OFFSETTING PLAN FOR WETLANDS

FINAL VERSION

By Benoit Limoges
International consultant for biodiversity and ecological services

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A. CONTEXT

More and more natural resource projects are being created in Eeyou Istchee, the Québec Cree Nation territory, including Newmont Goldcorp's Éléonore gold mine located about 190 km east of the Wemindji Cree community. The mine began operations in October 2014 after more than four years of applications for permits and construction work. Located on Category 3 land, the Éléonore mine is located on the VC29 hatch lot under Angus Mayappo's responsibility. A road was built to connect the mine to the James Bay Highway. This road crosses the VC22 and VC28 trap lots, respectively under the responsibility of Ronnie Georgekish and Visitor.

As a result of the mining project, several wetlands have been or will be affected. A peat bog of about 28 hectares has already been destroyed by the first phase of the tailings facility which is expected to support the mining activities for five years. The next phases of the impoundment will be built as the mine progresses. As required by the Global Certificate of Authorization (Condition 2.1, November 10, 2011), the Éléonore mine will have to compensate for the loss of these wetlands. For its current requirements, the developer has selected Variant C as the tailings accumulation site. Accounting for the fact that part of this area is located in a wetland and that, according to the principles of the "avoid, minimize and offset" mitigation sequence in the approach chosen by the MDDEP, the developer will have to provide for offsetting for the loss of the wetlands concerned by the development of Site C. According to this approach, the losses judged to be inevitable must be offset by complying with an offset ratio proportional to the ecological value of the wetland destroyed or disturbed. These offset projects must be submitted to the Administrator for authorization before they are implemented. "

Allnatural resource projects should be designed to avoid impacts on the natural environment, mitigate the inevitable impacts, restore what can be achieved, and offset the residual impacts. The Ecological Offset Guide often advocates offsetting impacts on a wetland by measures that affect only the wetland environment, taking little account of variations between different ecosystems, urban and industrial development, and the characteristics of users of the affected site environment.

As early as 2012, Opinaca Mines Limitée (MOL) began thinking about how best to compensate for the loss of the wetlands. It appeared that the proposed guidelines were well applied in the southern part of the province, where many wetlands were destroyed in the past and where they are rarer. But these guidelines seemed less relevant in northern regions where wetlands are plentiful and not very threatened. It was then that an MOL employee undertook a master's degree at UQAM, in collaboration with UQAT, on this subject. The avenue to be explored in this study was to assess the relevance of the offset based on the one most valued by the Cree who were affected by the mining project.

A few years later, after the master's degree was published (Bois-Charlebois,2018), MOL incorporated the results of the university study into this offset plan, which aims at proposing measures that would allow environmental goals to be achieved while meeting the environmental and social characteristics of northern Québec.

B. DESCRIPTION OF THE RESIDUAL IMPACT

1. Introduction

Offset measures must be adjusted to reflect losses in the area and quality of ecosystems due to construction and industrial operation, once avoidance and industrial measures have been taken. Reductions achieved are the residual impacts. This is why this section presents a characterization of the affected water and wetlands as well as a quantitative and qualitative description of the residual impacts that affected them.

The residual impacts have been described in applications for Certificates of Authorization (CA) for regional authorities. In some cases, these requests specified a commitment to compensate for residual losses; in others, no.

2. Methodology

The following biological and hydrological characterizations are based on investigations carried out for impact studies and other reports commissioned to delineate wetlands in the project area (Exp, 2012; Geodefor, 2012; SNC-Lavalin and Englobe, 2015) (). (**Table 1**). These studies were to locate and delineate all wetlands within a specific polygon demarcated by MOL. All the different polygons comprise the study area of this report. Some parameters also come from work associated with the preparation of CAs.

Table 1- Main sources of knowledge about wetlands

Wetland numbering in this study	Demarcation	Ecological value	Flora
MH1-29, MH62-63	SNC-Lavalin and Englobe, 2015	Not rated	SNC-Lavalin and Englobe, 2015
MH30-58	Geodefor, 2012	Geodefor, 2012	Arseneault and Fenton, 2012
MH59-61 (waste impoundment peat bog)	Exp, 2012	Not rated	Arseneault and Fenton, 2012

A transect method was used to demarcate the wetlands. Transects were made from the outside to the inside of the bog by surveying peat thicknesses to the transition point between the land and wetlands, where vegetation passed from a predominance of non-wetland indicator species to a predominance of optional and voluntary species int he wetlands.

This transect method facilitated the precise determination of the peatland boundary at the point where the thickness of organic matter passed the 30 cm. threshold. The peat samples submitted to the Von Post scale classification criteria were collected by manual samplings using a soil auger.

Incursions in wetlands and water were calculated on the basis of estimates made for applications for Certificates of Authorization. These areas had been validated by detailed mapping that integrated all available data. Some areas were modified after the work so that the data obtained represented reality as closely as possible to the ground. No field work was carried out specifically for this section of the offset plan.

The descriptors to determine ecological value were chosen from those suggested by Joly *et al.* (2008) based on their relevance in the project area and the data available to evaluate them. Determining the ecological value of an ecosystem is highly subjective (Sinclair et al., 2015). If a mathematical method is selected, one must determine the criteria to be assessed and the weight of each criterion; these decisions greatly influence the final outcome.

In this study, the ecological value index was assessed by expert judgement within a quality gradient ranging from 0 - 100% or 0 - 1, since in biodiversity, accounting systems are being seen increasingly in international projects (see, for example, Munnee et al., 2003; Parkes, et al., 2003). The method of determining the quality index is based on all the descriptors studied but is not the result of a complex mathematical method. Rather, it is on an expert judgement based on all the available data according to a template which has been specifically adapted for this project (**Table 2**).

Table 2 - Template to determine the ecological value

Quality index	Environmental characteristics
0	Degraded and contaminated site
0.2	Degraded ecosystem, dominated by anthropogenic characteristics, such as non-indigenous species
0.4	Ecosystem created by Man, semi-natural, with few representative characteristics
0.6	Ecosystem transformed by Man, but still includes several natural features
0.8	Integrated ecosystem including all the typical characteristics of a natural habitat
1.0	Large, integrated habitat with rare or threatened species

Biodiversity is complex and any measure will be an imperfect representation of the variation (Pilgrim and Ekstrom, 2014). However, quantifying it is necessary to offset adequately. In our case, the Quality-Hectare index (QH) was calculated to quantify the residual impact. This index is most commonly used internationally to quantify biodiversity losses and gains (see Ekstrom and Rabenantoandro, n. d; Aiama et al., 2015; Parkes, et al., 2003; Temple et al., 2012). The International Council of Mines and Metals, better known by the English acronym ICMM, has published guidelines (ICMM and IUCN, 2012). The Quality-Hectare index (QH) is calculated simply by multiplying the area in hectare of habitat impacted by the quality index ranging from 0 to 1.

$$QH = Quality\ (0\text{-}1) \times Area\ (ha)$$

The residual impact (RI) is calculated by subtracting the Quality-hectare index after the project from the one assessed before the project.

$$RI = QH_{before} - QH_{after}$$

3. Impact on wetlands

3.1 Types of wetlands

Wetlands occupy an important part of the Éléonore mine territory, with the vast majority being ombrotrophic peatlands (bogs). Some 54 bogs have been demarcated near the mine. They are characterized by vegetation typical of northern peatlands, hydromorphic soil and 30 cm or more of thick organic matter. They are peatlands whose only source of water comes from precipitation (Rydin and Jeglum, 2006). They develop on impermeable or poorly drained soils, under climatic conditions where precipitation is greater than evaporation. Water saturation conditions, acidity and nutrient deficiency limit decomposition and result in an accumulation of plant debris that eventually form peat.

In Jamesia, peat accumulation can reach three or four meters (Roche, 2007). The differential accumulation of peat creates a micro-topography of mounds and troughs with sometimes a pond in the center. Deeper layers of more decomposed peat are permanently saturated with water and have low hydraulic conductivity. The surface layer corresponds to the fluctuation zone of the water table and is composed of free-living plants or recently died, especially sphagnum, which have a storage capacity and high hydraulic conductivity. The climate influences, the dynamics of vegetation in the ombrotrophic bog as reduced summer precipitation in summer lead to an increase in tree cover (Lallier, 2000), while a decrease in winter precipitation may promote the formation of permafrost at this latitude (Thibault, 2006). The peatlands in the study comprise this type, as they often have a tree cover, which distinguishes them from the large expanses of structured, open and uniform peatlands with non-oriented ponds (Buteau et al., 1994) found along the Opinaca River.

The seven wetlands (MH19, MH25-29 and MH36) identified as the maximum rating of the Opinaca Reservoir (215.8 m), with a 30 ha area, were probably the origin of ombrotrophic peatlands, but they can be considered as **floating bogs** (in red on **Figure 1**). When the reservoir level is high, water is present under the peat mat, which is more than a meter thick.

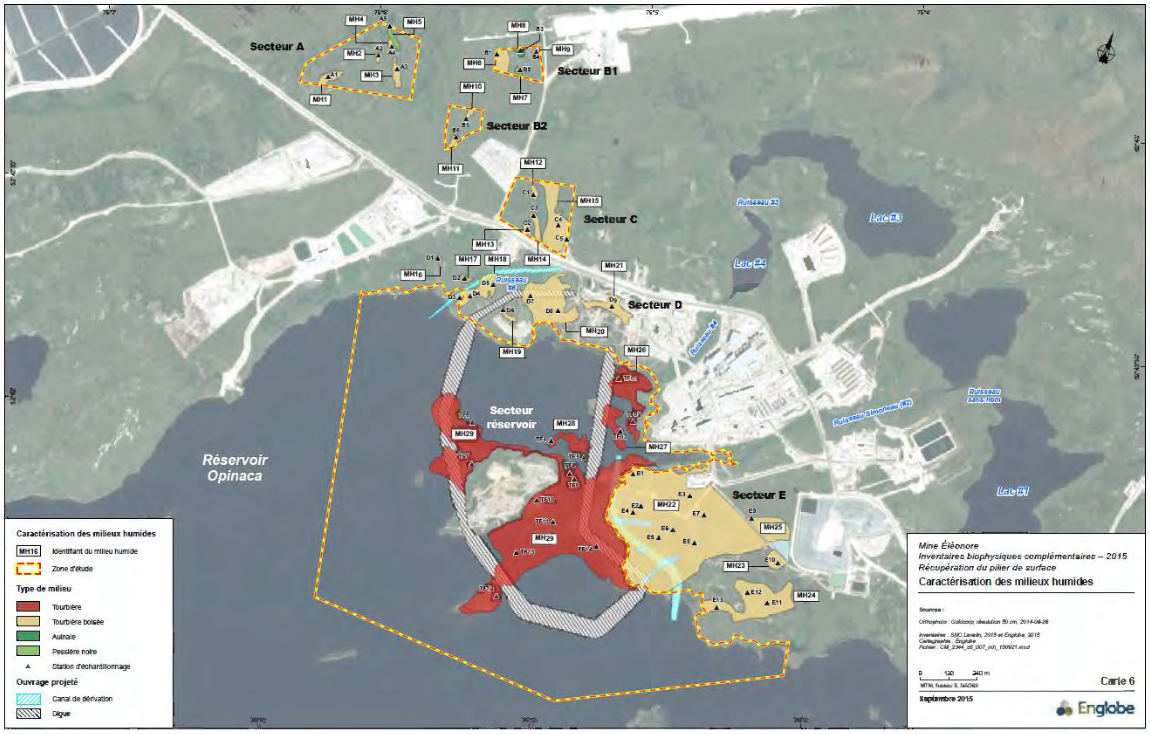


Figure 1 - Map of wetlands showing floating bogs (in red) on the Opinaca reservoir

These peatlands probably originated from peat bogs that were flooded during the expansion of the reservoir. It is possible that some sphagnum mats drifted and anchored more or less permanently in the bay formerly known as Ell Lake. These mats floating on the surface of the reservoir undergo different physico-chemical conditions and higher temperatures only in their original habitat. In addition, they are more or less flooded, depending on the level of the Opinaca reservoir. This is why these floating bogs are often in a process of degradation that generates methane gas emissions and converts them to other types of wetlands (Scott et al., 1999). These former peat habitats appear to be transitioning to another type of wetland. Golder, 2010 describes them as marshes dominated by a dense canopy of grasses, sedges and rushes with sparse shrubs such as willows and sweet gale (*Myrica gale*).

These floating bogs were demarcated mainly around Roberto Island, just above the gold deposit and mine ceiling. This is why, throughout the exploration, planning and construction process of the Éléonore mine, several boreholes were drilled in the Opinaca reservoir, many of which were done through these floating bogs.

More often than not, drilling was done during the winter to reduce impacts on wetlands. However, two rounds of drilling took place during the summers of 2013 and 2015. There was no significant encroachment in the wetland if the reservoir was high enough since these wetlands were flooded during construction, and drilling could take place by barge. Given the short duration and reduced magnitude of the impacts of this work on floating bogs, it was decided not to quantify them and not to deal with them further.

On the other hand, some ecosystems, although not hydromorphic soil, were considered to be wetlands on thin soil (SNC-Lavalin and Englobe, 2015). In fact, they had a thickness of about 25 cm of organic matter, on blocks or sand with very poor drainage. Vegetation was typical of wetlands (Bazoge et al., 2014). Black spruce was associated with two small wetlands (MH4 and MH7) with an area of 3900 m2 and not impacted by the project. They are not mentioned in this document either.

Marshes cover 212 ha or 8% of the mine area according to Roche (2007). They are concentrated along the Opinaca River, which is outside the area currently under study. The marsh plant community is dominated by a dense canopy of grasses, sedges and rushes with sparse shrubs such as willows and sweet gale. There are also fens that make up about 2% of the wetlands in the impact study area (Roche, 2007). Neither of these two types of wetland have been identified in the study zone or has been impacted.

In summary, some 63 wetlands have been demarcated in the surveyed areas, which cover an area of 239 ha (**Table 3**).

Table 3 - Number and surface area of wetlands in the sector under study

Type of wetland	**Number**	**Surface area (m^2)**
Ombrotrophic bog	54	2,108,055
Spruce	2	3900
Floating bogs	7	286,009
Total		2,397,964

Emphasis will be placed on wetlands that have been impacted by the project, namely ombrotrophic peatland, which will be studied in the following section. Water and riparian environments that have been slightly impacted will be dealt with later.

3.2 Ombrotrophic peatlands

3.2.1 Ecological value

This section aims to establish the ecological value of peatlands impacted from a series of factors recommended by the MELCC (Joly et al., 2008). Instead of a mathematical method where each factor would receive a quantitative index, we opted for a quantitative and qualitative description of each. However, at the end of the section, a quantitative assessment of ecological value will be assigned based on the most important relevant factors.

Uniqueness

The administrative region of Northern Québec is covered with approximately 110,104 km^2 of wetlands (13%), placing it in second place of regions with the highest rate of wetlands after Abitibi-Témiscamingue (24%) (Pellerin and Poulin, 2013). The project is located in the natural province of the Great River Hills, which is largely made up of 11%, 18% (MDDELCC, 2016).

Table 4 presents the different ecosystems in the area of the impact study before construction of the mine. Only 50% of the territory is covered by land plant communities, of which only 14% is forested. Some 21% are made up of wetlands, mainly ombrotrophic peatlands. In this northern territory, there are, therefore, more wetlands than forests, which could give the latter greater ecological value than wetlands .

Table 4 - Ecosystems in the impacted study zone

Vegetative community	Surface area (ha)	Proportion of the study area (%)
Land vegetative community		
Dry stripped	177	1
Dead organic matter	1	0
Burnt	4718	35
Shrub vegetation	91	0.7
Leafy forest	28	0.2
Mixed stands	217	1.6
Open softwood stands	686	5
Black spruce-moss	967	7
Subtotal	6890	51
Vegetative communities of wetlands		
Ombrotrophic bog	2529	19
Fen	51	0.4
Marsh	211	1.6
Subtotal	2793	21
Other		
Open water	3806	28
Total	**13490**	**100**

(Source: Roche 2007.)

A detailed summary map of wetland and water environment is presented in **annexe 1** and a representation is inserted below for information purposes (**figure 2**). The territory of this study corresponds to the two polygons covered by the Englobe, EXP and Geodefor teams visible in red dash line. The proportion of ombrotrophic peatland in this territory is 33% (**Table 5**), which shows that ombrotrophic peatlands are common in this territory.

Table 5 - Proportion of ombrotrophic peatland in the land territory studied

	Surface area
Total territory studied (including the reservoir)	780 ha
Land territory (without the reservoir)	576 ha
Surface area of the peatland in the land territory	191 ha
Proportion	33%*

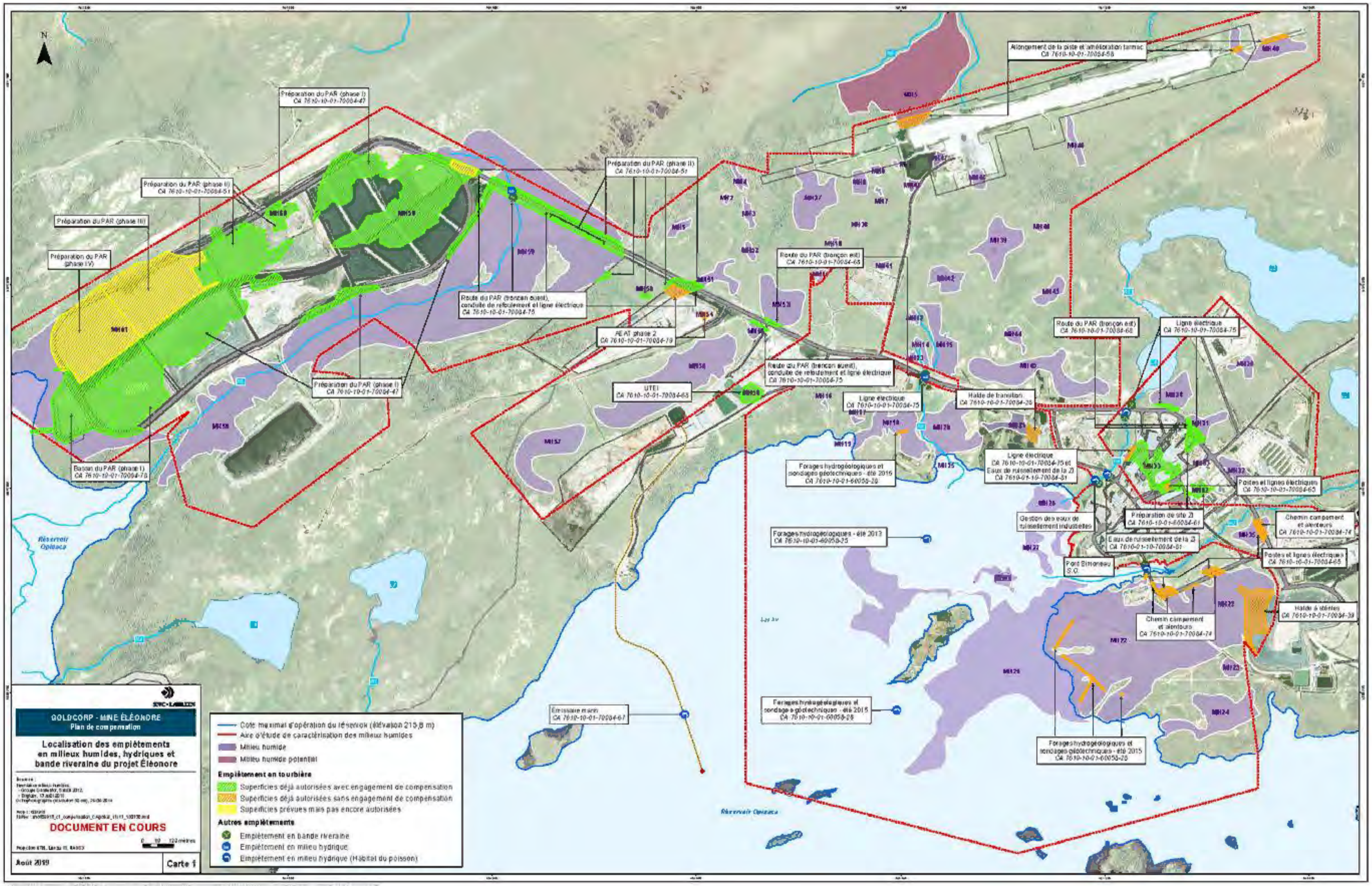


Figure 2 - Summary map of the wetland and water environment

These data allow us to assess the uniqueness of peatlands in the project area as being low. Indeed, Geodefor (2012) had also concluded that the peatlands it had assessed all had low uniqueness and strong representativeness. None of the peatlands that have been characterized appear to have a unique character, which reduces their ecological value.

Conservation value

The vegetation of the ombrotrophic peatlands corresponds to the grouping of *Kalmia angustifolia - Chamaedaphne calyculata - (Picea mariana) / Cladina* spp. (CEGL006225 according to Nature-Serve) which has the G5 rank, i.e. "clearly safe", thus not unique or threatened. This status determines the risk of extinction of a global ecosystem.

