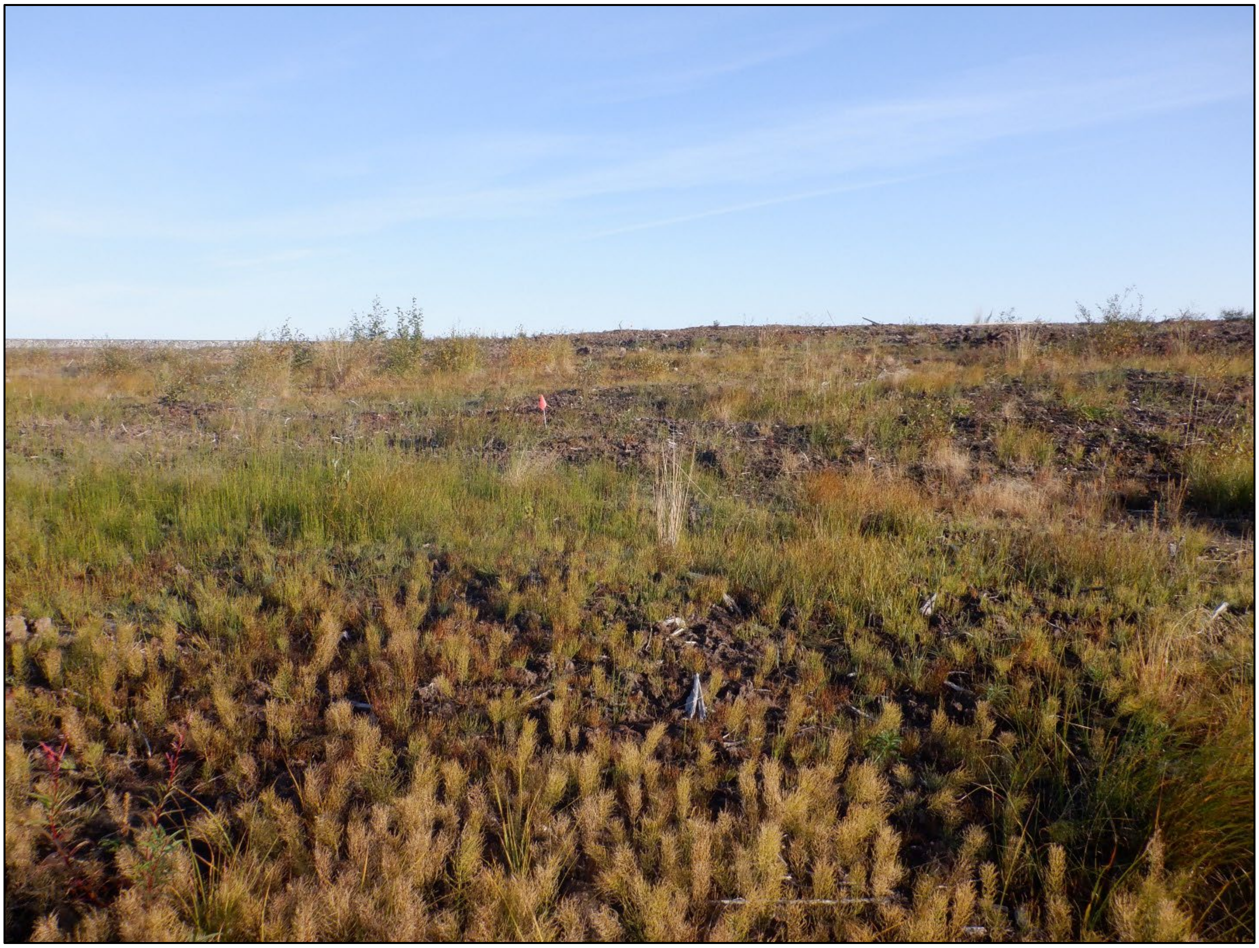


Photo 5-1: Naturally regenerating vegetation on EMPA D23(1)-E

Photo 5-2: Jack pine seedlings growing near erosion channels in Borrow Area G-3

5.3.2 TREE REGENERATION STATUS IN 2022

Only one of the eight rehabilitation locations planted in 2020 and 2021 had a live stem density that met or exceeded the target of 2,500 stems/ha for a woodland as of 2022 at the 95% confidence level.