Surface area

The peatlands in the study area have an average area of 38,666 m2, or 4 ha. Of the peatlands that have been demarcated, the smallest peatland has an area of 95 $m^{2,}$ while the largest covers 68 hectares, or nearly 10,000 times more. **Figure 3** Shows that most are very small and that there are not many large ones. Encroached peatlands have a surface area of 7 ha. This is because the two largest peatlands (MH59 and 61) are encroached by the tailing's impoundment. These two large bogs form, with a third small peat bog (MH60) and R5 stream, a vast peat wetland complex

Peatland code	Surface area (m^2)
MH36	95
MH25	171
MH38	461
MH54	513
MH9	607
MH16	662
MH50	672
MH19	704
MH7	710
MH2	863
MH63	899
MH17	990
MH10	1,073
MH40	1,093
MH41	1,155
MH11	1,258
MH8	1,411
MH12	1,582
MH13	1,631
MH47	1,967
MH52	2,154
MH62	2,725
MH14	3,143
MH4	3,201
MH3	3,246
MH55	3,422
MH1	3,436
MH46	4,277
MH44	4,379
MH30	4,703
MH23	4,733
MH58	4,781
MH6	5,183
MH48	5,684
MH43	6,934
MH60	7,366
MH32	7,995
MH28	8,789
MH27	9,274
MH21	9,276
MH35	10,017
MH42	10,241
MH31	12,305
MH34	15,116
MH51	15,615
MH33	17,348
MH49	18,937
MH15	21,181
MH26	22,564
MH39	22,975
MH53	24,422
MH37	27,604
MH18	28,137
MH20	32,142
MH57	34,867
MH24	35,654
MH45	44,029
MH56	82,050
MH5	113,123
MH29	262,855
MH22	300,635
MH61	483,944
MH59	676,975
Total	**2,435,952**
Average	**38,666**

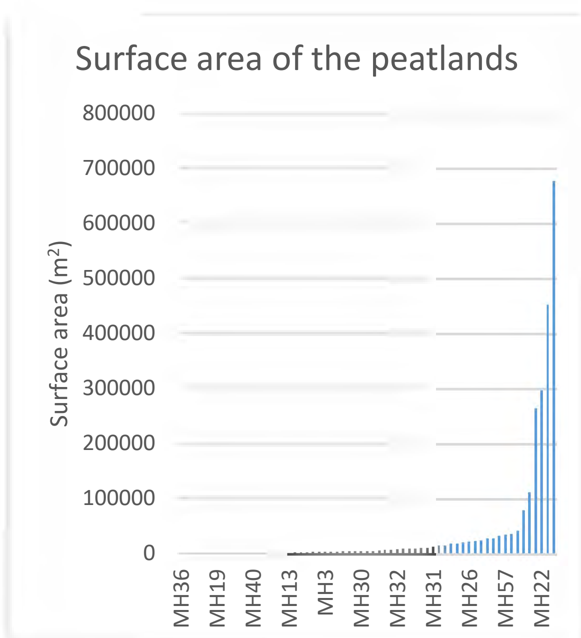


Figure 3 - Surface area of peatlands in the area studied

In equal shape, the largest peatlands can meet the needs of species adapted to the conditions of the habitats (McHattie et al., 2004), species with stricter ecological requirements and generally less common. The ecological value of large peatlands is, therefore, greater.

Shape

The higher the edge/area ratio, the more the wetland can meet the needs of the species requiring indoor habitats (McHattie et al., 2004). Thus, on an equal surface, round-shaped marshes are generally less affected by the border effect than environments with a very meandering or more fringed perimeter. The border effect promotes some fragmentation of the environment. Geodefor (2012) conducted an analysis of the shape of 38 peatlands in the area under study. Most (63%) had a rounded shape while a few (37%) had a complex shape and an increased edge effect.

Hydrological characteristics

The connectivity of the wetland to the surface water system is an indicator of sustainability for this by guaranteeing the hydrological conditions necessary to maintain it. Even if, in its definition, an ombrotrophic bog has no dependents, this one can still be connected to a runoff or a body of water during certain episodes of floods. This criterion is assessed by the density of intermittent and permanent streams on the periphery of the wetland. Geodefor (2012) conducted an analysis of the hydrological connectivity of 40 peatlands in the area under study. In most of cases (31), peatlands were not related to a water environment. In nine cases, the bogs were connected to a runoff, a small lake or the Opinaca reservoir. Six of the encroached peatlands have hydrological connectivity with Simoneau Creeks, R4 or R5 (MH22, 33, 34, 35, 59 and 61), which gives them greater ecological value.

Water retention capacity and drainage were assessed as being high and low, respectively, for the peatlands (Geodefor, 2012). The first criterion is of great interest as it characterizes one of the main ecological functions of a wetland and is directly related to its filtration capacity, an ecological service valued in the south, but irrelevant in this context.

Structural diversity

A peat bog can be open (unforested) or wooded; in the latter case, it consists of trees more than four metres high and has a canopy of 25% or more, (Bazoge et al., 2014). These plants are most often conifers, but sometimes also alders. The black spruce (Picea mariana) is usually stunted in open bogs but becomes a tree in wooded bogs.

For the 29 peatlands mapped by Geodefor (2012) and the three by Exp (2012), areas of high and medium density were delineated as wooded while low-density areas have been described as non-wooded peatland. These densities correspond to the criterion of Bazoge et al. (2014), a cover of more than 25% of the area of trees and shrubs more than 4 metres high.

On the other hand, SNC-Lavalin and Englobe (2015) used another criterion and determined that peatlands were forested if they were characterized by over 25% of trees and shrubs, without any height accuracy. As a result, all the peatlands studied were considered wooded, except for floating bogs. In fact, peatlands have a high proportion of cover by shrubs, but these have a height of less than 4 m. Several trees also have a height of less than 4 m, growing often in a stunted form.

Based solely on Geodefor's (2012) results, only 26% of peat bogs is wooded. Peatlands with a high proportion of woodland have a greater ecological value than unforested peatlands. Most of the affected peatlands contain wooded sections.

The ponds located in the peatlands are biodiversity hotspots, supporting a variety of species, including plants (Grondin and Ouzilleau; 1980, Poulin et al., 1999; Poulin et al., 2002), invertebrates (Danks and Rosenberg, 987), amphibians (Mazerolle, 2005) and migratory birds (Desrochers, 2001). Thus, peatlands that host one or more ponds have a greater ecological value than those without any. At least one bog (MH39) has a pond in its centre, which helps increase its value compared to others.

Specific diversity

Bogs generally have a lower floristic diversity than fens. Three tree species are found in peatlands, in descending order of frequency: Black spruce, Grey Pine (*Pinus banksiana*) and Laricin Larch (*Larix laricina*). Many peatland trees burned in previous decades. A dozen species of shrubs, twenty species of herbaceous plants and twenty species of bryophytes are commonly found in peatlands. In fact, conifers and ericaceous shrubs dominate the landscape in peatlands and around these. Black spruce, calculated cassandra (*Cassandra caliculata*) and *Sphagnum fuscum* are also commonly found both in open and wooded bogs (Grondin and Ouzilleau,1980). The most common plants include the small mulberry bramble (*Rubus chamaemorus)*, the murk andromeda (*Andromeda glaucophylla*) and blueberries. Occasional plants include round-leaf drosera (*Drosera rotundifolia*) and purple buckwheat (*Sarracenia purpurea).* The peatlands that burned are colonized by the vaginay linaigrette, polytricum and lichen *Trapeliopsis granulosa* (Roche, 2007).

Larger peatlands are often home to more species than smaller peatlands, which gives them greater ecological value

Rare or endangered species

Studies show that no species of trees, shrubs, herbaceous plants or rare bryophytes, unusual or threatened has been listed in the various peatlands, which reduces their ecological value.

Disturbances

Under this criterion, all aspects related to the impact of human activities prior to the project such as: wetland fragmentation, connectivity with the adjacent natural environment, and the occupation of this environment latter. Since none of the peatlands studied, as well as their adjacent environments, had been directly altered by humans before the start of the project, the level of disturbance is zero, which increases the ecological value. Their naturalness is considered complete.

Invasive non-indigenous species

While no invasive non-indigenous species were inventoried by Geodefor in 2012, four species inventoried by SNC-Lavalin and Englobe (2015) in some peatlands: the white clover *(Trifolium repens*), the meadow grass pea (*Lathyrus pratensis*), the meadow hawk (*Hieracium caespitosum*; syn. *Hieracium pratense*) and the daisy (*Leucanthemum vulgare*). These are probably species that were introduced during the construction work associated with the project, probably by machinery. As peatlands were not colonized by these species prior to the start of the project, they will be assigned a perfect score in this regard.

Development

Under this criterion are all aspects related to human use by whites that are pre-project activities, such as recreational or tourism activities. No outfitter camp uses this territory. There has been no conservation activity either, which reduces the ecological value. The Cree's activities will be detailed under the heading "Ecological Services."

Ecological services

The ecological services provided by peatlands in the project area are divided into two categories, according to the carbon storage and sequestration, which benefit all humans; all other ecological services benefit the local Cree people.

Carbon storage and sequestration

The Global Climate Regulatory Ecological Service includes carbon storage and carbon sequestration. Let us begin with storage.

To assess the exact amount of peat or carbon stored in peatlands, it is necessary to know the average thickness of the peat. In the three peatland studies, 1,436 peat-depth surveys were conducted. Some 657 stations revealed a thickness of peat sufficient to be considered a peat bog, 30 cm or more. In these stations, the average peat thickness was 45 cm, with higher thicknesses of up to 120 cm detected. However, these values correspond only to the thickness of undecomposed peat, the H1 to H7 horizons according to the Von Post decomposition. The decomposed peat horizons (H8 to H10) have not been measured, making these values useless to quantify the peat.

Estimates of the total volume of peat were made by separating the large peatlands encroached by the construction of the other smaller peatlands further east.

To estimate the variability of thicknesses, Garneau et al. (2014) believe that the topography of the region plays a key role. In the valley hosting the tailings facility, the site's stratigraphy consists of a peat horizon, followed by a horizon of clay silt, followed by a till deposit resting on the bedrock. The peat thickness varies from nil, at the perimeter of the site, to 5 m in the centre of the valley, for the two main encroached bogs (**Figure 4**). According to Garneau's equations, a maximum thickness of five metres corresponds to an average thickness of 3.25 m, for the entire bog. This average thickness multiplied by the area encroached to date (25 ha) gives a theoretical volume of peat of 812,500 m^3. So, it is this volume that should be found in the peat pile.

All the peat collected in MH59, MH60 and MH61, during the construction of the tailing's impoundment, was piled in the peat pile. However, in other peatland construction, such as the UTEI and the industrial zone, peat was carried to the plant-based pile. The peat pile is currently believed to contain 512,000 m^3 (Painchaud, pers. comm.) of peat, as it is considered to be at full capacity.

This 512,000 m^3 peat volume is less than the predicted value. Once spread over the 25ha peat area that has been stripped so far, this equates to an average peat thickness of two metres. This thickness is less than previously estimated (3.25 m). These results are explained by the fact that this estimated value applies to all of these peatlands, while sections that have been emptied to date correspond to sections with smaller sections of peat thicknesses, including the small bog MH60 (**Figure 4**). In the next phases of the tailing's impoundment, peat thicknesses will be slightly higher than what was observed in the first phase This is why an average thickness of 3.25 m seems realistic for these large peatlands and it will be used in subsequent calculations

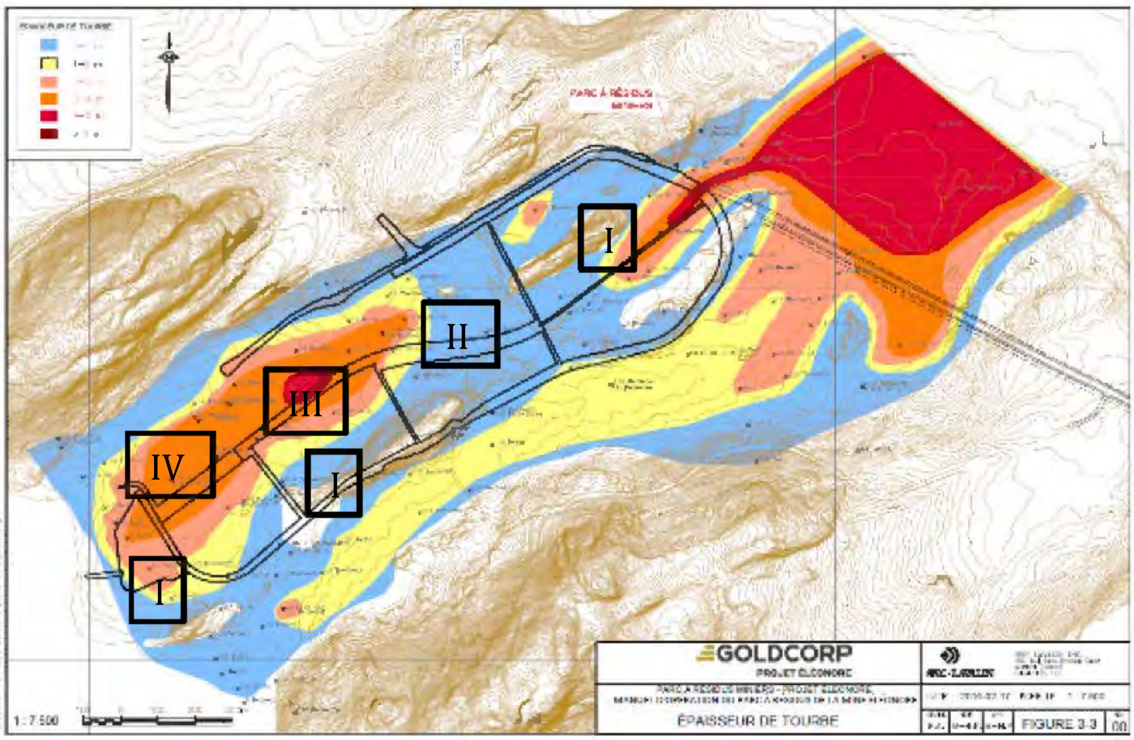


Figure 4 - Figure - Peat thicknesses in peatlands encroached by the tailing facility: in the box, the development phases.

The other peatlands are located in a landscape with a much flatter topography than the peatlands of the tailings facility located in a valley. This is why, for other peatlands, we will use the average thickness of peatlands in the Wemindji region according to Garneau et al. (2014),i.e. 2.25 m. **Table 6** summarizes the amounts of carbon and CO2 equivalents in the peatlands. In summary, prior to the start of the project, there was approximately 288 kt of carbon stored in the 6 million m^3 peat bogs in the study area, which is equivalent to one megaton of CO2, according to 3.67 tons of CO2 per ton of carbon (Olivier et al., 2015).

Table 6 - Estimated peat and carbon stocks

Peatlands	Location:	Total peatland surface area (ha)	Average thickness (m)	Total volume of peat (m^3)	Carbon mass (kg C/m^2)[1]	Total carbon mass (kt)	Equivalent CO_2 (kt)[2]
MH59 and MH61	Tailing facility	116	3.25	3,770 000	135	157	576

Other peatlands	Other sectors	127	2.25	2,857,500	103	131	481
Total	-	243	-	6,627,500	-	288	1057

[1] Ratio drawn from Garneau et al. (2014)
[2] One ton of carbon is equivalent to 3.67 tons of CO2 (Olivier et al., 2015)

Peatlands are wells that store carbon, but also heavy metals and sulphur from acid rain (De Vleeschouwer et al., 2004). Air pollution is characterized by the presence in the air of fine dust particles that, once deposited on the ground, release heavy metals contaminants (lead, zinc, copper...). By its geochemical characteristics, peat stores these traces of metals.

There is also the sequestration of carbon by the living ecosystem of the bog, the carbon sink as such. Because the rate of decomposition is slower than that of primary production, this causes an accumulation of organic matter at an approximate rate of 0.23 t C/ha/year (Garneau et al., 2014; Baird et al., 2009). Prior to disturbance, peatlands at the study site were sequestered at approximately 56 t C/year, or 205 t of CO2 equivalent.

Other ecological services

The ecological services of which the Cree are the beneficiaries were described in detail by Mhaly Bois-Charlebois in his master's thesis filed in April 2018 (Bois-Charlebois, 2018). Most of the following information is extracted almost verbatim from this book. Primary references have been removed in order to lighten the reading. In this context, a literature review and interviews were used to collect data. Interviews were conducted with 21 Cree respondents at Wemindji and the Éléonore mine site in 2013, 2014 and 2015. The interviews aimed to understand how the territory of Eeyou Istchee is used as a whole, and what are the main ecological services it provides. Other issues focused on wetlands and their importance compared to other ecosystems.

An analysis of interviews and secondary data sources identified ecological services and analyzed the context in which they were mentioned. Thus, a list of ecological services has been prepared. An analysis of the importance and deficiencies associated with each was also made. This analysis was whether ecological services were a concern for the Cree and whether their availability tended to increase, be stable or decrease.

Procurement services

Procurement services were the most frequently mentioned in interviews.

Food supply

Respondents mentioned 21 genus or species of animals collected by hunting, fishing or trapping. Canada geese (*Branta canadensis*) and moose (*Alces americanus)* were most frequently mentioned. The geese are directly associated with the ponds of peat bogs, where they stop in migration. The Cree associate these wetlands with other species identified: beaver (*Castor canadensis)*, partridge (*Bonansa umbellus*), black bear (*Ursus americanus*) and muskrat (*Ondatra zibethicus)*. According to available data, moose density in Hunting Area 22 is constantly increasing due to logging in the southern part of the area, which has allowed the animal to increase suitable habitats.

The Cree mentioned eight species of fish. Fish contribute a lot to the diet of the Cree who prefer white-fleshed fish. In contrast, the most mentioned species was grey trout (*Salvelinus namaycush*), or lake trout, an orange-fleshed fish.

Picking berries is one of the ecological services produced by peatlands. Six berries were mentioned: blueberry (*Vaccinium caespitosum, V. angustifolium, V. uliginosum*), black camarin (*Empetrum nigrum*), cranberry (*Vaccinium oxycoccos)* cloudberries (*Rubus chamaemorus*), raspberry (*Rubus idaeus*) and strawberry (*Fragaria virginiana*). Several other plants are used for the traditional Cree diet (**Table 7**).

Table 7 - List of certain plant species used by the Cree as food and potentially present on Eeyou Istchee (from Bois-Charlebois, 2018)

Name of species	Use	Decreasing or to be monitored on Eeyou Istchee
Amelanchier sp.	Fruit eaten	No
Betula papyrifera	Sap used as syrup	No
Corylus cornuta	Nuts eaten	No
Elaeagnus commutata	Berries used to make wine	No
Fragaria virginiana	Fresh or preserved berries	No
Gaultheria hispidula	Berries eaten	No
Nuphar variegata	Fruit eaten and petals compressed to drink water	No
Populus sp.	Internal bark consumed in spring	No
Prunus pensylvanica	Cherries eaten fresh or preserved in jam	No
Prunus virginiana	Cherries eaten fresh or preserved in jam	No
Ribes glandulosum	Fruit eaten	No
Ribes triste	Red currants freshly used or for preserved jam	No
Rhododendron groendlanticum	Leaves used to make tea	No
Rubus idaeus	Fresh or dried used berries	No
Fresh or dried used berries	Blackberries and brambles used	No
Sium suave	Root eaten	No
Sorbus americana	Fruit eaten	No
Vaccinium angustifolium	Berries eaten	No
Vaccinium macrocarpon	Berries eaten fresh	No
Vaccinium myrtilloides	Berries eaten	No
Vaccinium oxycoccos	Fresh or boiled berries with sugar	No

Material supply

The majority of the animals are taken by the Cree for both food and fur. According to The Cree culture, the animal should be used as much as possible as a sign of respect. This is why most of the species mentioned above are, therefore, consumed and used as materials.

The mink (*Neovison mink*) was most often mentioned, followed by the marten. The marten is the second species most trapped by the Cree for its fur and its trade is significant. Other furry animals often collected are otters (*Lontra canadensis*), lynx, muskrat, red fox (*Vulpes*), arctic fox (*Vulpes lagopus*), weasel (*Mustela spp.*) and wolf (*Canis lupus*).

Black spruce is the best species for shelter construction, although wood is less used than in the past. This species is also used to make baskets for collecting fish and berries, as well as for storage. Larch wood is used to make buoys for fishing nets and goose-shaped sculptures used for hunting.

Fuel supply

Firewood is crucial to the survival of the Cree, especially white birch (*Betula papyrifera)*, considered the best for this use, followed by black spruce and grey pine (*Pinus banksiana*).

Supply of medicinal plants

The Cree interviewed did not spontaneously mention medicinal plants, and very few claim to know them well. Some use them sometimes; for example, a person uses cedar (Thuja occidentalis) to treat colds and coughs. A list of several medicinal plants used by natives of the Canadian boreal forest can be found at **Annexe 2**.

Fresh water supply

Ecological water-related services go beyond drinking water consumption. Water helps preserve the health of ecosystems, wildlife and people and provides habitat and breeding grounds for fish and wildlife while regulating the climate. It serves as a route for procurement and other traditional activities. It supports the tallyman system and finally contributes to Cree identity and spirituality.

Socio-cultural services

Several socio-cultural services were mentioned by the Cree, including the practise of traditional and family activities related to land use. The *goose break* is still considered to be the annual event bringing together the most families.

Educational potential has often been mentioned, including the learning of traditional activities, which is of major importance in the education of children. According to one respondent, several Cree rituals are related to nature, such as *the walking out ceremony.*

Ecosystems also serve as a temporal reference; Aboriginal people have always used seasonal changes to be time-bound, and they serve as the basis for their annual calendar, including certain rituals, but also to determine what will be trapped, hunted, fished or picked.

Nature also serves as a geographical reference, as the physical characteristics of ecosystems provide several visual cues to be located in the territory. Since the Cree are traditionally hunters, trappers and fishermen, this ecological service is of great importance in their way of life. The river system is widely used as a landmark and gathering point.

Despite their importance in the cultural identity of the Cree, traditional knowledge tends to be lost over the years. The preservation of traditional identity and activities is paramount to the well-being of Indigenous Peoples' communities. Several factors explain the Cree's deep cultural, emotional and spiritual attachment to their territory. For example, the Cree feel pride when they talk about their trapping territory, in connection with certain natural symbols such as important streams and the beauty of the landscape in which they operate. For the Cree, rivers are definitely key places, a concept used to define places that are particularly important in the culture of a people. In the spectrum of the trap lands affected by the Éléonore mine, the Opinaca River and the bodies of water surrounding the Éléonore mine are undoubtedly important elements.

Overall health

Overall health (*miyupimaatisiiun)* as perceived by the Cree includes more than body health and also includes psychological, emotional and spiritual health. This concept of overall well-being is closely related to the natural environment. In fact, despite the fact that medicinal plants seem to be used less than in the past, some Cree believe that the healthy lifestyle they adopt in the forest helps to maintain their good physical health. There is a correlation between time spent in the territory and the rate of psychological distress. This is due to an increase in family time, contact with nature, a spiritual relationship with animals, a reaffirmation of cultural identity, improved physical health and a decrease in the consumption habits of harmful substances, among others. Many go to their trap area to relax, or just to have fun.

Regulatory services

No regulatory services were mentioned in the interviews. However, the Cree benefit from many of them, most often unconsciously. The main regulatory services in the Cree territory are, in addition to the one related to the regulation of the global climate presented above, those related to water and air purification and the degradation of organic waste. However, because contamination is limited, these services are scarce and difficult to identify. The one that is most associated with peatlands is flood control. In fact, peatlands can store and retain water during floods, control runoff flow and prevent flooding, shoreline erosion and property damage to Cree communities and road infrastructure.

Summary of ecological services

The carbon sink function of peatlands and their role in climate regulation has been brought to light. This ecological service of international importance is most pronounced in the larger peat bogs with a thicker peat bed.

The research by Bois-Charlebois (2018) demonstrates the strong link between the Cree and their territory, but the role of peatlands in the provision of priority ecological services has yet to be demonstrated. The abundance of this type of wetland, the absence of issues related to pollution and waterproofing of the territory, its naturalness and low population density renders the ecological services rendered by peatlands obvious and less prioritized by Cree users.

As proof, the choice of the large peatbog MH59 and MH 61 by the tallyman as the site of the tailings facility (see next section) concretely expresses this prioritization of habitat types, prioritization which could not be verbalized during the interviews for reasons related to Cree culture. Appreciated by their users, however, the ecological services of peatlands are not valued.

Determination of the ecological value

Based on previous descriptions, the ecological value of the two large peatlands obtains a 90% quality index, while the rest get a slightly lower index, 80%. All peatlands studied are 100% natural; it is mainly their size and the absence of rare species that slightly reduce their quality. The result is shown in **Table 8**.

Table 8 – Determination of the peatlands quality index

Peatland code	Favourable factors	Unfavourable factors	Quality
MH59 and MH61 (The two large peatlands of the tailings facility)	- Total naturalness - High representation - Large surface area - Structural diversity - Large quantity of carbon	- No endangered species - No development - Few valued ecological services	0.9
MH1-MH58 and MH60 (All others)	- Total naturalness - High representation - Structural diversity	- No endangered species - No development - Small and average surface areas - Average amount of carbon - Few valued ecological services	0.8

3.2.2 Residual impact

Throughout the construction of the mining project, the impact mitigation hierarchy was applied (avoid, minimize and offset). The case of the tailings facility is special and will be discussed in the next paragraph. With regard to the design and construction of other infrastructure, namely the industrial zone, the airport and the different dumps, it is remarkable to observe the avoidance efforts **(Figure 5)**. In fact, while peatlands cover about 33% of the land area under study, encroachments account for only 3% of it. Avoidance measures in the design of the project kept 38 peatlands intact in the study area, despite the high proportion of wetlands that prevail. The reduction of impacts, or minimization, has been maximized throughout the project, by the implementation of the many environmental management measures detailed in the impact assessment. This chapter will, therefore, address the residual impact that could not be avoided or minimized, and which must be compensated.

Figure 5 - Aerial photo of the airport showing the avoidance of peatlands, shown in mauve.

The choice of the site of the tailings facility was made in a formal and systematic way to determine where it would have the least technical, social and social impact (Golder, 2010). This process was carried out through two studies covering a radius of 10 km around the concentrator, as per MELCC Directive 019.

In compliance with the principles of sustainable development, a weighted analysis took into account the social, financial and environmental issues. Initially, environmental and financial criteria identified three potential sites, one of which, potential site C, is 50% peatland-covered. Once the social selection criteria were applied, it was established following consultations that users favoured the installation of the tailings facility on Site C, i.e. the site that encroached on wetlands. The main reason for this choice is that the Cree use little wetlands and preferred protecting mature forests that provide them with more ecological services.

However, it was possible to minimize the impact by reducing the area impacted. During the design, the decision was made to go to a filtered tailings facility, which allows for a stacking at height and thereby a significant reduction in the area of the tailings facility.

Also, a balance culvert was installed in the peatland section southeast of the tailings facility to ensure the hydraulic connectivity of the bog on either side of the road and thus minimize impacts on it.

In 2011, the global CA (3214-14-042) authorized the construction of the tailings facility in a peat valley, without specifying an area exact, but by demanding offset. Since then, during the development of the mining project, there have been 15 other CA's allowing the encroachment of 42 hectares that were issued by the regional authorities. According to projections, there are still 15 hectares to encroach whose authorizations are coming. Among the rest of the calculations presented in this document, these planned encroachments are considered to be already achieved. **Table 9 – Summary of peatland encroachments by CA** details all the encroachments carried out and planned.

All CAs that aim to build the tailings facility commit MOL to offset for wetland losses. However, sometimes CAs regarding the construction of the industrial zone and other facilities commit to offsetting; other times, no. According to projections, there would be 60 ha with a clearing commitment and 4 ha without a commitment to offset, which represents about 6% of total peatland encroachments.

Table 9 – Summary of peatland encroachments by CA

Request for certificate of authorization	Title	Surface areas (m^2)			Comments
		Approve	As complet	Projected	
7610-10-01-70084-74	Camp and surroundings road	5200	2501		Reduced value due to duplication, i.e. an area already allowed by another CA.
7610-10-01-70084-65	Power stations and lines	4767	4371		Reduced value due to duplication, i.e. an area already allowed by another CA.
7610-10-01-70084-58	Extension of the runway and tarmac improvement	9500	4748		The majority of the work has never been done. The only real encroachments are the small tip in MH5 (3398 m2) and the trail for lights in MH49 (1350 m2)
7610-10-01-70084-70	Expansion of the area adjacent to the airstrip	3500	0		Work never done
7610-10-01-60058-28	Hydrogeological drilling and geotechnical surveys - summer 2015	2875	2875		No revisions carried out after work
7610-10-01-70084-39	Waste rock pile	16,878	16,878		Area calculated after work, as no data in CA application
7610-10-01-70084-79	AEAT Phase 2	3138	3138		No revisions carried out after work
7610-10-01-70084-28	Transitional pile	1996	1996		No revisions carried out after work
7610-01-10-70084-81	Industrial zone IZ (art. 32) runoff water	234	234		No revisions carried out after work
7610-10-01-60084-61	IZ site preparation	20,586	20,987		Exact surface areas not available when requested by the CA
7610-10-01-70084-68	PAR Route (east section: 0 +000 to (2+050)	3392	3392		No revisions carried out after work
	IWTP:	4781	4781		No revisions carried out after work
7610-10-01-70084-47	PAR preparation (phase1)	106,000	219,295		Exact surface areas not available when requested by the CA

Request for certificate of authorization	Title	Surface areas (m^2)			Comments
		Approve	As complet	Projected	
7610-10-01-70084-78	PAR Basin (phase 1)	113,002	113,002		No revisions carried out after work
7610-10-01-70084-75	PAR road, back-up line and power line	27,504	27,504		No revisions carried out after work
	Power line - East	1886	1886		No revisions carried out after work
	Electric pole north of the paste backfill	196	196		No revisions carried out after work
7610-10-01-70084-51	Tailings facility (phase 2)	56,950	56,950		Work ended
Not submitted	Tailings facility (phase 3)			76885	Estimate to be validated during detailed engineering
Not submitted	Tailings facility (phase 4)			74608	Estimate to be validated during detailed engineering
	TOTAL:	382,385	484,734	151,493	
In orange Surface areas already allowed without an offset commitment			36,741		
In green Surface areas already allowed without an offset commitment			447,993		
In yellow: Expected surface areas, but not yet allowed			151,493		

The direct impact of construction on ombrotrophic peatlands most often corresponds to the following activities:

- Deforestation, when necessary, and grubbing;
- Stripping of plant soil, and transporting with wood residues and stumps to the furniture material pile;
- Excavation of peat and transport to the loose-material pile or to the peat pile, depending on the case,
  - Excavation of clay, in some cases, to reach the bedrock, and transport to the drop-off clay area;
  - Blasting rock outcrops, crushing and reusing equipment;
  - Construction of the foundation, etc.

Some of the work located in peat bog, roads for example, are carried out by consolidation by overload. This method involves leaving the peat in place and covering it directly with the materials that make up the foundation layer of the road. Sometimes the bog will be covered with a geogrid to improve carrying capacity (**Figure 6**). This technique reduces the risk of disturbance to the environment.

Figure 6 - Example of backfill on geogrid (CA request of November 26, 2012)

When crossing a peatland, the installation of culverts installed in accordance with the practises prescribed by the RNI promotes a drainage as similar as possible to the one prior to construction.

Some peatland work consists of the construction of soil exploration trenches, which requires the movement of mechanical shovels in bogs over short distances. If necessary, soil protection measures are put in place on traffic lanes and work areas to ensure that increase soil carrying capacity and limit the formation of ruts. The protective measures are removed at the end of the work. During the excavation of peatland exploration trenches, a mechanical shovel is used to excavate soils at a maximum depth of 5 m to identify the nature of the materials and the depth bedrock. Approximately 5 x 10 m in size, the trench is then backfilled with excavated materials. The layer of organic matter, previously separated from the overburden, is placed on top after the backfilling of the slices.

Potential impacts on wetlands during construction and during operation were assessed in the study (Golder, 2010) and are summarized in the following tables.

Table 10 - Importance of Potential Impacts during the construction phase (Wetlands) (Golder, 2010)

Approximate value	**Degree of disturbance**	**Intensity**	**Geographic extent**	**Duration**	**Importance of potential impacts**
					☐ Very high
■ High	☐ High	☐ High	☐ Regional	■ Long term	☐ High
☐ Average	☐ Average	■ Average	☐ Local	☐ Medium term	■ Average
☐ Low	■ Low	☐ Low	■ Occasional	☐ Short term	☐ Low
					☐ Very low

Table 11 - Importance of Potential Impacts during the Operational Phase (Wetlands) (Golder, 2010)

Approximate value	**Degree of disturbance**	**Intensity**	**Geographic extent**	**Duration**	**Importance of potential impacts**
					☐ Very high
■ High	☐ High	■ High	☐ Regional	■ Long term	■ High
☐ Average	■ Average	☐ Average	☐ Local	☐ Medium term	☐ Average
☐ Low	☐ Low	☐ Low	■ Occasional	☐ Short term	☐ Low
					☐ Very low

Six small peatlands are completely extinct (MH47, MH50, MH54, MH58, MH60 and MH62), all of which are less than one hectare. Some 19 peatlands have been partially backfilled. **Table 12** Specifies the area encroached on each peatland and the responsible infrastructure.

Table 12 - Encroachment of peatlands

MH code	MH surface area (m^2)	Number of encroachments	Encroached surface area (m^2)	Remark	Reason
MH5	113,123	1	3398	MH potential	Airport
MH49	18,937	2	1979		
MH21	9276	1	1949		Transitional pile
MH22	300,635	4	25438	8 different sections encroached under 4 CA - 4000 separate from CA, mining camp era	Sterile dump and drilling
MH18	28,137	1	228		
MH31	12,305	3	4763		Industrial Area
MH33	17,348	3	17411		
MH34	15,116	2	1051		
MH35	10016	2	2802		
MH62	2728	1	2728	3 separate sections completely encroached	
MH54	513	1	513	Completely encroached	AEAT
MH58	4781	1	4781	Completely encroached	IWTP:
MH50	672	1	672	Completely encroached	Tailings facility and road
MH51	15,615	3	7055		
MH53	24,422	1	810		
MH55	3422	2	678		
HM59	676,975	2	169989	Encroached by 2 CAs and Phase I and II. Does not include some overlaps. Part of a larger bog.	
MH60	7366	3	7366	Completely encroached by Phases I and II	
MH61	483,944	5	394172	Includes a section considered peatland by the MELCC; encroached by 2 CAs and phases II, III and IV to come	
Total	**1,745,331**	**-**	**647783**		

Peat removed from peatlands for work is estimated at two million cubic meters, a carbon mass equivalent to 85 kilotons (**Table 13**). This amount represents about 30% of the total peat present in the study area.

Table 13 - Estimate of peat and carbon removals

Peatlands	Location:	Encroached surface area (ha)	Average thickness (m)	Estimated peat volume (m^3)	Carbon mass (kg C/m^2)[1]	Total carbon mass (kt)	Equivalent CO_2 (kt)[2]
MH59 and MH61	Tailings facility	56.4	3.25	1,833,524	135	76	280
Other peatlands	Other sectors	8.4	2.25	188,152	103	9	32
Total	**-**	**64.8**	**-**	**2,021 675**	**-**	**85**	**311**

[1] Ratio drawn from Garneau et al. (2014)
[2] One ton of carbon is equivalent to 3.67 tons of CO2 (Olivier et al., 2015)

With respect to carbon sequestration, estimated at a rate of 0.23 t C/ha/year (Garneau et al., 2014; Baird et al., 2009), this biogeochemical activity ceased in the encroached areas of peatlands. Thus, after encroachment, the rate of carbon sequestration decreased by 15 tons/year (**Table 14**). Since one ton of carbon is equivalent to 3.67 tons of CO2 (Olivier et al., 2015), this equates to - 55 tons of CO2 equivalent per year.

Table 14 - Impact of carbon sequestration on encroachments

	Peatland surface area (ha)	Sequestration	
		Carbon (t/year)	Equivalent CO_2 (t/year)
Before encroachment	175	40	147
After encroachment	110	25	92
Reduction due to encroachments	- 65	- 15	- 55

To quantify the residual impact on peatlands, the Quality-hectare index was calculated. By multiplying the quality index calculated in the previous chapter by the encroached areas, we obtain the residual impact, i.e. a loss of - 57 QH of bogs. Some 3 QHs were authorized without an offsetting commitment, representing 5% of the total. Calculations are shown in **Table 15**.

Table 15 - Calculation of the residual impact on ombrotrophic peatlands.

Peatlands	Surface area (ha)	Pre-impact quality (0-1)	Post-impact quality (0-1)	Quality-hectare index (QH)
MH59 and MH61 (with commitment)	56.4	0.9	0	- 50.8
Other peatlands (without commitment)	4.3	0.8	0	- 3.4
Other peatlands (without commitment)	3.97			- 3.2
Total	64.7	-	-	- 57.4

4. Impact on water and shorelines

Since encroachments on water and riparian environments are minimal, less than half an hectare (4473 m^2), this section will be less thorough than the previous one, dealing with wetlands. However, as there are legal commitments to compensate for some of these losses (289 m^2, or 6% of the total), it is necessary to estimate them quantitatively (**Table 16**). The habitats treated here are of four types: permanent and temporary fish habitats, water environments and their riparian strips that do not harbour a fish population.

Table 16 - Summary of peatland encroachments by CA

Request for certificate of authorization	Title	Surface area (m^2)			
		Fish habitat		Waterborne environment	Shoreline strips
		Permanent	Temporary		
7610-10-01-70084-67	Sea discharge	62			
9510-001-35-969	Simoneau bridge	154			508
7610-10-01-70084-68	PAR road (east section: 0 +000 to (2+050)	43	17	50	2,054
7610-10-01-70084-75	PAR road, back-up line and power line			117	1,175
7610-01-10-70084-81	IZ runoff (art. 32)	14	60		60
7610-10-01-70084-81	Industrial runoff water management- 2016	6			120
7610-10-01-60058-25	Hydro-geological Drilling - Summer 2013	1			
7610-10-01-60058-28	Hydrogeological drilling and geotechnical surveys - summer 2015	32			
	TOTAL:	**312**	**77**	**167**	**3917**
In orange Surface areas already allowed without an offset commitment		207	60	0	3917

Request for certificate of authorization	Title	Surface area (m²)			
		Fish habitat		Waterborne environment	Shoreline strips
		Permanent	Temporary		
In green Surface areas already allowed without an offset commitment		105	17	167	

4.1 Ecological value of water environments

The encroachments occurred in five different ecosystems, the Opinaca Reservoir and four different streams visible on the general map (**Appendix 1**): Simoneau stream, codified R2, and three other unnamed streams, R4, R5 and R6. The seven small natural lakes that dot the edges of the industrial zone and the PAR have not been encroached.

4.1.1 Opinaca reservoir

Since 1980, the installation of various infrastructure for hydro power generation has led to the creation of the Opinaca reservoir. With a maximum area of 1040 km^2, an average depth of 8.2 m and a volume of 8.4 km^{3,} this is the main body of water in the study area. The flows and levels are managed by the Sarcelle regulatory structure, located at the northern end of the reservoir, according to hydroelectric needs and not natural conditions. In fact, the operating level of the reservoir fluctuates by 4 m, between the ratings of 215.80 and 211.84 m while the average annual level is 212.05 m. (Hydro-Québec, 2004). The deep areas of the reservoir are located at the site of the ancient lakes, including Ell Lake located in the study area. The flow into the Opinaca reservoir is very slow, even at the highest flows, and the reservoir freezes like a lake from the beginning of November.

Golder (2010) has characterized the Opinaca Reservoir ecosystem. Its shores are made up of a sandy and sometimes organic deposit, on which have sometimes developed riparian wetlands. These environments are also present along lakes or other rivers found in the study area. In the upper part of the shore there are shrub swamps composed of balsam, rough alders and willows. Bulrush and sedge marshes sometimes colonize the lower parts of the Opinaca Reservoir shores.

According to the available information, 20 species of fish are present in the Opinaca reservoir. According to fishing campaigns on the coastal area of the reservoir (Roche, 2007b, Roche, 2007g and Roche, 2007k), the great species caught most abundantly are the great whitefish, the great northern pike and walleye. Burbot, cisco, the longnose sucker, the white sucker and perch were also commonly caught along the shoreline.

Lake sturgeon (*Acipenser fulvescens*) have a status of concern according to COSEPAC and likely to be designated a provincially threatened or vulnerable species Studies by Hydro-Québec indicate that the lake sturgeon population uses primarily the Opinaca River and the portion of the basin near the mouth of the river. Near the industrial water discharge point of the Éléonore mine, the area is not considered to be a habitat heavily used by lake sturgeon (Golder, 2010).

Therefore, based on habitat use by major fish species, an **average ecosystem value** was assigned by Golder (2010). In line with this assessment, and since the reservoir is a semi-natural habitat created by humans and the study area is little used by lake sturgeon, a quality of 50% has been given Q as the quality index = 0.5.

4.1.2 Creeks

The water system in the study area is not very branched. In general, drainage is done in the direction of the Opinaca reservoir. Most of the habitats involved are channel-type lentic environments. Some of the streams in the study area have been investigated (Roche, 2007k; Geodefor, 2009b).

R2 creek flows from L2 Lake to Opinaca Reservoir. The width of its channel varies between 10 and 23 m, while the width of the flood varies between 1.6 and 2.4 m. At the time of the habitat assessment, the depth of the water varied between 0.19 and 0.34 m, the current was 0.19 m/s and the flow estimated at 0.07 m3/s. The substrate was made up of a predominance of blocks, with sand and organic matter. Vegetation covered 30-100% of the water surface and riparian vegetation consisted mainly of balsam and alder. In places, water flows under terrestrial vegetation, through the gaps between blocks of different sizes.