The obvious reasons for the low live stem density were a combination of low planting density combined with early stem mortality. Estimated planting density appeared to be lower than the target density for four of these rehabilitation locations. Planted jack pine stem mortality exceeded one-third of the planted stems in one-third (10 of 31) of the planting areas. Black spruce stem mortality exceeded 10% of planted stems in most of the areas planted with that species.

The reasons for the high levels of planted stem mortality were uncertain. Some of the possible contributing factors were unsuitable substrates, environmental stresses, or poor planting techniques. Future monitoring as well as data collected to develop the target habitat types for the Vegetation Rehabilitation Plan may narrow down the possible causes.

Natural regeneration (predominantly black spruce) made substantial contributions to live stem densities in some planting areas. However, this was mostly in planting areas adjacent to uncleared forest and where there was minimal ground cover and substrate disturbance. It is likely that natural regeneration will continue to increase total stem densities in these areas. However, it was uncertain if natural regeneration will significantly contribute to stem densities in the portions of planting areas where the ground cover and surface substrate were removed.

Two factors appeared to have contributed to higher living stem vigour in a planting area. Higher vigour and high levels of natural regeneration tended to coincide in planting areas. This combinations suggests that soil conditions are favorable for tree growth. Another contributor was having a substrate where the mineral and organic material had been mixed during site preparation. Some of the areas with higher stem vigour (PA-5 in Borrow Area G-3 and PA-3, 7 and 8 in EMPA D27(4)-E) were noted to be a composite of mineral and organic material during preliminary surveys. With one exception, planting areas with poor vigour generally had coarse mineral, rocky, and/or compacted mineral substrates based on preliminary surveys.

The exception was the planting area in EMPA D23(1)-E. While this area had organic material spread on the surface, the seedlings were generally in poor condition. However, it appeared that the organic material was spread on the surface but not mixed with the underlying mineral. Surveys for developing the target habitat types for the Vegetation Rehabilitation Plan will confirm substrate conditions in the areas planted.

Monitoring has shown that additional tree planting will likely be required in some of the areas if substantial new natural regeneration does not occur. This conclusion is based on a combination of low live stem densities, high rates of stem morality and low vigour, and the potential for a continuing decline in stem density (low average live stem density along with poorer average vigour can be an indicator for future mortality).

Supplemental planting is needed for the EMPA D23(1)-E planting area. This is based on the current live stem density being far lower than the target density for a woodland.

It is too soon to determine other areas requiring additional tree planting. When the boundaries of the temporary Project areas are ultimately delineated, portions of the provisionally defined planting areas may be removed because they are needed for operation. Also, portions of the temporary Project areas will not be planted because they often have standing water or have other conditions that are unsuitable for supporting woodland or forest habitat. Removal of such areas will increase the average stem density for the overall planting area. Once target habitat types are developed for the temporary Project footprint, an assessment of the areas already planted can be made to determine which areas require supplemental planting or additional site treatments.

6.0 SUMMARY AND CONCLUSIONS

Terrestrial habitat rehabilitation mitigates adverse Project effects on terrestrial habitat, ecosystems and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits. Terrestrial habitat will be rehabilitated in areas not required for Project operation and in some permanent Project areas (e.g., access road side slopes). Some of the planned rehabilitation addresses potential adverse Project effects on intactness by blocking or hindering access from Project areas to surrounding areas.

Monitoring of trail blocking and habitat regeneration in 2022 found that the status of that trails were physically blocked was unchanged. For the remaining trails, natural regeneration following the 2013 wildfire (which was not caused by the Project) has obscured the trails and removed the need for these trails to be blocked by other means.