R4 creek flows from the L4 water body to the Opinaca Reservoir. The flooded width of the stream ranges from 0.7 to 2.1 m, with a channel width ranging from 5.6 to 26.5 m. In some places, water flows through large blocks or underground; the average depth was 0.15 m at the time of the survey. In the upper stream, the current is slow, and the substrate consists of hard sediments (block pebbles) and organic matter. In the lower reaches, the current is faster, and sand forms a larger proportion of the substrate. The riparian vegetation consists of alder, balsam and meadowsweet and forms a canopy of 10 to 100% above the stream.

R5 creek is in the western part of the study area. It flows into R1 stream, which flows into the main bed of the reservoir. There is a channel defined from the confluence with R1 creek to about 1.5 km upstream. In the permanent part of the channel, the water depth was 0.6 m up to more than 1 m and the substrate consisted of organic matter. The average width was 2 to 3 m, with a maximum of 6 m. The maximum width of the channel is estimated at nearly 75 m. The riparian vegetation consists of various grasses and shrubs. No aquatic vegetation is observed in the channel, although terrestrial vegetation is sometimes flooded. In the southern part of the stream, the habitat potential of the fish is considered nil or limited, given the characteristics of the habitat.

No surveys have been made in R6 stream, but it is thought to be like the previous ones.

According to Roche (2007b and 2007g) the spotted Chabot, burbot, the longnose sucker, and perch are found in these streams.

Because this type of ecosystem is common in the landscape and it has no single attribute, because its use by fish is reduced, because its level of naturalization is great, because no disturbance was detected there, 80% quality was granted to it, i.e. Q - 0.8. This index will apply to both the river itself and its waterfront.

4.2 Residual impact

Some eight CAs were awarded encroachments into the water and shoreline environments. (**Table 16**). The encroachments resulting from these authorizations are presented in **Table 17**.

Table 17 - Encroachment in water and shoreline environments

Code or name	Length of stream (m)	Number of CAs	Encroached surface area (m^2)				Remark	Reason
			Permanent fish habitat	Temporary fish habitat	Waterborne environment	Shoreline strip		
Opinaca Reservoir	N. d.	3	95					Drilling and underwater pipeline
Creek 2 or Simoneau	1277	1	154			508	Encroachment in the section of the stream below the maximum reservoir rating	Simoneau bridge
Creek No. 4	540	2	20	60		180		Bridges and stream water
Creek No. 5	2348	1			117	1175		PAR road
Creek No. 6	634	1	43	17	50	2054		Bridge and power line
Total		**8**	**312**	**77**	**167**	**3917**		

In the reservoir, these approvals resulted in hydro-geological drilling and geotechnical surveys during the summers of 2013 and 2015, as presented in the section. There was also the impact of the installation of the underwater pipeline. These impacts were minor: 95 m^2 of the permanent fish habitat.

Some river crossings required permits. The work required clearing the shoreline and in some cases the widening of the Simoneau Bridge (**Figure 7** and **Figure 8**), the drying up of the work areas, the earthworks and protection of abutments and stabilization of embankments by rockfill.

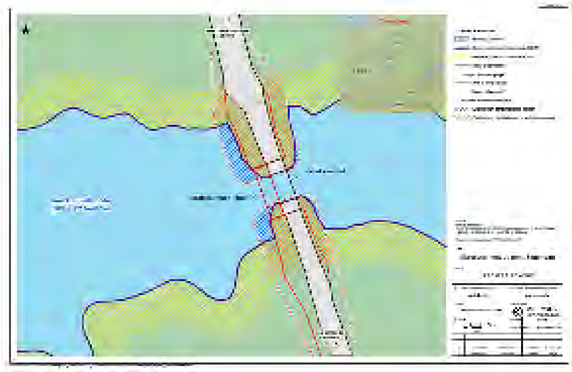


Figure 7 – Simoneau bridge before its widening

Figure 8 - Simoneau bridge widening plan drawn from SNC-Lavalin (2012)

In other cases, for example for the crossing of R5 creek by the traffic road and the back-up line, a circular culvert, with a diameter of 1000 mm and a length of 36 m, was installed in the creek on the entire width of the right-of-way.

The impact mitigation hierarchy has been implemented as part of this work. One example among other measures of impact minimization: work in the fish habitat was carried out outside the restricted period for aquatic fauna from April 15 to June 15.

The residual impact on water and riparian environments was also calculated using the Quality-hectare index (**Table 18**). In conclusion, the residual impact due to water and shoreline encroachments is -0.4 QH, of which 6% includes an offset commitment. This impact corresponds to 0.6% of the calculated impact for peatland encroachments.

Table 18 - Calculation of the residual on the water and shoreline environments

Ecosystem	Habitat type	Surface area (m^2)	Pre-impact quality (0-1)	Post-impact quality (0-1)	Quality-hectare index (QH)	QH with commitment	QH with no commitment
Opinaca Reservoir	Permanent fish habitat	95	0.5	0	-0.005	-0.003	-0.002
Streams	Permanent fish habitat	217	0.8	0	-0.017	-0.004	-0.013
	Temporary fish habitat	77	0.8	0	-0.006	-0.001	-0.005
	Waterborne environment	167	0.8	0	-0.013	-0.013	0
	Shoreline strip	3917	0.8	0	-0.313	0	-0.313
Total		**4473**	**-**	**-**	**-0.354**	**-0.021**	**-0.333**

5. Summary

Given the small amount of water and riparian environments to be compensated (-0.4 QH), the residual impacts related to both types of environments were affected for a total of 58 QH of wetlands. The details of the calculation of the total residual impact to be offset are presented at the **Table 19**.

Table 19 - Total residual impact for all impacted environments

	With offset commitment (QH)	With no offset commitment (QH	Total (QH)
Wetlands	-54.2	-3.2	-57.4
Water environments	-0.02	-0.02	-0.04
Shoreline environments	0	-0.31	-0.31
Total	**-54.22**	**-3.53**	**-57.75**
Proportion	94 %	7 %	100 %

MOL management decided to compensate for all residual wetland, water and shoreline losses that have been quantified in this section, regardless of whether there was a commitment legal or not. This is about 7% more than was contractually requested in CAs.

C. EXCHANGE EQUIVALENCE

It is proposed by MOL that the 58 QHs to be offset be the subject of habitat development different from those that have been lost. This corresponds to the results obtained by Bois-Charlebois (2018) during his research as well as during his consultations with the Cree. In fact, it has demonstrated that the ministry's guidelines contained in the guide Wetlands and Environmental Authorization (Government of Québec, 2012) are difficult to apply in the territory of Eeyou Istchee. The proposed offset offsetting options are based on the fact that the wetlands of southern Québec are few and very threatened by human activities, while those in the north are numerous and not very threatened.

To ensure that the exchange is fair, it is necessary to respect the rules of the art, which are divided into a set of principles that incorporate the recommendations of Bois-Charlebois. The purpose of this section is to present them and demonstrate that the proposed exchange respects them.

1. Offset principles

The following principles are derived primarily from the recommendations of the Business and Biodiversity Initiative (BBOP, 2012), IUCN (2014) and Pilgrim and Ekstrom (2014).

Application of the impact mitigation hierarchy

The goal of zero net wetland loss can only be achieved using offset measures if adherence to the impact mitigation hierarchy has been demonstrated. In the previous chapter, it was noted that both the impact on peatlands (Section 3.2.2) and the impact on water and riparian environments (Section 4.2) were the subject of avoidance and minimization measures.

Limits to be offset

There are situations where certain types of environments or habitat of certain rare species cannot be compensated because of their irreplaceability or vulnerability to extinction. This does not apply to common habitats that have been lost.

Technical ability to offset

In 2019, creating an bog ecosystem remains technically out of reach. However, the restoration of damaged peatlands in the past is possible. A review of the success of different types of offsetting has yielded more success for water environments and certain types of open and emerging plant marshes (Castelle et al., 1992). It was shown that it is very difficult if not impossible to replicate a bog.

The proposed offset measures must take these limits into account and rely on complementary actions for other natural elements.

Social equity

An offsetting plan must be designed in a fair manner. Risks, responsibilities, disadvantages and benefits must be distributed among stakeholders in a balanced and fair manner, respecting local customs and regulations. Special considerations are needed to respect the rights recognized nationally and internationally to indigenous peoples. Families responsible for the VC22, VC28 and VC29 trap territories should be given priority to the projected biodiversity and ecological service gains. Projects designed without the participation of Indigenous Peoples should not be imposed. This plan aims to align with local concerns and contribute to cultural survival as recommended by Mulrennan *et al.* (2012).

Involvement of interested parties

The best way to reduce the risk of failure of offset measures is to include the various stakeholders throughout the planning and implementation process through targeted, participatory and respectful of Cree culture. This requires transparency, guaranteeing a process free of corruption and conflict of interest. The planning of offsetting measures must be based on a solid scientific basis as well as on traditional environmental knowledge. In our case, the expertise is loud. Local governments must intervene in the area of territorial planning and the protection of developed sites.

Implementation of offset measures should generate equitable long-term partnerships, collaboration at every stage with local institutions, promotion of joint learning and capacity building all partners.

Process flexibility

It is advisable that the selection process for offset measures be flexible to allow the selection of solutions best suited to the circumstances. So far, the best results have been achieved when a variety of stakeholders had been involved in the process.

Probability of persistence

Each biodiversity gain has a risk of disappearing due to known or unknown factors at the starting point. All known risks must be assessed considering current knowledge to minimize them and ensure long-term results. A monitoring program is needed to assess the evolution of ecosystems developed as offsetting. This follow-up should be able to identify whether interventions are needed, such as the control of invasive alien species. Long-term adaptive management is needed to ensure that the result of tracking clearing sites is incorporated into decision-making and that the necessary measures are implemented to sustain earnings. This means that an organization must vouch for long-term results and be accountable for the maintenance of offsetting sites.

Clear accounting

Especially if the offset is subdivided and distributed in several different locations, it is necessary to adequately quantify the gains made by the various developments to counter any criticism, later. The indices used must be precise and pragmatic. In fact, they must avoid multiplying the number of elements to be offset, without being too vague to allow offsetting by any type of ecosystem.

National or regional targets

Wetlands are Québec-wide ecosystems that are prioritized to achieve the goal of "zero net loss." This target, which applies to the entire province, is based on an analysis of the wetland situation south of the province. Indeed, in the southern region of Québec, wetlands are rapidly disappearing, and their ecological, monetary and socio-cultural values justify a specific law dedicated to their conservation. No regional targets apply to the wetlands or water in Jamesia or the territory of Eeyou Istchee, although many wetlands have disappeared locally due to hydroelectric projects in the past.

Additionnality

The offsetting plan must generate gains in biodiversity and ecological services that are greater than what would have been observed without its implementation. To properly assess the additionality, it is necessary to know well the state of reference, that is, the evolution of ecosystems that would have occurred without the application of offset measures.

2. Terms of exchange

For the exchange between losses and gains to be adequate, four aspects of equivalence must be considered: in time, in space, in quality and in quantity.

Time equivalence

The biodiversity gains covered by the offsetting plan must endure at least if the impacts are to be observed. If the impacts are permanent, such as the residual impacts considered in this case, the gains must be permanent as well. Thus, the concept, implementation and follow-up of the proposed offset measures must ensure that the gains are long-term, if not forever.

The reference period for an offsetting plan is the period at which the target of zero net loss is expected to be met. Often, in mining projects, the goal is to achieve zero net loss at the end of the project and its closure phase. Ideally, by this time, planting must have reached a maturity that corresponds to the expected quality gains.

Equivalence in space

Offsetting measures are usually located near impacted sites. In fact, the location of the offsetting is important to users of the lost ecosystem. There are also the hydrological consequences of the loss of the wetland that advocate offsetting in the same watershed as the one where the loss of ecological function took place. In our case, the trapping territories VC22, VC28 and VC29 are targeted.

However, in terms of biodiversity conservation, the optimal site is not necessarily close to the impact site. Investments could be more profitable for biodiversity if they are made at a site prioritized as part of regional planning.

When there are various industrial development projects that must offset for residual impacts, it is sometimes better to group the different developments to carry out a project of more with more partners and more chance of success.

In other cases, it may be necessary to consider multiple clearing sites, each development having the objective of increasing a particular element of biodiversity or an ecological service. This may also be necessary when stakeholders have divergent objectives.

In a case like this, where vast areas are sought, it seems difficult to find a single site large enough to carry out all the necessary offsetting measures. It is easier to find several small clearing sites that, when combined, will equal the desired biodiversity gain.

Quality equivalence

In general, the biodiversity elements lost are offset by gains corresponding to those same elements. Thus, a loss of cattail marshes is usually compensated by the development, restoration or protection of a cattail marsh.

Where this is not technically, politically or socially possible, the "equal or better" rule is used to select the type of environment that will be the subject of the offset measures. This rule is based on the conservation value of lost items. Thus, low-interest environments can be offset by environments with a higher conservation value (BBOP, 2012; Pilgrim and Ekstrom, 2014). Nature-Serve grades are useful in determining whether alternative ecosystems are of greater conservation value. Pilgrim and Ekstrom (2014) also advocate offsetting by environments that generate priority ecological services.

This type of exchange should only be concluded if there is a strong social consensus to this effect. It is, therefore, important to carefully record the exchanges with the stakeholders to preserve the evidence that led to the social acceptance of the exchange.

In our case, we would have to obtain gains from wetlands, ideally from bogs. However, for the following reasons, offsetting will be done differently:

- Low conservation value (G5) given to this type of wetland (see section conservation value),
- Low uniqueness of peat bogs in the regional landscape,
- Ecological services generated by locally undervalued peatlands,
- Significant carbon sinks,
- Low Indigenous value given to peatlands,
- Great technical difficulty to create a bog.

Thus, the gains in biodiversity will instead be realized by the creation or restoration of environments with a higher conservation value, generating ecological services valued locally, because lost, rare or in decline, and also acting as carbon sinks. These new environments will need to be developed without jeopardizing existing habitats with greater conservation value, while integrating judiciously into existing ecosystems.

Quantity equivalence

The number of wetlands and water to be compensated was calculated in the first chapter, dealing with the residual impact, i.e. - 58 QH. In theory, offsetting measures should create the same amount. But in fact, this amount is often multiplied by an exchange ratio, or multiplier. Ratios are recommended for the following reasons (Castelle et al., 1992):

1. **To ensure a significant positive contribution to national or regional targets.** Multipliers can be applied to prioritized types of ecosystems such as, for example, in Bill 132 on wetland and water conservation where the R multiplier varies from 1 to 2, depending on the wet or water scarcity by region. The R-2 ratio applied to metropolitan areas is intended, in particular to discourage developers from encroaching on these environments. As the site of this project is part of Zone 3, a non-priority area, the multiplier is equal to 1.

2. **To reduce the uncertainty associated with the success of compensatory measures.** It is difficult to predict the feasibility of restoring an environment and the success rate of such a development project. In the event that the risk of failure is high for a particular type of development, a higher multiplier is chosen to ensure that, in the end, the desired gain has actually been achieved. This is relevant when the landscaping methods used for offsetting are not well known and well-established. The ratio is intended to create a surplus that acts as a guarantee of the success of the offsetting plan.

3. **To compensate for the temporary loss of ecological services.** A temporary reduction in biodiversity has no negative influence, if no one uses it and if the gain adequately replaces the loss at the end of the reference period. However, if priority ecological services become unavailable to their beneficiaries for a period of time, this represents a net loss of benefit for those who have used to appreciate them. This is why multipliers can be used to compensate for the temporary loss of ecological services. It is as if, to be forgiven for reducing certain benefits to local people for a period of time, they choose to provide more in the long run.

In this case, the recommended ratio is 1 for the following three reasons, corresponding to the three previous paragraphs:

1. Bogs are not a national or regional target.

2. Although not all of the offsetting measures chosen are commonly implemented, reliable and guarantees of success, the fact that they are planned over 20 years gives ample time to adjust in case of technical problems.

3. Encroaching peatlands did not generate priority ecological services for Cree users.

3. Preferred directions

To comply with the stated principles and the terms of exchange presented, offsetting measures should meet the following criteria:

- A flexible consultation process for The Cree and various government institutions is needed;
- The involvement of the various stakeholders, including the various Cree institutions, must be made as soon as offsetting measures are designed, during their implementation and during their follow-up;
- Focus on near-impact developments, either near the industrial site and along the road;
- Focus on facilities with a high success rate and having already been carried out under similar conditions;
- Focus on the use of sites to be restored for offsetting measures;
- If a high level of risk is associated with the types of development because of their innovative nature in the northern environment, a ratio of more than 1 could be applied to offset for possible failures;
- Aim for zero net loss of biodiversity at the end of the mine's life;
- Plan to ensure that by the end of the mine's life a large part of the plantings has reached sufficient maturity for the habitats created or restored are of a high quality and that the accounting shows that the intended gains are achieved. This is possible with gradual restoration;
- If the offsetting measures comprise various types of development located at various sites, some of which are in partnership, a rigorous development and earnings monitoring program should be planned biodiversity, including a precise and transparent accounting system.

D. BIODIVERSITY GAIN STRATEGY

1. Ministry guidelines

According to departmental guidelines on wetlands and environmental approval (MDDEP, 2012), offsetting measures include:

1. **Restoration**, the restoration of a degraded wetland;
2. The **creation** of a new wetland;
3. **Protection**, such as wetlands of conservation interest, or when it strengthens connectivity between various wetlands or participates in a biological corridor project;
4. Or the **ecological enhancement** of an existing wetland or its ecotone, that is, by developing it to increase its functions and its ecological value. The ministry states that in Abitibi and northern Québec, this option may be acceptable in terrestrial environments without a combination with a wetland. This means that developments increasing biodiversity and ecological services of terrestrial habitats are possible for Éléonore.

2. Éléonore's context

The Éléonore mine is located in a fairly natural landscape. Near the industrial site, the most marked human footprint is the Opinaca reservoir, a body of water created by Hydro-Québec 35 years ago. The main anthropogenic land site is the Sarcelle power plant complex, located 34 km west of the mine.

There are no degraded wetlands in this pristine territory. Similarly, terrestrial environments are very natural. The potential is, therefore, very limited in terms of restoration. However, as it is mainly a sparse forest of black spruce and grey pine, which partially burned in fires dating back to the 1990s and early 2000s, there are development potential in terms of forest planting. In fact, the forest area is about 14% in the study area.

The only visible "scars" are the infrastructure associated with the mining project itself. This is where the main dining and development opportunities lie. This is why the option chosen is to obtain gains in biodiversity and ecological services necessary to offset for the losses identified previously by developing the sites degraded by the project, beyond the minimum restoration required by law.

3. Development of sites degraded by the project

Concept

Some definitions from the Conservation Lexicon (Limoges et al., 2013):

Ecological rehabilitation:	Actions to restore certain minimal natural features to a degraded, contaminated or completely artificialized site.
Ecological restoration:	Actions aimed, in the long run, to restore a more natural character to a degraded or artificialized ecosystem, in terms of its composition, structure, dynamics and ecological functions.
Sustainable landscaping:	Ecosystem interventions to maintain or increase the productivity of biological resources or other ecological services.
Sustainable enhancement:	Interventions to promote the sustainable use of an ecosystem or biological resource.

In theory, sites disturbed by the project cannot be used for offsetting, since there is already a legal obligation to rehabilitate and restore them. However, the gain in biodiversity and ecological services needed for offsetting could be generated by going beyond simply restoring degraded sites as required by law, i.e. to transform them into productive habitats and thus generate ecological services (**Figure 9**).

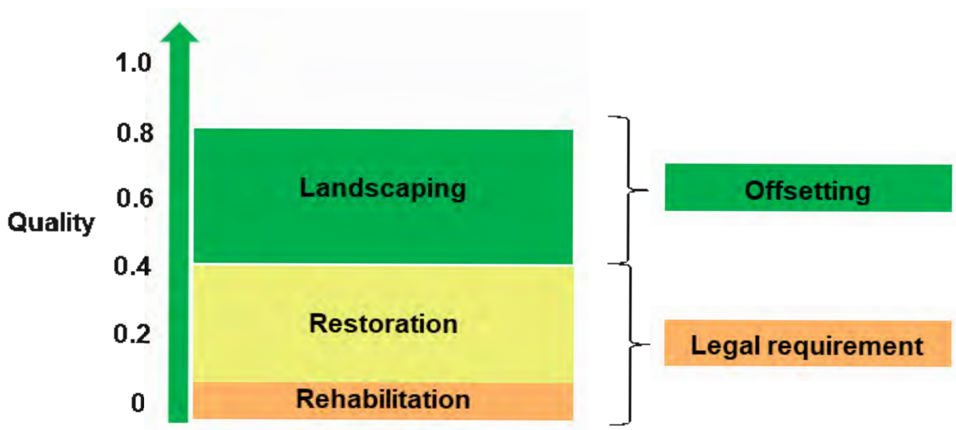


Figure 9 - Quality gain through landscaping beyond statutory restoration

Let's look at the various documents governing the standard of restoration required by law in the case of Éléonore.

Remediation plan

Éléonore's remediation plan covers all sites that have been disrupted by the construction or operation of the mining project and support infrastructure (Goldcorp, 2011). They must be rehabilitated or gradually restored once their use has been completed. In fact, “The objective of the gradual restoration is to ensure that the site is returned as quickly as possible to its natural environment’’. In it’s restoration plan, MOL aims in particular:

- The re-vegetation of the tailings facility at the end of each phase,
- The grading and revegetation of borrow pits after the use of materials.

The objectives of this restoration work are to restore the site to a satisfactory state, in other words:

- Eliminate risks;
- Limit the spread of harmful substances;
- Aim at eliminating all forms of maintenance and follow-up;
- And return the site to a condition that is visually acceptable to the community.

The sites to be restored are divided into two groups, depending on the technical challenge associated with each:

1. Tailings facility. The other piles (sterile, clay, peat...) are temporary storage sites whose equipment will be used during the active life of the mine or during its closure
2. The industrial site and road, which include using the borrow pits, access roads, site of the various components of the mining process, camp, wastewater treatment facility.

Regarding the tailings facility, which is expected to have a total footprint of 80 hectares, the purpose of MOL's restoration plan is to return the land to conditions that meet the requirements of the decree issued by the Government of Québec and authorizing Opinaca Mines for the Éléonore gold mining project, especially those related to contaminated leachate releases. When the restoration plan was drafted in 2012, it was expected that, when they reached their final level, the residues would be covered with geomembrane, natural soils and vegetation. It is not specifically a question of reforestation, but rather of developing techniques that are environmentally acceptable and that will meet the needs for closure. Vegetation on the tailing could be herbaceous or shrubs.

On other surfaces, restoration work is aimed at the vegetation of unused sites. "Rolling surfaces, embankments, cuttings and embankments will be redeveloped to prevent erosion; rolling surfaces and roads deemed unnecessary will be scarified, levelled and reforested. ((...) Quarries and sandpits will be regaled in accordance with the Quarry and Sandpit Regulations, which state regulations mention ‘’ restoration of soil cover (trees, shrubs, lawns) culture)" (Q-2, r. 7 - Quarry and sandpit regulations).

The MERN guide

This guide is silent on the type of vegetation to be implanted during restoration. "All land affected by mining activity (e.g., building site and mine waste and waste rock accumulation areas, road surfaces and shoulders) must be set up to control erosion and restore the site to a natural appearance in harmony with the surrounding environment. (…) return the site to a condition that is visually acceptable to the community. (...) Once in place, plants must be robust, sustainable in the long term and require no amendments or maintenance to maintain them. It is recommended to choose native plants, herbaceous plants or shrubs." In short, all that is required is that it be green, stable and visually acceptable.

Examples of restoration according to the standard required by law

To assess the quality of the restored environments according to the standard required by law, various examples of restored sites were examined. An effort was made to select sites at the same latitude, under similar conditions.

Sarcelle

The first reference is a site restored by the James Bay Energy Corporation (SEBJ) near the Sarcelle Power Plant. The site was visited in 2014 (**Figure 10**). The vegetation is made up of two strata. The hydraulically seeded herbaceous stratum is probably the SEBJ mixture of seven species of grasses and exotic legumes. In the shrub layer, the green alder was planted in a row probably at an average density of 3000 plants/ha. As has been demonstrated elsewhere in James Bay, this helps restore soil fertility, reduce wind and water erosion, and accelerate return to natural conditions (Polygéo, 2008).

It is a man-made ecosystem that includes some native species but is very undiversified both on a specific and structural scale. Based on the quality determination template (**Table 2**), the quality of the ecosystem created by restoration is estimated at 40% (Q-0.4), as shown in **Figure 9**.


Figure 10 - Site recently restored by the SEBJ near the Sarcelle power plant: left in 2014, right in 2017.

Opémiska Mine

Through an Access to Information request, two documents relating to the restoration of an orphan mine were obtained, work that was carried out by the "Ministère des Ressources naturelles et de la faune" from 2009 to 2011. This is vegetation work following the failure of the southern dyke of the Polishing basin of the Opémiska mine, located near Chapais. The documents obtained are the vegetable estimate (Ecogeny and SNC-Lavalin, 2009) and an inspection report (Ecogeny, 2009).

Four terrestrial sections were vegetated. Two sections (26 ha and 2 ha) were only hydraulically seeded with herbaceous mixtures adapted to the environmental conditions (**Figure 11**). The mixtures contained 5-10 exotic herbaceous species, only grasses and legumes.

Figure 11 - Illustrations from the Inspection Report (Ecogeny, 2009) showing seeding

Two other sections were seeded in the same way, this time accompanied by trees (larch, black spruce, balsam poplar) and shrubs (green and speckled alder, discoloured willow) at a density of 400-500 trees and shrubs per ha. Trees and shrubs were planted in small islets, which means that the majority (up 90%) surfaces have only been vegetated with herbaceous plants.

A rigorous follow-up was conducted to ensure a recovery rate of more than 70% for seeding and a survival rate of more than 80% for planting trees and shrubs.

In conclusion, the vegetation work commissioned by the Ministry of Natural Resources and Wildlife consisted mainly of various but exotic herbaceous seedings aimed primarily at stabilizing soils and shorelines. These were man-made ecosystems that included some native woody species, but mostly exotic herbaceous species. Based on the quality determination template (**Table 2**), the quality of the restored ecosystem is estimated here at 40% (Q-0.4).

Gain beyond the restoration standard

The development of a quality wildlife habitat or an ecosystem that generates valued ecological services could create an environment of around 70% quality (Q-0.7). Of course, these values are hypothetical estimates used to assist in the decision. The difference between the two would be a 30% gain (Q-0.3), which could be considered an eligible compensatory measure (**Figure 9**).

4. Offsetting sites

Potential offsetting sites are sites to be restored that have been divided into four categories:

A. sandpits;
B. quarries;
C. stretches of road;
D. and the industrial zone.

They have been mapped on a very detailed map that is in **Annexe 3**. A representation is inserted here as an indication (**Figure 12**).

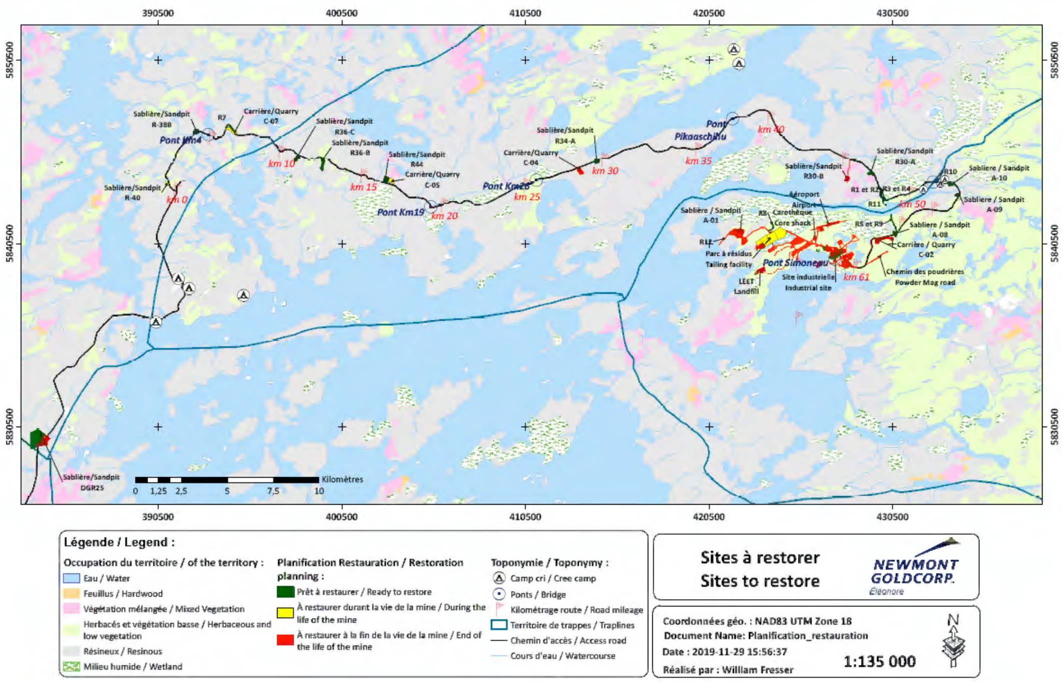


Figure 12 - Sites to be restored

4.1 Sandpits

The sandpits are borrow pits where sand and gravel have been extracted since 2007. They are spread along the main road and around the industrial site. At least 12 sandpits have been used in the past decade. Depending on their past or projected use, they have been subdivided into 17 sections (**Table 20**).

In this table, as in the map, a colour code was adopted:

- The sites ready to restore are in green;
- The sites that will be ready to restore a little later in the life of the mine are in yellow;
- And the sites that can only be restored at the end of the mining project are in red.

In the case of sandpits, eleven are shown in green; they are, therefore, closed and ready to be restored. The other six are still in use, they are yellow or red.

Sandpits must be restored under certificates of authorization obtained under the Regulation respecting pits and quarries, Environment Quality Act (Chapter Q-2, r. 7).

Over the years, a considerable amount of granular materials needed for the various phases of the project have been extracted. These sandpits were used during the construction of the winter road, then during the construction of the permanent access road, about 60 km long, as well as several secondary accesses. Granular materials have also been used for concrete manufacturing, in embankments and dykes, for the stabilization of abutments and as a granular cushion to support industrial infrastructure such as camp areas workers, airstrip, industrial storage areas, wastewater treatment plant, etc.

The deposits exploited by the borrow pits of this region are generally shallow, about five meters deep, which often requires the mining of large areas to obtain large amounts of aggregates. The deposits mined at the sandpits consist of approximately 25% gravel, 25% fine sand and 50% medium to coarse sand.

The study area is located northeast of the Sakami Moraine, which consists of river-glacial and pro-glacial materials forming vast deltaic plains or long, asymmetrical ridges whose dimensions may be 8 km x 6 km x 40 m (Hardy 1982). These deposits align perpendicular to the eskers and ice flow marks. Thicknesses of up to 80 m of sand-gravel accumulations well sorted by glacial melting waters were observed. The composition of the moraine layers is clearly dominated by well-sorted sands and gravel. Variable proportions of pebbles are added in some segments or layers, while silt beds appear locally in accumulations at low altitudes. The materials are composed of laminated sand, gravel and pebbles, and the percentage of silt is less than 2%. The distribution of these granulometric components within deposits is complex and changing. These extensive repositories of construction-prone materials have been extensively used for hydroelectric developments in the James Bay, including the construction of LG-2 and the Eastmain and Opinaca River diversions.

The development of the sandpits began with deforestation and storage of discovery land and vegetal soil been swathed, in preparation for the restoration of the site. Operations must always be carried out more than one metre above the groundwater table.

Six sections of sandpits are still used regularly while eleven others are now useless and need to be restored (**Table 20**). Most of the sandpits to be restored have not been emptied of all the granular materials available. Rather, their end of their useful life is justified by the fact that the construction work is completed and that those that remain active are considered sufficient to meet the projected demand during the life of the mine. Of the eleven sandpits to be restored, five have already been fully or partially re-raped, to reduce the steep slopes characteristic of the sandpits and bring them back to slopes 30o compared to the horizontal.

Of the eleven sandpits to be restored, five have already been fully or partially re-raped, to reduce the steep slopes characteristic of the sandpits and bring them back to slopes 30° compared to the horizontal.

Table 20 - Characteristics of the sandpits

Codes	Location:	Surface area (m^2)	Current use	Substrate granulometry	Trap line	Restoration
Sandpits ready for restoration						
DG-R25-O (West)	20 km before the start of the road	494,000	-	Sand, moraine	VC22	Former HQ sandpit now under the responsibility of MOL. Reprofiling done by HQ.
R-38-B	4 km	30,000	-	Sand, gravel	VC22	-
R-36-C	11 km	39,000	-	Sand, gravel	VC28	-
R-36-B	13 km	69,000	-	Sand, moraine	VC28	North-west part already re-profiled
R-44	16 km	68,000	-	Sand, moraine	VC28	Only deforested and little exploitation in the past (30 trips).
R-34-A	29 km	30,000	-	Sand, moraine	VC28	-
R-30-A	47 km	29,000	-	Sand, moraine	VC28	-
A-10	52 km	29,000	-	Sand, gravel	VC29	Reprofiling completed
A-09	53 km	20,000	-	Sand, moraine	VC29	Some sectors have already been re-profiled
A-08-B (northern part)	57.5 km	12,000	-	Sand, moraine	VC29	Organic soil already on site
A-08-A (southern part)	57.5 km	17,000	-	Sand, moraine	VC29	Some of the organic soil stored in the northern part could be used
Subtotal	**11 sections**	**837,000**				

Codes	Location:	Surface area (m^2)	Current use	Substrate granulometry	Trap line	Restoration
Sandpit to be restored during the life of the mine						
R-40	1 km	29,000	Crushed storage to use later	Sand, moraine	VC22	-
Subtotal	**1 section**	**29,000**				
Sandpits to be restored at the end of mine life						
DG-R25-O (East)	About 20 km before the start of the road	145,000	Extraction	Sand, moraine	VC22	Former HQ sandpit now under the responsibility of MOL. Partially re-profiled by HQ.
DG-R25-E (East)	About 20 km before the start of the road	23,000	Extraction	Sand, moraine	VC22	Former HQ sandpit now under the responsibility of MOL. Partially re-profiled by HQ.
R-30-B	46 km	60,000	Extraction	Sand, moraine	VC28	-
A-01 (southern and northern parts	68.5 km	290,000	Recovery by PAR	Gravel, gritty sand and sand	VC29	-
A-01 (enlargement)	68.5 km	27,000	Extraction	Gravel Gritty sand Sand	VC29	Some sectors have already been re-profiled
Subtotal	**5 sections**	**317,000**				
TOTAL:	**17 SECTIONS**	**1,183,000**	The colours correspond to the legend of the map of sites to be restored (Figure 12 and Appendix 3).			

The closed and ready-to-restore sandpits were the subject of a complete floristic and biophysical inventory (**Annexe 4**). We'll refer to it for more details. The main vegetation outcomes are:

- Deforested areas around the excavated sandpit area are generally composed of native species and have an average richness of 12 species. They are often well vegetated;
- The stripped areas are home to a mixture of native and naturalized species with an average richness of 12 species as well. Their natural regeneration is generally low to medium;
- As for the excavated areas, they have an average richness of 8 species and are also composed of a mixture of native and naturalized species. Their natural regeneration varies from zero to low.

Where it has been possible to detect one or more dominant species that could constitute the vegetation cover of future regeneration, these are the following species, in descending order of occurrence:

1- Green alder (14 occurrences);
2- Grey pine (10);
3- Black spruce (3);
4- Paper birch (1);
5- Quaking aspen (1).

This means that in most cases, vegetation cover appears to be evolving toward stands composed in whole or mostly of green alder. In other cases, it is toward a pine forest with grey pine or a black spruce that this seems to be evolving. There are only two sites where paper birch or aspen will occupy a prominent place.

Additional information was inserted for some sandpits in **Annexe 5**, Most of the information comes from CA requests.

4.2 Quarries

There are currently four quarries, located along the road and near the industrial site (**Table 21**). The two quarries west of the road (C-07 and C-05) are still in use, but could be closed soon, once the work required to finalize the permanent road is completed and could be restored over the life of the mine. The other two quarries are located closer to the industrial site (C-04 and C-02) and will remain in use until the project closes to meet the stone need. These are schools of white gneissic pegmatite with no potential for acid generation.

Quarrying began with deforestation and storage of discovery land and vegetal soil been swathed in preparation for restoration. Processes used include drilling, blasting crushing and sieving. The material is extracted in fronts ten meters in size, then crushed. This produces various types of granulometry ranging from stone dust to 0-2-foot granulometry. The aggregate is then temporarily stored in piles before being trucked away. They are used for the construction and maintenance of the roads and infrastructure of the industrial site.

Quarries must be restored under certificates of authorization obtained under the Environment Quality Act. According to the Regulation respecting pits and quarries, Chapter Q-2, r. 7, if a quarry is located on the side of a hill, the final vertical cut should never exceed 10 m. The operator may arrange several 10 m superimposed vertical cuts provided that these are interspersed with horizontal bearings at least 4 m wide.

As all quarries are still in use, (**Figure 13** and **Figure 14**), their detailed description will only be made when they close.

Figure 13 - C-05 quarry in full operation in 2012

Figure 14 - C-02 quarry in 2013

Table 21 - Quarry characteristics

Codes	Location:	Surface area (m^2)	Future use	Distance from road (m)	Trap line	Restoration
Quarries to be restored during the life of the mine						
C-07	6 km6	88,000	Extraction	0	VC22	Currently mined
C-05	16 km6	79,000	Extraction	100	VC28	
Subtotal	**2 sections**	**167,000**				
Quarries to be restored at the end of the mine life						
C-04	28 km6	71,000	Extraction	80	VC28	
C-02	58 km6	132,000	Extraction	0	VC29	
Subtotal	**2 sections**	**203,000**				
TOTAL:	**4 SECTIONS**	**370,000**	The colours correspond to the legend of the map of sites to be restored (Figure 12 and Appendix 3).			

4.3 Unused and discarded stretches of road

Mining exploration activities by Opinaca Mines began drilling in 2006 to better understand the characteristics of the deposit. In 2007, MOL submitted to COMEX a permanent road project to support the construction of the mine. But pending the analysis of the impact study and the authorization, it was decided to build a winter road of about 60 km by following as much as possible the same route as that of the road, which was under consideration, to minimize the impacts.

During the construction of the winter road, it was necessary to deviate somewhat from the intended route to avoid certain rocky hills requiring blasting or to bypass areas requiring large embankments. In fact, this happened in 5% of the route, that is, over 3 km. Later, in 2012, a permanent access road was built to support mining operations and preparatory work. This was built according to the original layout, so that some sections of the winter road were not covered by the permanent road, leaving 9 sections unused and to be restored (R1, R2, R3, R4, R5, R6, R9 R10 and R11) (**Table 22**). Another stretch of road is also to be restored (R8). This is an access route to the explosives that is no longer in use today. This brings the total number of road segments to be restored to 10. Only one section of road will be restored at the end of the project (R12).

The deforestation activities required to develop the winter road resulted in vegetation losses of 15 m or about 60 hectares of mature and regenerating forest stands. In addition, 5.4 hectares of wetlands were affected by the construction of the winter road. The requirements of the *Regulation respecting standards of forest management for forest in the domain of the State (RNI)* have been followed, including the protection of shorelines, lakes and creeks.

The temporary winter road will have been used for about 5 years, during the months of November to April, depending on the climatic conditions. These winter roads are categorized as non-permanent intermediate paths (class 04, forest road grid). The span is 5.5 m wide.

It is difficult to determine precisely the granulometry of the aggregates that were used for the construction of these sections, but it is likely that MG-112 was used as a foundation and MG-20 on top. The substrate to be restored is, therefore, made up of gravel 0-3/4 inches (0-20 mm).

Added to these road segments, there are road widenings, known as "transects" because they were used for commercial vehicles during construction. These 131 transects were surveyed in 2011. They measure between 20 and 3130 m^2. The largest of these have been included in the sites to be restored at the request of the tallyman. Indeed, these roadside sites sometimes receive campers or hunters, which does not please them.

Figure 15 - Aerial view of the R6 winter road section on the right, from the permanent road to the center with on either side, the C-07 quarry, in 2017

Table 22 - Features of road sections to be restored

Codes	Location:	Surface area (m^2)	Length	Trap line	Restoration
Abandoned and ready-to-restore road					
R-1	48 km6	3000	614	VC28	Filling done partially with gravel
R-2					
R-3	48 km6	8000	383	VC28	Filling done partially with gravel
R-4					
R-5	57 km6	4000	4000	VC29	-
R-6	7 km6	27,000	201	VC22	
R-8	66 km6	7000	606	VC29	-
R-9	57 km6	9000	835	VC29	-
R-10	52 km6	2000	275	VC29	
R-11	48 km6	3000	470	VC28	
Subtotal	**10 sections**	**63,000**			
Road section to be restored at the end of the mine life					
R-12	-	12,000	730		
TOTAL:	**11 SECTIONS**	75,000			

The main results of the floristic inventory carried out (**Annexe 4**) are:

- There are more native species in the roadside deforested area, with an average richness of 10 species.
- The road embankment contains more naturalized species and an average richness of 14 species, significantly higher than that of the deforested area.

Where it has been possible to detect one or more dominant species on the road segments that could constitute the vegetation cover for future regeneration, this has most often resulted in species in descending order of occurrence:

1- Green alder (6 occurrences);
2- Black spruce (3);
3- Grey pine (2).

This means that in half of the cases, vegetation cover appears to be evolving into stands composed in whole or mostly of the green alder. In other cases, it is toward a pine forest with grey pine or a black spruce that this seems to be evolving.