Evaluation of overall revegetation in the temporary Project areas in 2022 found that there was very little change in vegetation cover and structure since 2021. Only 0.2% of the mapped temporary Project areas changed, and most of this change was due to an increase in vegetation cover in previously barren areas. It is expected that natural regeneration will continue to decrease the non-vegetated cover in many portions of the temporary Project footprint.

For the areas seeded with grasses in 2020, updated mapping found that the total seeded area did not change. While the 2022 mapping is not directly comparable to the 2021 mapping, it suggests that overall vegetation cover in the 2020 seeding areas has increased since 2021. However, from 36% to 59% of the seeding areas across both rehabilitation locations remained barren (i.e., vegetation cover < 10%).

In 2022, tree regeneration surveys were conducted in rehabilitation locations that were planted in 2020 and 2021. These locations included EMPA D27(4)-E (planted in 2020), Borrow Area G-3 (planted in 2020 and 2021), Borrow Areas KM-9 and N-5, Haul Roads 3-4, and EMPAs D35(1)-E, D23(1)-E, and D23(2)-E (planted in 2021). In both years, jack pine and black spruce trees were intended to be planted at a spacing of 2 m x 2 m in all planting areas.

For the locations planted in 2021, monitoring found that the estimated planted stem density met or exceeded the target stem density for four of the seven locations (95% confidence level; monitoring in 2021 found that EMPA D27(4)-E also did not meet the planting target). As of September 2022, live stem density (including natural regeneration) for one (Borrow Area G-3) out of the eight locations met or exceeded the target stem density.

Planted jack pine stem mortality ranged from 0% to 80% depending on the planting area, while planted black spruce stem mortality ranged from 0% to 50%. Overall mortality was highest in Borrow Area G-3.

Live tree stem vigour also varied depending on the planting area. Lower average vigour appeared to correspond with planting areas that were noted to have coarse or rocky mineral and/or compacted substrates. Higher vigour tended to correspond to areas where the substrates were mineral and organic materials that had been mixed during site preparation and/or natural regeneration was abundant. Future rehabilitation monitoring and fieldwork for developing the target habitat types for the Vegetation Rehabilitation Plan will confirm if this is the case.

To date, natural tree regeneration has been confined to a few planting areas. In these areas, natural regeneration was a substantial contributor to the live stem density. This natural regeneration was concentrated in areas where both only vegetation clearing occurred and there was an adjacent uncleared area with a seed source. Continued natural tree regeneration will likely continue in these areas, increasing total stem densities.

It appears that some of the areas planted in 2020 and 2021 may need additional planting. However, it is generally not feasible to determine which areas this applies to before the boundaries of the temporary Project areas are finalized, and after substrate conditions are mapped for the Vegetation Rehabilitation Plan. The exception is the EMPA D23(1)-E planting area, where supplemental planting is needed.

At the time of this report, there are no recommendations to modify the study methods based on monitoring results to date. However, the efficacy of using drones as an alternate method for collecting some of the monitoring data is being evaluated and may result in modifications to the methods.

Rehabilitation implementation and regeneration monitoring will continue in 2023. Also, the first recovery success monitoring will begin in the 2016 tree planting areas.

7.0 LITERATURE CITED

ECOSTEM Ltd. 2017. Wuskwatim Generation Project: Operation Monitoring: Effects on Ecologically Sensitive Plant Species. Report # 17-09. A report prepared for Wuskwatim Power Limited Partnership by ECOSTEM Ltd., May 2017.

ECOSTEM Ltd. 2018. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2018-07: Habitat Rehabilitation Implementation and Success Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2018.

ECOSTEM Ltd. 2022a. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2022-01: Habitat Loss and Disturbance Monitoring. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2022.

ECOSTEM Ltd. 2022b. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2022-02: Priority Habitats Monitoring. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2022.

ECOSTEM Ltd. 2022c. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2022-06: Habitat Rehabilitation Implementation and Success Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2022.

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. December 2012.

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

Keeyask Hydropower Limited Partnership (KHLP). 2015b. Keeyask Generation Project Vegetation Rehabilitation Plan. Winnipeg, Manitoba. December 2016. 24+vi pp.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/