4.4 The industrial sector

The industrial site consists of several sites that will be in use until the end of the mine's life. It is possible that some infrastructures will never be restored, because they could then be found new uses. Once the buildings have been removed, there will still be areas to be restored with an estimated area of 189 ha (**Table 23**). The substrate to be restored will be similar to that of stretches of road, i.e. gravel.

Table 23 - Industrial site features to be restored

Sector	Location:	Surface area (m^2)	Current use	Trap line	Restoration
Industrial site ready to restore					
Cell 1 and 2 of the landfill in a trench (LEET)	48 km6	6000	Closed	VC29	Already seeded. Technical constraints prevent development for biodiversity.
Industrial sites to be restored during the life of the mine					
PAR cell 1	66 km6	280,000	Operating schedule: 2014-2017	VC29	
PAR cell 2	66 km6	225,000	Operating schedule: 2018-2023	VC29	
PAR cell 3	66 km6	197,000	Operating schedule: 2024-2029	VC29	
Subtotal	**3 sections**	**702,000**			
Industrial sites to be restored at the end of the mine's life					
PAR cell 4	66 km6	160,000	Operating schedule: 2025-2034	VC29	
Industrial sector	60 km	1,885 000		VC29	
Subtotal	**2 sections**	**2,045 000**			
TOTAL:	**5 SECTIONS**	**2,747 000**	.		

4.5 The tailings facility

The tailings facility is certainly the biggest technical challenge for gradual restoration. Composed of four cells, each will be restored when it reaches its full capacity. The **Table**

23 indicate the times when it is planned to fill and restore the different cells. Cell 1 was built in 2013 and completed in 2017.

As part of this offsetting plan, the technical estimate that will guide the recovery of mine tailings will not be delayed. Various scenarios are being studied in collaboration with UQAT. While, in the initial plans, a membrane was to be used to waterproof the deposits, various membrane-free options are being studied, combining available materials, such as the sterile, overburden, clay and sand.

The surface areas to be restored may vary in the future, but the total area of the tailing facility will be about 86 hectares. A first area of 28 hectares should be available for restoration soon. Vegetating the tailings facility will be more difficult than other surfaces to restore due to steep slopes and technical constraints due to overlay.

4.6 Summary

It is estimated that 439 hectares of the project will have to be restored at the end of the project's life cycle, unless the project continues, or infrastructure is reused (**Table 24**). This does not include the access road that should be maintained. The largest areas to be restored are those of industrial sites, including the PAR, with more than 275 hectares, the majority of which are done when the mine closes (**Figure 16**). Then come the sandpits with 120 ha. About half of the sandpits are ready to restore now.

It should be noted that the sites to be restored may change slightly over time, as the needs of MOL evolve as well as the aspirations of the tallyman regarding their vocation. The image presented here still represents a very good estimate of the situation that will prevail when the offsetting plan is implemented.

Table 24 - Summary of sites to be restored

Type of site	Ready to be restored (ha)	To be restored during the life of the mine	To be restored at the end of the mine's life (ha)	Total (ha)
Sandpit	84	3	32	118
Quarry	0	17	20	37
Road section	6	0	1	7
PAR:	0	70	16	86
Industrial sector	1	0	189	190
TOTAL:	**91**	**90**	**258**	**439**

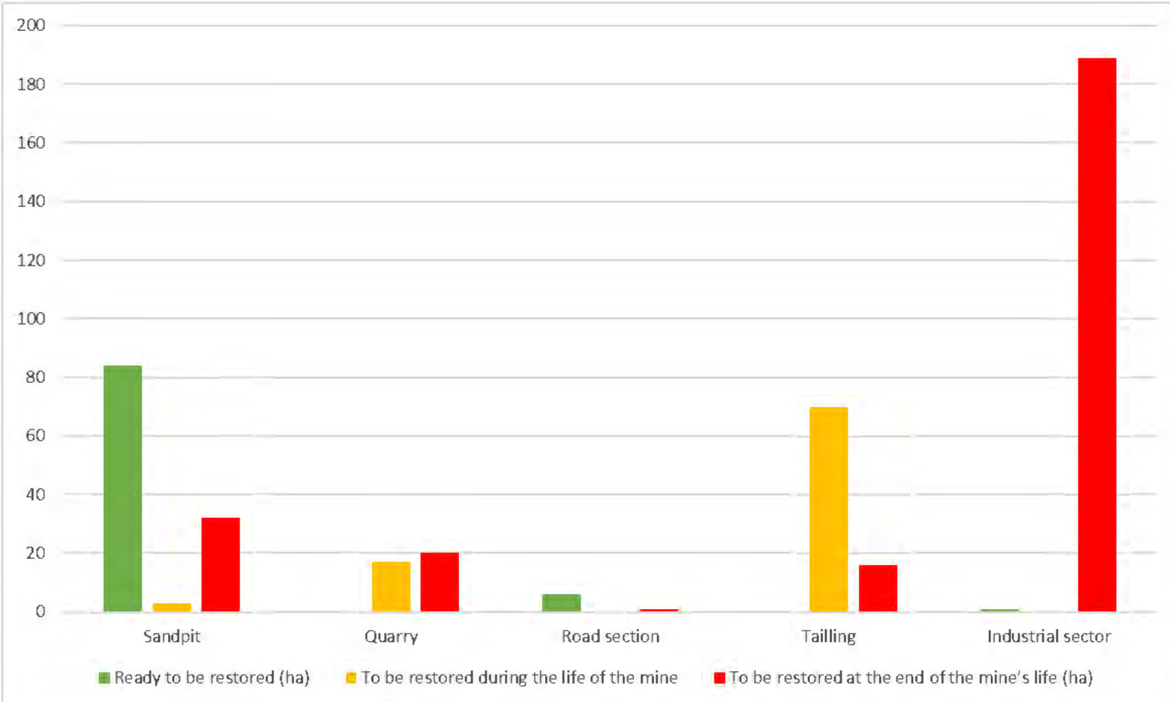


Figure 16 - Surface areas to be restored for each type of site

Figure 17 otherwise illustrates the time planning of progressive restoration.

There are now 94 hectares to be restored, mainly composed of sandpits. Then, during the life of the mine, there would be 87 more ha, consisting mainly of cells 1 to 3 of the PAR. The largest restoration effort, 258 hectares, is planned when the mine is closed.

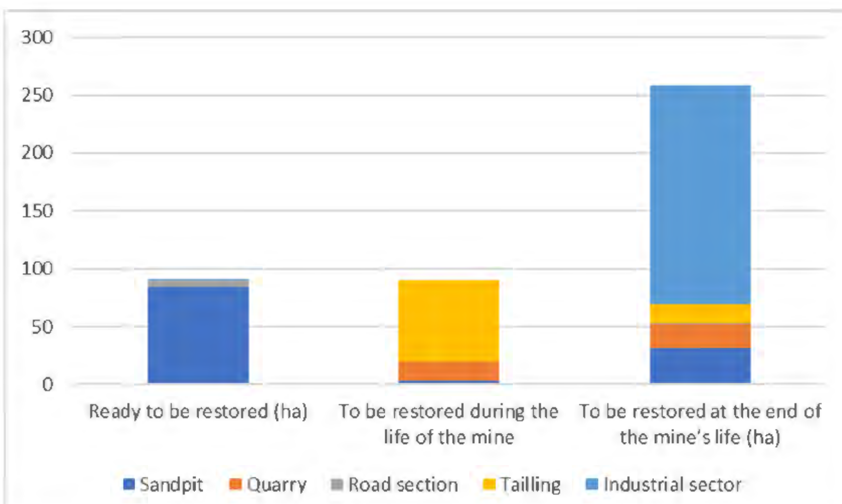


Figure 17 - Surface areas to be restored by the time the mine closes

5. Offsetting accommodation goals

Based on its research and consultations, Bois-Charlebois (2018) has identified priority ecological services to be restored for the Cree. They are shown in detail in **Annexe 6**. It proposes the restoration of 16 ecosystem services used by the Cree and considered to be decreasing, too few or to be monitored in the territory of Eeyou Istchee, i.e. the following services:

- **Food supply**: geese, moose, lake owls, beavers, caribou, hares, sturgeon;
- **Supplies of materials**: moose, beaver, caribou, hare;
- **Supply of firewood**: white birch;
- **Supply of medicinal animals**: geese, beaver;
- **Water purification;**
- **Climate regulation.**

To these priority ecological services, Bois-Charlebois adds a general concern about knowledge about medicinal plants, the overall health of the Cree and the practise of traditional activities. This concern observes that procurement and socio-cultural services often overlap; indeed, the way to source is through traditional activities.

By removing duplicates and ecological services associated with water environments, which can hardly be developed at selected clearing sites, the 10 priority services and species are:

1. Geese;
2. Moose:
3. Beaver:
4. Caribou:
5. Hare:
6. White birch:
7. Water purification:
8. Climate regulation:
9. Medicinal plants:
10. Traditional practises.

Bois-Charlebois also outlined concrete recommendations to restore or develop some of these ecological services from natural elements. **Table 25** presents a summary of the recommendations of Bois-Charlebois as well as the suggested actions for each of the ten priority ecological services next paragraphs.

Table 25 - Suggested developments for priority ecological services

Ecological service or species to be developed	**Bois-Charlebois Recommendations**	**Suggested action**
1. Goose	Herbaceous vegetation and pond	Create targeted accommodations for the **geese**
2. Moose	Deciduous (birch, aspen and willow), mixed or fir stands near forests	Create targeted **moose** facilities
3. Beaver	Deciduous populations	Combine moose facilities
4. Caribou	Dense softwood settlements with lichen	Create targeted development for **caribou**
5. Hare	Same requirements as moose	Combine **moose** and **caribou** facilities
6. White birch	Reforestation	Combine moose facilities
7. Water purification	Filtering marshes	Incorporate wetland developments, particularly **geese** ponds, in particular
8. Climate regulation	Countering invasive alien species	Plant as many trees as possible to sequester carbon as in **moose** and **caribou** facilities
9. Medicinal plants	Increase medicinal plants	Integrate medicinal plants into all three types of landscaping

Ecological service or species to be developed	Bois-Charlebois Recommendations	Suggested action
10. Traditional practises	Capacity building	Involve the Cree in the design, construction and maintenance of all three types of landscaping

In summary, three different development objectives emerge from the recommendations of Bois-Charlebois. These are arrangements for three "umbrella species":

1. **Facilities for geese, and waterfowl in general.** These developments include the digging of favourable ponds and nearby feeding areas, mainly herbaceous and shrub plantations.
2. **Facilities for moose**, as well as beaver, hare and white birch. These developments consist of planting deciduous trees and shrubs, such as white birch, aspen, willow, etc. According to Roche (2007), the construction of the road caused the loss of more than 200 hectares of habitat and 150 ha for the hare.
3. **Facilities for caribou,** also favourable for hare. This involves planting dense softwoods and promoting the presence of territorial lichens. The other species he appreciates are the same as moose, with cherry, service berry, larch and blueberry. According to Roche (2007), the construction of the road caused the loss of more than 320 ha for this species. Areas between kms 16 to 24 and 39 to 48 are favourable to caribou (Roche, 2007).

These three scenarios can also help provide other environmental services prioritized by:

- creating wetlands that will purify runoff **water**;
- incorporating **medicinal and edible species** into the developments;
- planting forests that store carbon and fight **climate change**;
- creating sites that are conducive to **traditional Cree activities.**

In addition, a consultation workshop on offsetting arrangements was held on November 6, 2018 at the Éléonore Cree Cultural Site in the presence of members of the three affected families, the managers of the three trap areas affected by the mine and the two representatives of the Cree Nation Government (CNG) and several MOL employees. The full report is available on request. In all, about 20 people participated in this bilingual workshop. The objectives were to consult with those affected about the type of landscaping and the species that would be planted at the 21 restoration sites in the first phase.

The priority ecological services of Bois-Charlebois were presented and nine other priority procurement services were added by the participants (**Table 26**). The assembly then validated the proposed approach to habitat development for the three umbrella species associated with the new ecological services. (**Figure 18**).

Table 26 - Priority ecological services added by consultation workshop participants and suggested actions.

New priority environmental services	**Suggested action**
The otter	Combine with **goose** arrangements
The bear	Combine arrangements for **geese**, **moose** and **caribo**u
The lynx	Combine with **moose** and **caribou** facilities
Combine moose and caribou facilities	The **porcupine**
The marten	Combine with **caribou** facilities
The partridge	Combine **moose** facilities
The willow ptarmigan	Combine with **moose** and **caribou** facilities
The quaking aspen	Combine **moose** facilities
Mushrooms, mainly Matsutake.	Combine with **caribou** facilities

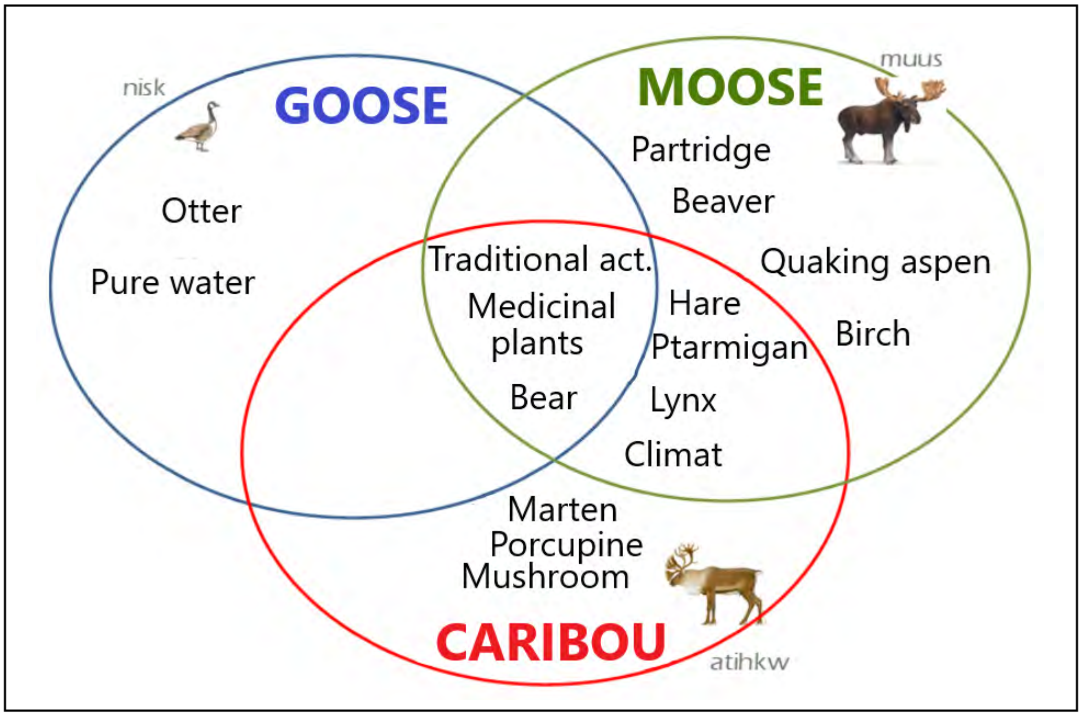


Figure 18 - Conceptual scheme illustrating the 19 priority ecological services under the three types of development

6. Objectives for each restoration site

Once the three main objectives of offsetting arrangements have been decided, it is necessary to determine which one to assign to each of the restoration sites. During the first phase of restoration, 11 sandpits and 9 sections of winter road will be developed, for a total of 41 hectares. To determine the vocation of each of the 19 sites, two types of factors come into play:

1 Social factors;
2 Biophysical factors.

6.1 Social factors

To determine the preferences of affected families, preliminary consultations were held in the summer of 2017 and in the fall of 2018 with each of the three families of tallyman who manage territories with Restoration.

The 21 restoration sites are located in three different trap territories:

- The VC22 trap territory under the responsibility of Ronnie Georgekish, between km 0 and 6 of the road;

- The VC28 trap territory under the responsibility of Isaac Visitor, between km 6 and 52;
- The VC29 trap area, under the responsibility of Angus Mayappo, which includes the mine and the adjacent road segment (km 52 to 70).

The summary of this consultation is presented in **Table 27**.

Table 27 - Results of the tallyman' consultations on the vocation of food sites and other social factors

Restoration site	Trapping territory	Vocation preferred by the trap master	Other Cree social factors[1]
SANDPITS			
R-38-B	VC22	Naturalization	Area valued by the Cree
R-36-C	VC28	Naturalization	Proposed protected area and area valued by the Cree
R-36-B	VC28	Naturalization	Proposed protected area and area valued by the Cree
R-44	VC28	Naturalization	Proposed protected area and area valued by the Cree
R-34-A	VC28	Naturalization	Area valued by the Cree
R-30-A	VC28	Habitat for waterfowl and goose hunting, naturalization of the outing located on the other side	Proximity to the camps
A-10	VC29	Naturalization, especially with fir trees	Proximity to the camps
A-09	VC29	Habitat for waterfowl and goose hunting, if compatible with aircraft landing	Proximity to the camps
A-08-B	VC29	Naturalization	
A-08-A	VC29	Naturalization	-
ROAD SECTIONS			
R-1	VC28	Naturalization	Proximity to the camps
R-2	VC28	Naturalization	Proximity to the camps
R-3	VC28	Naturalization	Proximity to the camps
R-4	VC28	Naturalization	Proximity to the camps
R-5	VC29	Naturalization and block entry	
R-6	VC22	Reprofiling to let water pass, then naturalization	Area valued by the Cree
R-8	VC29	Naturalization	Area valued by the Cree

Restoration site	Trapping territory	Vocation preferred by the trap master	Other Cree social factors[1]
R-9	VC29	Naturalization	
R-10	VC29	Naturalization	
R-11	VC28	Naturalization	
R-12	VC29	Keeping access to the reservoir	Access to the potentially useful reservoir.

[1] The areas valued come from Golder (2009), while the proposed protected areas come from Nasr and Labrecque (2007), as shown in the map of the restoration sites (**Figure 12** and **Appendix 3**).

In general, tallyman want the scars left by the construction of the road and mine to be erased and disappear completely, nature to take over and everything will return to the way it was. This is what is meant by the term "naturalization." There is a preference for natural restoration, that is, to expand the plant soil conducive to natural regeneration.

But letting natural regeneration proceed most often means colonization of the sites by the green alder, a species that is not valued by the Cree. It is, therefore, necessary to find a restoration plan that allows to regain a natural character, while avoiding invasion by the green alder.

At the November 2018 consultation workshop, families expressed their preference for the three types of development for each of the restoration sites in their territory (**Figure 19**).

Figure 19 - Consultation session on accommodations with the families of tallyman

6.2 Biophysical factors

The main biophysical factors to consider in suggesting a specific vocation to each of the restoration sites are specified in the inventory report presented in **Annexe 4**. A summary is presented in **Table 28**, followed by planning recommendations

Basically, the general concept suggested is to favour moose in more heavily populated areas east and west of the road. The central area would be dedicated to caribou, given the presence of suitable habitat for this species.

Table 28 - Biophysical Characteristics, Recommendations Based on Biophysical Factors and Final Recommendations of the Assembly

Restoration site	Biophysical features	Recommendations based on biophysical factors	Final recommendation of the meeting
SANDPITS			
R-38-B	Low natural regeneration in green alder	Refill and plant in hardwoods to create moose-friendly stands	Geese and pine plantation
R-36-C	Low poplar regeneration	Dense planting of various conifers to create shelter for caribou and hare and reduce fragmentation of the surrounding forest	Caribou
R-36-B	Low mixed regeneration	Dense planting of various conifers to create shelter for caribou and hare and reduce fragmentation of the surrounding forest	Caribou
R-44	Little regeneration; caribou territory	Dense planting of various conifers to create shelter for caribou and hare and reduce fragmentation of the surrounding forest	Caribou
R-34-A	Little regeneration; near caribou territory	Dense planting of various conifers to create shelter for caribou and hare and reduce fragmentation of the surrounding forest	Moose
R-30-A	Little regeneration; caribou territory; waterproof floor	Digging a pond for waterfowl and planting low vegetation for geese	Goose Build a parking lot a little far from the designated site

Restoration site	Biophysical features	Recommendations based on biophysical factors	Final recommendation of the meeting
A-10	Little regeneration	Planting a mixed stand including fir and deciduous trees to create moose-friendly stands	Goose Planting for geese without ponds because of the proximity of the road
A-09	Little regeneration	To study the feasibility of developing a pond for waterfowl and planting low vegetation for geese	Goose Pond if soil conditions permit. Create a parking lot a little far from the designated site.
A-08-B	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
A-08-A	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
ROAD SECTIONS			
R-1	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
R-2	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
R-3	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
R-4	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
R-5	Covered in vegetable soil	Plant hardwoods to create moose-friendly stands	Moose
R-6	Little regeneration	Dense planting of various conifers to create shelter for caribou and hare and reduce fragmentation of the surrounding forest	Caribou Planting pines and firs Leave the road accessible in its western portion
R-8	Little regeneration	Plant hardwoods to create moose-friendly stands	Moose
R-9	Strong alder regeneration	Refill and plant in hardwoods to create moose-friendly stands	Caribou Conifer planting to consolidate softwood stands

Restoration site	Biophysical features	Recommendations based on biophysical factors	Final recommendation of the meeting
			along the river that form a corridor for caribou
R-10	Low alder regeneration	Plant hardwoods to create moose-friendly stands	Leave as a boat park
R-11	Well regenerated by wetland plants in the northern section, little regeneration in the dry section south of the section	Refill and plant in hardwoods to create **moose**-friendly stands	Moose
R-12	Erosion of the path to the reservoir, growing riparian strip in the near part of the reservoir, little regeneration in the rest of the stretch	Plant hardwoods to create moose-friendly stands	Leave as a boat park

6.3 Summary

Table 28 sets out the recommended development objectives at the consultation session on November 6, 2018.

In summary, according to the biophysical criteria of the sites to be restored and the recommendations of the tallyman, 3 sandpits and 7 sections are intended for the creation of habitats for moose, 3 sandpits and 2 sections are for caribou and 4 sandpits could host a habitat for geese, for a total of 19 sites to be restored. Two sites remain as is for Cree uses.

7. Plant species of offset facilities

Species to be planted in restored sites must contribute to the priority ecological services presented in **Figure 18**. Various sources have been used to establish a list of species to be planted in the landscaping:

- Éléonore Wildlife Inventory Register: Some 126 plant species have been identified in the project area (MOL, internal document);
- List of subspecies useful to the Cree (Golder, 2010): Cree-useful species were compiled on the basis of discussion with communities during the impact study for the Eastmain-1 project (Foramec, 2004) and during an inventory of Golder (2008), and the books of Assiniwi (1972 and 1988) and Fleurbec (1987). Approximately 55 species of vascular plants, herbaceous plants, shrubs and trees are used for food, tool production, housing and traditional medicine ;

- List of certain plant species used by the Cree as food and potentially present on Eeyou Istchee (**Table 7**; Bois-Charlebois, 2018) ;
- List of medicinal plants potentially present on Eeyou Istchee (**Appendix 2**; Bois-Charlebois, 2018);
- Methodological approach for assessing the effective usefulness of the edible flora of the boreal forest in a survival situation (Tranquard, 2018).

For the consultation of November 6, 2018, a list of 26 species and genera of deciduous and coniferous trees, shrubs and grasses were compiled to submit to the families of the tallyman for appreciation. A trilingual map of photos for each plant was prepared, which was printed in three copies. During the consultation, a presentation of each species was made, including their edible and medicinal properties. Then, the families indicated on the map whether they were interested in having this species planted in their trapping territory. *(***Figure 20***).* The results are shown in **Table 29**.

Figure 20 - Exercise of assessment of plants by the families of tallyman during the consultation. Participants were invited to paste stars of different colours depending on their interest in the species.

Table 29 - Appreciation of plants by the families of tallyman.

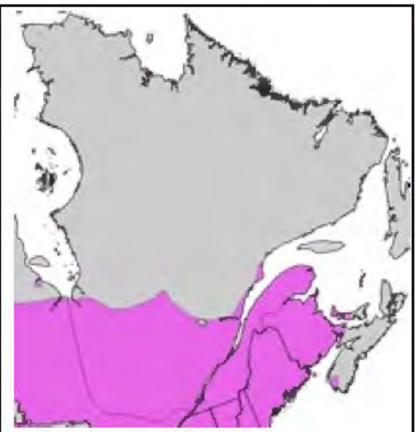
X means that they agree with the planting of this species in their trap territory, while O means otherwise. Blue species are useful species for The Cree that have not been recorded in the territory of Éléonore

English name	French name	VC-22	VC-28	VC-29	Total	Comments
Jack pine	Pin gris	X	X	X	3	Feeds porcupine, hare and grouse. Good for caribou. Construction wood
Balsam Fir	Sapin baumier	X	X	X	3	To be planted near the road for easy access to natural medicines. Tepee floor.
Trembling aspen	Peuplier faux-tremble	X	X	X	3	Feeds beaver, porcupine and provides good firewood.
White birch	White birch	X	X	X	3	Good firewood and ignition. For shovel shafts, utensils and canoes.
Larch, Tamarack	Mélèze laricin	X	X	X	3	Grows back after fires. Feeds porcupine Good for snowshoes, sleds and sculpture. Medicinal.
Wild Cherry	Cerisier de Pennsylvanie	X	X	X	3	Feeds several animals. Medicinal.
Currant	Gadellier glanduleux	X	X	X	3	Good for animals and humans.
Raspberry	Framboisier	X	X	X	3	Good for jam, pies and wine.
Mountain ash	Sorbier d'Amérique	X	X	X	3	Feeds birds and bears.
Blueberry	Bleuet	X	X	X	3	Jam, pie and fish salad.
Cranberry tree, Mooseberry	Pimbina	X	X	X	3	Good for jam, donuts and as medicine.
Sedge	Carex	X	X	X	3	Feeds geese For the periphery of goose ponds.
Cattail	Quenouille à feuille large	X	X	X	3	For the periphery of goose ponds

Wild Strawberry	Fraisier américain	X	X	X	3	
Balsam poplar	Peuplier baumier	X	X	X	3	Feeds beaver and ptarmigan. Light wood for sleeves. Medicinal.
Dwarf birch	Bouleau nain	X	X	O	2	
Black spruce	Épinette noire	O	X	X	2	Feeds squirrels Medicinal and tinctorial. Construction wood
Cedar	Cèdre	X	X	O	2	Let's see if it will grow. Since this wood floats, it would be good for buoys. In addition, it is easy to sculpt. For racket frames.
Mint	Menthe du Canada	X	X	O	2	
Sweet gale	Myrique baumier	X	O	O	1	
Willow	Saule	O	X	O	1	They should be left to grow naturally
Bulrush, Rush	Jonc	O	X	O	1	It attracts bees! For the periphery of goose ponds
Hazelnut	Noisetier	O	X	O	1	Feed beavers
White spruce	Épinette blanche	O	X	O	1	Ready to try it near my home.
Shadbush	Amélanchier	O	?	O	0	
Sarsaparilla	Aralie hispide	O	O	O	0	
Total		**18**	**23**	**16**	**-**	

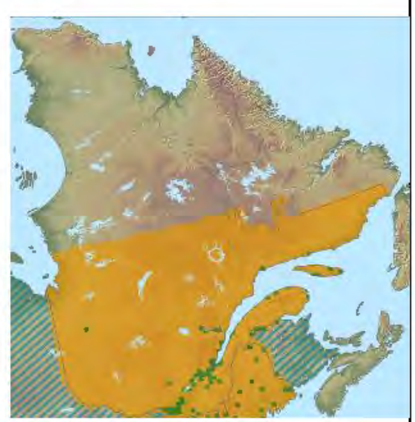
Cree families selected an average of 19 of the 26 species proposed, representing 73%. Species inscribed in blue in **Table 29** are species that are little or unknown to them. Five of them were selected, which is also equivalent to an average of 73%. This suggests that their choice was not significantly influenced by this fact, despite a reluctance to unknown or southern species. The five species are already present south of Eeyou Istchee (**Figure 21**). This represents a form of assisted migration of species to the north, where their climate niche is moving. According to modelling by the Ouranos Consortium (**Figure 22**), Éléonore's climatic conditions in about 20 years should be similar to those of Matagami and Waskaganish.

White spruce (Arboquebecium)



Cedar (Arboquebecium)

Balsam poplar (Arboquebecium)



Mint of Canada (CC-bio)

Field strawberry (canadensys.net)

Figure 21 - Distribution maps of the 5 plant species not recorded around Éléonore

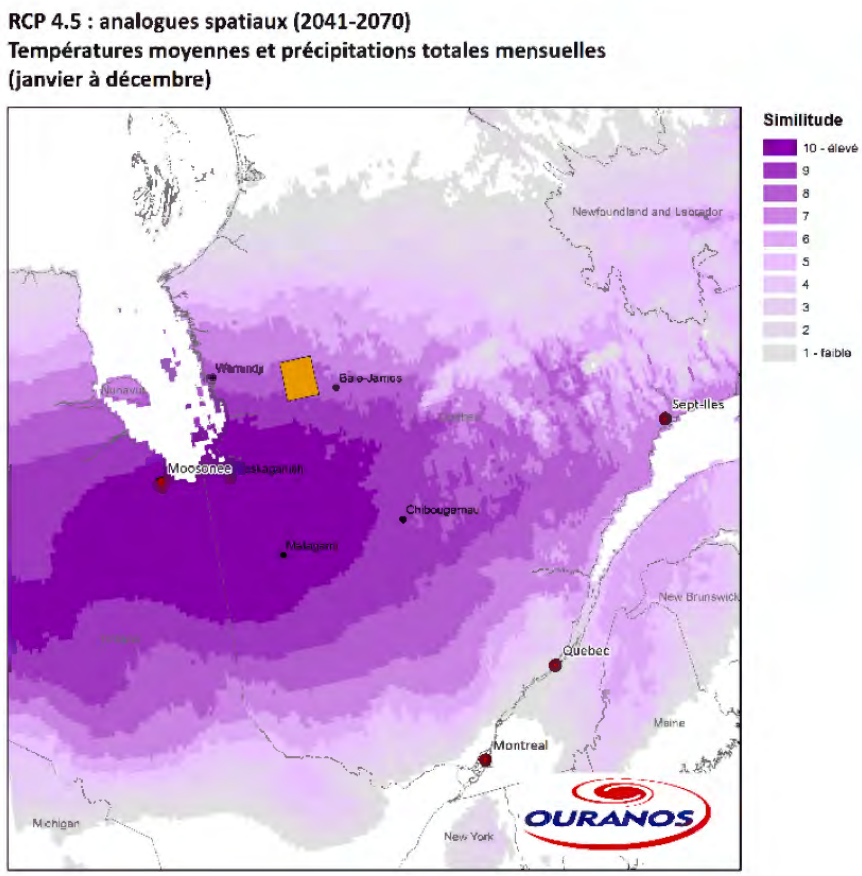


Figure 22 - Projection of climate niches for the Éléonore site. The climatic conditions expected in 2014-2070 inside the orange rectangle (area under study) are similar to the current climatic conditions of the dark purple areas.

The introduction of these species, which are currently absent from the project area, will generate the following results:

1. Provide new ecological goods and services for families living in the area;
2. Extend wildlife habitats;
3. Adapt to climate change;
4. Increase ecological value as well as the conservation value of biodiversity in restoration sites.

In fact, the planting of these species could create source populations that will gradually expand and, potentially, colonize ecological niches that will be left vacant by species that will no longer be adapted to the new climate. For example, cedar could spread to niches left vacant by dwarf birch, a species at the southern limit of its distribution. Far be it from us to predict the extinction of this species common to Éléonore; this is just one example of changes in the specific composition of ecosystems that is planned by various researchers, notably by the CC-Bio group of UQAR.

Risks associated with assisted migration include:

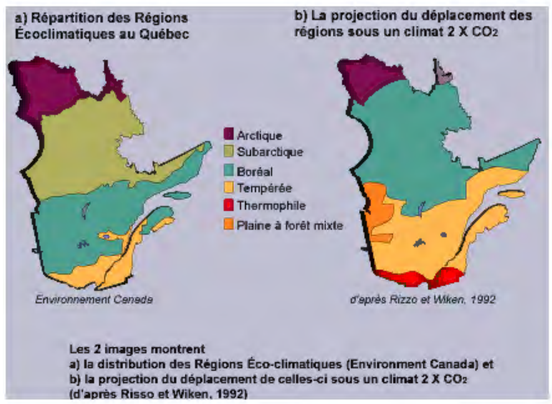
- Higher seedling mortality;
- Introducing invasive alien species.

These risks will be minimized as much as possible by:

- Using northern genotypes if possible;
- Planting several different species;
- Planting in small numbers at the beginning to avoid large losses, if any;
- Planting in sheltered conditions, such as a southern slope surrounded by trees;
- Production of seedlings in northern climate;
- Inspection when seedlings arrive at the site to detect any undesirables;
- Regular monitoring of plantations to detect any unwanted species, then eradication if necessary.

Why assisted migration?

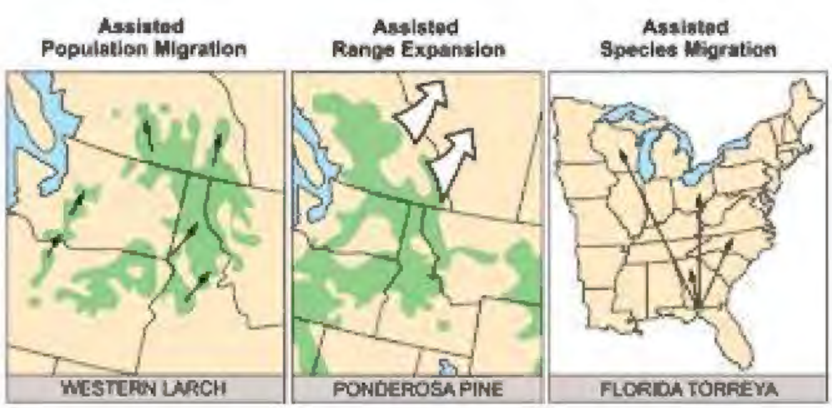
According to the James Bay Advisory Committee's (2007) report "The Known Portrait and Environmental Impacts of Climate Change in James Bay" show an increase in the average annual temperature in the boreal forest by 1 to 1.5 degrees Celsius. Climate models suggest an increase in temperatures of about 4ºC for the James Bay Territory, and an increase in precipitation of 2 to 32% per day by 2050.



The evolution of climate change is much faster than the migration capacity of trees. The forest moves from 100 to 200 meters per year. The expected speed of climate movement northward or toward high altitudes is rather 2 to 10 km per year.

Significant changes in habitat potential for tree species are expected and could lead to a new composition of plant communities. In addition, the speed of climate change could lead to local extinction or extinction of species with low dispersal capacity or limited dispersal area. For example, between 1960-1990 and 2050, the boundary of mixed forest in Québec will have moved more than 230 km to the north.

Assisted migration helps to adapt to these changes and reduce the apprehended negative impacts.



This group of species will serve as the basis for detailed planting planning, which will be adjusted at each site based on:

- The preference of tallyman;
- Planning objective: geese, moose or caribou;
- Plant availability;
- Site features.

8. Details of the developments

Creating new productive ecosystems requires good planning and proper development of restoration sites. As mentioned in the section 0, the planned developments will be well above the minimum required by law. The "traditional" rehabilitation of sandpits and quarries is sometimes aimed at the "forest" production of degraded sites. Valuing the production of woody material requires a different soil preparation than recommended here and aimed at the installation of maximum biodiversity and the production of increased ecological services.

For this reason, certain measures in the Sandpit Regulations may not be followed to the letter. For example, it states that "Any development covered in paragraph C of section 37 must be designed to prevent water stagnation. Except for the part dealing with slope flattening, section 38 states that the body of water must reach a depth of 2 m or more at the lowest water level." A CA application will be filed before these adjustments are completed.

In fact, the refilling of the restoration sites will be carried out in such a way as to retain water and avoid excessive drainage that could cause erosion and reduce the amount of water in the surface layers of the soil that will be necessary to feed the seedlings.

The main recommendations for soil preparation before planting are contained in **Table 30**. This table deals with the planned improvements in the restoration sites that are already ready to be restored, the first phase.

Table 30 - Key features of the planned developments in the first phase

	Arrangements for geese	Arrangements for moose	Arrangements for caribou
Approximate surface area	11 ha	9 ha	21 ha
Reprofiling	Creating ponds as described in figure 23. If possible, technically or otherwise, according to the tallyman	Ripples perpendicular to the flow of water. In the case of road sections, a ripper will be hung behind a bulldozer and will be used to soften the rolling surface	
Access	Before planting, delineate a path that walks around the restoration site to have access by mountain bike or snowmobile for monitoring and maintenance of plants.		
Vegetal soil stored around the edge	Extend over the entire area to be restored	Use to prepare planting soil that will be used in planting pits	
Piles of boulders	Put in small piles to create reptile and insect habitats. If there are too many, bury them.		
Piles of trunks	Shred and spread	Shred and use as mulch at the base of seedlings.	
Parking	Provide parking spaces away from the hunting area. Block any vehicle entry.	Provide space at the entrance to the sandpits to park two vehicles, a space well bounded by boulders and a ditch to avoid any vehicle entry.	
Signage	Provide an explanatory poster for each site to protect seedlings from the risk of trampling.		
Plant density	3000/ha	3500/ha	4000/ha
Estimated number of seedlings	33,000	31,500	84,000

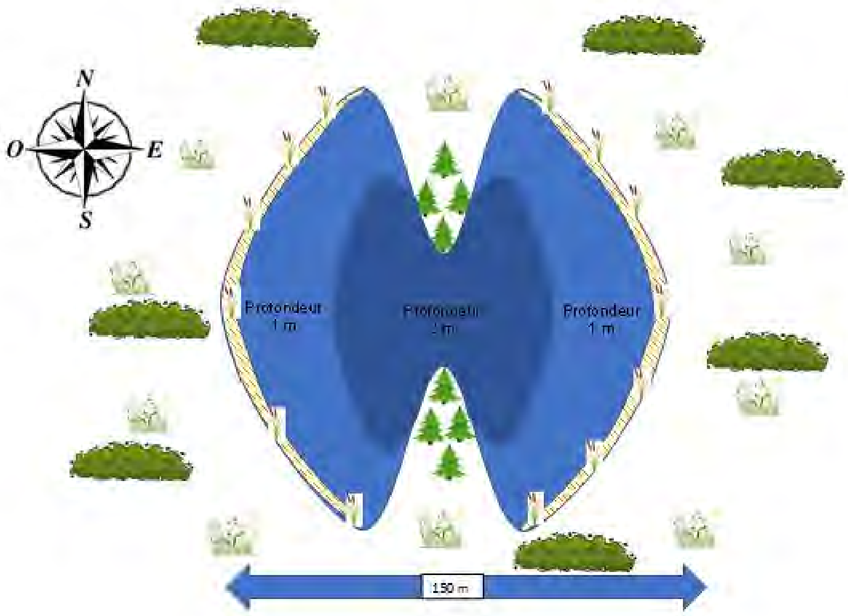


Figure 23 - Setting up a goose pond, designed by Angus Mayappo, Tallyman

The success of the planting work will be ensured by the commitment of a company specializing in mining rehabilitation. Potential implementation partners include various Cree organizations such as the and the Cree Trappers Association (CTA).

9. Time planning

The offsetting project will take place in three stages, corresponding to the three colours used in the tables and map:

1. Phase 1 (approximately 5 years): Estimated total of 150,000 seedlings over 41 hectares corresponding to sandpits and stretches of road ready to be restored, except DG-R25-O, the latter having an uncertain status as it will be possibly returned to Hydro-Québec;
2. Phase 2: Gradual restoration of sandpits, quarries and waste park cells as they become available as restoration sites;
3. Phase 3: Closure of the industrial site and the last cells of the tailings facility. According to the closure plan of (2011), restoration work will continue for approximately 2 years following the closure.

There is a possibility that the closure will be postponed and that the plant will continue to operate well beyond the current deadlines. In this case, to supplement the biodiversity gains required for full offsetting, other options could be considered, such as the enrichment of the sites restored by the Bay-James on the periphery of the Teal project. These sites have been restored by green alder plantations (see section 0 and Figure 10). Ecological conditions are now favourable for planting more valued species, for example, by removing 1 out of 3 alders and inserting deciduous trees.

Although Phases 2 and 3 have not been described in detail as Phase 1, they are expected to continue with the same spirit and coordination with the Cree.

10. Estimating biodiversity gains

This section aims at estimating the biodiversity gains that could be achieved by implementing the previous actions. It should be remembered that the biodiversity gain that can be accounted for offsetting is one that exceeds the minimum required by law, as explained in section 0. It was estimated that this minimum standard corresponds to a quality of 0.4. Therefore, any gain in quality above this value will correspond to a valid biodiversity gain for the offsetting of lost environments.

It is estimated that the ecosystems that will be created on the restoration sites corresponding to sandpits, quarries, winter road sections and the industrial zone, will have a quality of 0.7. However, it is foreseeable that plantations on the tailings facility will have to take into account more technical constraints which could prevent the creation of an ecosystem as diverse as on other sites.

Table 31 - Details of the estimate of the quality index of the ecosystems created

	Sandpits, quarries, winter road sections and industrial area	**Tailings site**
Quality by government standard	0.4	0.4
Estimated quality to be achieved	0.7	0.6
Expected quality gain	0.3	0.2
Justification	- Native species - Strong specific diversity - Structural diversity due to the three strata - Plant distribution by mimicking nature - Uncommon forests at this latitude - Wildlife Habitats	- Native species - Low structural diversity due to the absence of trees - Moderate specific diversity - Plant distribution by mimicking nature - Wildlife Habitat

	Sandpits, quarries, winter road sections and industrial area	Tailings site
	- Adaptation to climate change due to assisted migration	- Adaptation to climate change due to assisted migration

Table 32 - Estimated biodiversity gains details for each phase

Type of site	Phase 1 Ready to restore			Phase 2 To be restored during the life of the mine			Phase 3 To be restored at the end of mine's life			Total (QH)
	Surface area	Quality	QH	Surface area	Quality	QH	Surface area	Quality	QH	
Sandpit	34.3	0.3	10.3	3	0.3	0.9	32	0.3	9.6	**20.8**
Quarry				17	0.3	5.1	20	0.3	6	**11.1**
Road section	6.3	0.3	1.9				1	0.3	0.3	**2.2**
PAR:				70	0.2	14	16	0.2	3.2	**17.2**
Industrial Area							189	0.3	56.7	**56.7**
TOTAL:			**12.2**			**20**			**75.5**	**108**

This estimate is shown graphically in **Figure 24**. The gain sought for offsetting (58 QH) would not be achieved only by restoring sites made available during the life of the mine (phases 1 and 2). However, the complete restoration of the sites during the three planned phases would bring more than the gain required for offsetting. This leaves ample room for adjustments as a result of changes or failures.

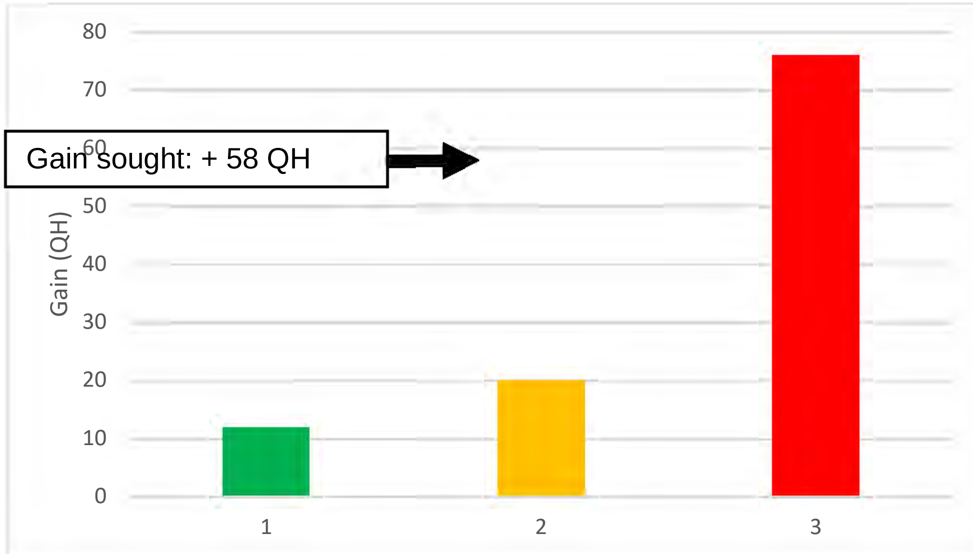


Figure 24 - Estimated biodiversity gains by phase

11. Offsetting for carbon sequestration loss

To offset the loss of carbon sequestration by encroaching peatlands, i.e. - 15 t C/year (**Table 14**), it is suggested to calculate carbon sequestration by planting trees in restoration sites. At this stage, it is difficult to establish an accurate balance sheet, but it seems that reforestation areas that were forested at only 14% should be sufficient to increase the sequestration rate sufficiently to make up for the loss. More precise calculations should be made when the details of the plantations are better known.

12. Monitoring and evaluation

This project is long-term. It will require small-scale testing before restoration on a large scale. In addition, there will certainly be failures and restoration techniques will have to be adjusted as well as the expected results. This is why a monitoring and evaluation program is needed at two levels, as described in **Table 33**. These follow-up programs will continue throughout the life of the mine.

Table 33 - Restored site tracking programs

Follow-up program	Periodicity	Indicators	Adaptive management
Agronomic success of plantations	Every year	Mortality rate by species Abundance of unwanted species	Adjustment of techniques Capacity building
Biodiversity gains	Every three years	QH achieved	Adjusting predictions

Monitoring of impacted wetland surfaces must also be put in place to validate estimates of losses that have been assumed in calculating residual loss.

13. Warranty

The offsetting plan must specify the guarantees of implementation and follow-up of the measures. In this case, the duration of the Éléonore mine and the sustainability of MOL's presence on the site provide a form of guarantee for the gradual implementation of the offsetting plan. The supervision of its claim by MOL will also avoid any use incompatible with the vocation of the restoration sites.

One of the risks comes from the use of clearing sites outside the MOL claim. In fact, a certain part of the road, along which several clearing facilities will take place, is located outside its claim. Thus, Azimut Exploration, Osisko Gold Royalties, Osisko Bay-James SENC, Everton Resources and Luke Schuss own claims and these companies could use abandoned sandpits to set up an exploration camp. This is why an additional form of protection is needed to avoid such cases. Displaying restoration sites could reduce this risk, but a form of legal protection would be ideal, especially if this designation comes with an inscription in a public directory that can be accessed easily by all potential promoters discussions will have to take place with the MFFP to prevent the granting of intervention permits at the restored sites.

Section 13 of the *Natural Heritage Conservation Act, amended by the Wetlands and Water Conservation Act*, allows the Minister to designate certain environments by defining them on a plan distinguished by the rarity or exceptional interest of one of their biophysical characteristics. Also included in such a designation are wetlands and water that have been responded to as part of a program to restore and create wetlands and water environments. No certificate of authorization may be issued for such sites.

The protected environments are distinguished, regionally or nationally, by their integrity, rarity or surface area. The ecosystems created by this offsetting program could be distinguished at the regional level by their scarcity and by the ecological functions associated with adaptation to climate change. Discussions with the MELCC are to be expected to assess the value of such protection.

An additional statute could also be obtained, thus consolidating the previous one. The creation of an APAC, an Aboriginal People's Advisory Committee, should be envisaged. This type of protected area allows the conservation of natural environments, as well as the achievement of other social and cultural objectives. APACs share three characteristics:

- The community is closely associated with a well-defined territory or area;
- The community is the main player in the decision-making process, governance and implementation of the management of the territory or area;
- Community management decisions and measures allow the conservation of the territory and the cultural values attached to it.

The creation of an APAC or a series of small APACs on restoration sites requires the involvement of a community institution to develop and enforce regulations. In this case, the Community of Wemindji could recognize these areas as protected by an official resolution that would designate the tallyman as those responsible for their management. Discussions with the tallyman and Wemindji council will take place to assess the value of such a designation.

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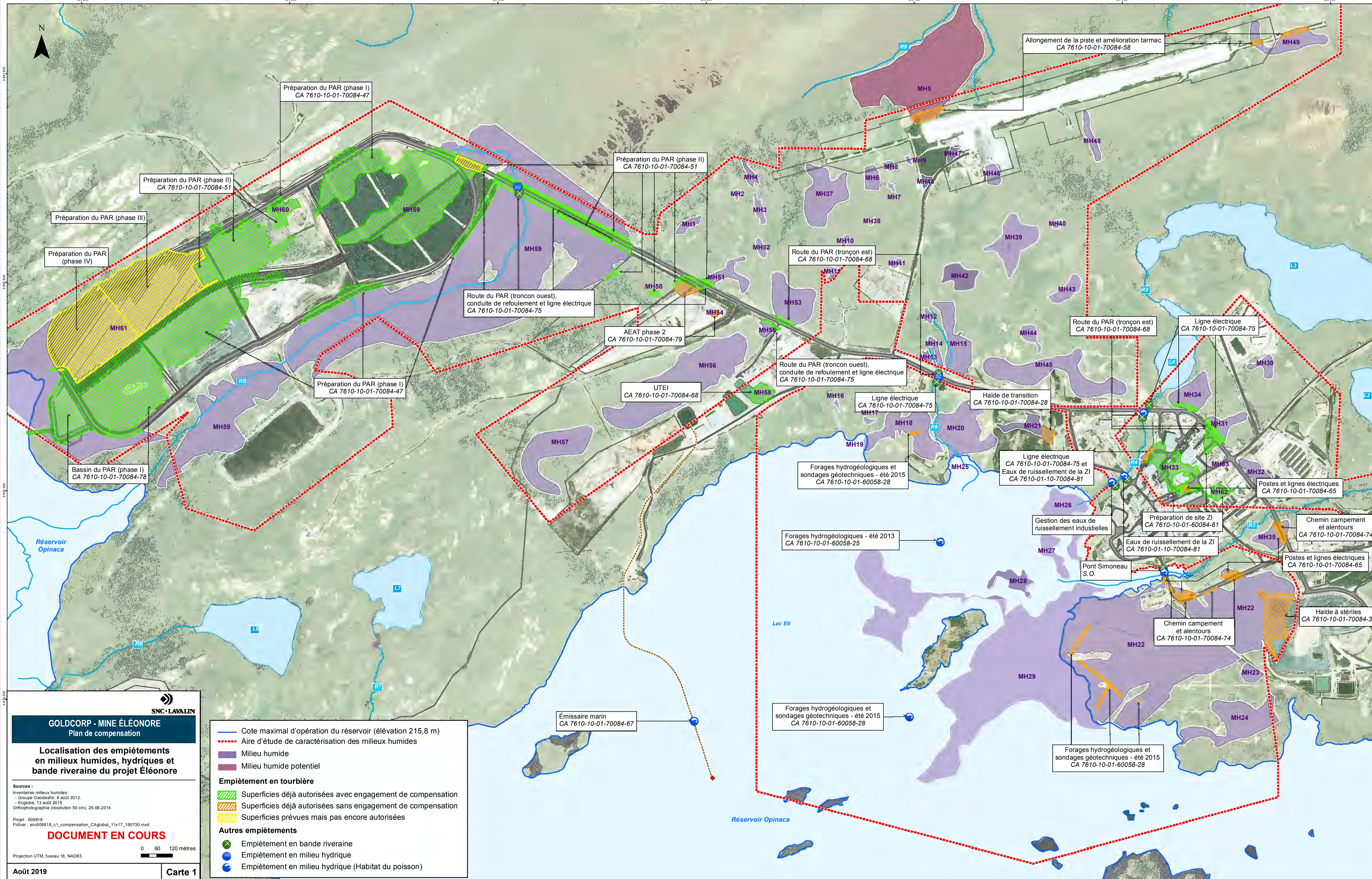
APPENDIX 1 - MAP OF WETLAND AND WATER INLAYS



SNC • LAVALIN

GOLDCORP - MINE ÉLÉONORE
Plan de compensation

Localisation des empiétements en milieux humides, hydriques et bande riveraine du projet Éléonore

Sources :
Inventaires milieux humides:
- Groupe Geodesfor, 8 août 2012.
- Englobe, 13 août 2015

Orthophotographie (résolution 50 cm), 26-06-2014

Projet : 609918
Fichier : snc609918_c1_compensation_CAglobal_11x17_190730.mxd

DOCUMENT EN COURS

0 60 120 mètres

Projection UTM, fuseau 18, NAD83

Août 2019 | **Carte 1**

Cote maximal d'opération du réservoir (élévation 215,8 m)
Aire d'étude de caractérisation des milieux humides
Milieu humide
Milieu humide potentiel

Empiètement en tourbière
Superficies déjà autorisées avec engagement de compensation
Superficies déjà autorisées sans engagement de compensation
Superficies prévues mais pas encore autorisées

Autres empiètements
Empiètement en bande riveraine
Empiètement en milieu hydrique
Empiètement en milieu hydrique (Habitat du poisson)

T:\Proj\609918 Goldcorp\4.0_Réalisation\4.5_SIG\3ArcGIS\1ProjetMXD\2Rapport\Plan_compensation_161025\snc609918_c1_compensation_CAglobal_11x17_190730.mxd

APPENDIX 2 LIST OF POTENTIALLY PRESENT MEDICAL PLANTS ON EEYOU ISTCHEE (FROM BOIS-CHARLEBOIS, 2018)

Nom latin de l’espèce	Usage
Abies balsamea	Traitement de divers maux internes
Achillea millefolium *	Contre les maladies dentaires, les plaies des gencives, les maux de gorge, la toux et le rhume
Acorus americanus	Contre les troubles de la peau, les piqûres d'abeilles, les coupures, les brûlures, les maux de tête, l'arthrite, les douleurs musculaires, les maux de gorge, la toux et le rhume, le diabète, la fièvre, les problèmes cardiaques, la paralysie faciale, la diarrhée et l'hypertension artérielle
*Acorus calamus**	Contre la toux et le froid, les troubles cardiaques, les maux de tête, la fièvre, des plaies infectées, les douleurs musculaires ou articulaires, y compris les rhumatismes
Actaea rubra	Comme thé purgatif et pour ralentir le flux menstruel
*Agastache foeniculum**	Contre les maux d'estomac, pour arrêter le sang dans les crachats, pour rafraîchir l’haleine
Alnus incana sp. rugosa	Comme laxatif, pour laver les des yeux douloureux, contre le diabète
Alnus viridis	Pour déclencher les menstruations, contre l'hydropisie, pour traiter les brûlures causées par l'eau bouillante
Andromeda polifolia	Pour traiter le diabète
Apocynum androsaemifolium	Pour augmenter la lactation chez les mères allaitantes, pour laver des yeux brûlés par la fumée ou contre la cécité créée par le reflet des neiges
Apocynum cannabinum	Plantes médicinale
Aralia nudicaulis	Pour traiter diverses affections, pour traiter les problèmes dentaires et les plaies infectées, pour stimuler la lactation, contre les maux de gorge, pour traiter les troubles de la peau, les piqûres d'abeilles, les coupures et les brûlures
Arctostaphylos uva-ursi	Pour augmenter la lactation chez les mères allaitantes, contre les maux de gorge, pour traiter les troubles de la peau, les piqûres d'abeilles, les coupures et les brûlures

Betula papyrifera	Pour traiter les problèmes dentaires, comme poudre pour, bébé, contre les maux de dos, pour induire la lactation, comme un nettoyant topique, pour traiter les troubles féminins, pour traiter l'asthme, comme un gargarisme pour les amygdalites, maux de gorge, et le froid, pour traiter les brûlures et les blessures, pour traiter les lésions et éruptions cutanées, utilisée par les femmes qui ne peuvent pas concevoir un enfant, utilisé comme écharpe ou bandage pour des membres cassés, foulés ou enflés, pour traiter les abcès et contre l'impétigo
Calla palustris	Pour traiter les jambes douloureuses
*Carum carvi**	Pour soulager les coliques et pour traiter la toux
Chamerion angustifolium	Appliqué comme un plâtre sur des contusions, comme un cataplasme sur les furoncles, les abcès ou les plaies ouvertes et pour prévenir l'infection, pour induire les menstruations
Chenopodium album, ***	Pour traiter les membres douloureux
Chimaphila umbellata	Appliqué sur des plaies ouvertes et ingérée comme tonique et diurétique, pour traiter les maux de dos ou les douleurs lancinantes dans la poitrine, contre la toux contenant du sang
Cicuta maculata	Appliquée sur les plaies
Cladina stellaris	Pour expulser les vers intestinaux
Cypripedium parviflorum	Comme sédatif, antispasmodique ou dépressif
Dryopteris expansa	Pour stimuler l'appétit, contre le cancer
Empetrum nigrum	Pour traiter le diabète et comme un diurétique
Equisetum arvense	Comme un diurétique ou pour traiter les troubles rénaux
Equisetum hyemale	Pour traiter les troubles rénaux
*Erigeron canadensis**	Contre la diarrhée
Fragaria virginiana	Pour traiter les problèmes cardiaques et la diarrhée
Gaultheria hispidula	Contre la congestion, la fièvre et l'hypertension artérielle, donnée aux bébés comme une sucette pendant la dentition et pour traiter le diabète
Geocaulon lividum	Plante médicinale

Geum aleppicum	Pour traiter les douleurs dentaires, les maux de gorge ou induire la transpiration
Geum macrophyllum	Pour traiter les douleurs dentaires
Geum rivale	Pour faciliter l'accouchement
Heracleum maximum	Pour traiter les parties du corps endoloris, l'arthrite, le rhume, les maux de dents, de tête, appliquée sur des furoncles, des gonflements et des chancres, pour nettoyer les infections de la peau et pour purifier le corps
Iris versicolor	Comme purgatif
Juniperus communis	Pour traiter le diabète et les symptômes liés et la douleur
Juniperus horizontalis	Pour traiter les problèmes dentaires, les maux de dos et les problèmes des voies urinaires
Kalmia angustifolia	Pour traiter le diabète, les troubles intestinaux et comme tonique
Larix laricina	Pour arrêter les vomissements, utilisé sur les furoncles, comme un sirop contre la toux, les maux de gorge ou de bouche, pour traiter les maux d'estomac, les engelures, les hémorroïdes, les plaies infectées, les brûlures ou les coupures, pour traiter la dépression, utilisé comme un collyre contre une irritation de l'oreille, pour traiter le diabète, pour traiter les problèmes cardiaques, les engelures et les coupures profondes, soulager l'indigestion, et pour traiter la cécité causée par le reflet des neiges
Leymus mollis	Pour traiter le diabète
Lilium philadelphicum	Pour traiter l'appendicite et les maux de dents
Lonicera dioica	Pour laver les cheveux et pour les faire pousser, comme un diurétique, pour aider la coagulation du sang après l'accouchement, et contre les maladies vénériennes, pour traiter les problèmes rénaux, de la vessie et les affections cardiaques
Lycopodium clavatum	Pour traiter le diabète
Maianthemum canadense	Comme un bandage pour traiter les gonflements des membres

Matteuccia struthiopteris	Pour traiter les maux de dos et accélérer l'expulsion du placenta
*Medicago sativa**	Pour traiter l'arthrite, les douleurs musculaires et les ulcères
Mitella nuda	Pour traiter les maux d'oreilles
Petasites frigidus	Pour soulager les démangeaisons pour traiter la varicelle, pour guérir les plaies et prévenir les infections
Picea glauca	Pour soulager les infections de la peau, les coupures, les éruptions cutanées, la gale, les brûlures, les plaies persistantes, les furoncles, et la peau gercée ou craquée et pour traiter le diabète
Picea mariana	Prévenir les problèmes de respiration, l'essoufflement, les problèmes cardiaques et l'hypertension artérielle, pour traiter le diabète, pour traiter une oreille douloureuse, les maux de gorge ou les maux d'estomac, pour prévenir l'infection de kystes, pour traiter les plaies infectées, les éruptions cutanées, les cloques, les croûtes sur la tête ou la varicelle, utilisée pour traiter le diabète, pour traiter les maux de gorge, pour soulager les maux de dents ou de bouche, pour traiter les maladies vénériennes et pour traiter le diabète
Pinus banksiana	Pour guérir une coupure profonde et pour traiter le diabète
Pinus sp.	Pour soigner les coupures
Plantago major, ***	Pour traiter les brûlures, pour traiter les maux de dents ou d'oreilles, pour arrêter les hémorragies internes ou soigner blessures, pour traiter les troubles cardiaques et pour traiter une plaie infectée
Podophyllum peltatum	Comme cathartique et pour traiter les troubles du foie
Polygala senega	Pour traiter les maux de gorge, appliquée sur les coupures, pour traiter les maux de bouche, de gorge et de dents, la toux et le rhume, pour traiter les troubles de la peau, les piqûres d'abeilles, les coupures et les brûlures
Polygonum amphibium	Pour traiter diverses affections

Polypodium virginianum	Contre la tuberculose
Populus balsamifera	Soulager une dent douloureuse, pour traiter les problèmes cardiaques et l'hypertension, pour traiter le diabète
Populus grandidentata	Pour prévenir une grossesse et réduire le flux menstruel
Populus sp.	Pour traiter les furoncles, les abcès, et la teigne, comme un purgatif léger, pour traiter le diabète, les infections urinaires et comme cataplasme pour traiter la cécité causée par le reflet de la neige
Populus tremuloides	Pour traiter les maladies vénériennes, les troubles de l'estomac, la diarrhée, la toux, le cancer ou le diabète, arrêter les crachats de sang, comme un cataplasme, comme un tonique, pour couvrir les plaies et arrêter le saignement et pour soigner les piqûres d'insecte
Prunella vulgaris	Pour soulager les maux de gorge
Prunus pensylvanica	Pour traiter la bronchite, la toux, l'empoisonnement du sang, les maux des yeux et la coqueluche
Prunus virginiana	Pour traiter la diarrhée, pour soulager les maux d'estomac, comme purgatif et émétique, contre les rhumes, la grippe, la fièvre et la pneumonie, pour traiter les problèmes cardiaques et l'hypertension sanguine
Pyrola asarifolia	Pour arrêter une toux contenant du sang et pour traiter les maux des yeux
Rhododendron tomentosum	Pour traiter le diabète
Ribes glandulosum	Pour prévenir la coagulation du sang après la naissance
Ribes hudsonianum	Utilisée pour traiter les troubles post-partum
Ribes oxyacanthoides	Utilisée pour traiter les troubles post-partum
Ribes triste	Pour induire les menstruations
Rhododendron groenlandicum	Comme diurétique, pour traiter la pneumonie et la coqueluche, pour prévenir la perte de cheveux, pour soulager les douleurs rhumatismales, renforcer l'estomac, soulager les maux tête et activer la transpiration, contre la

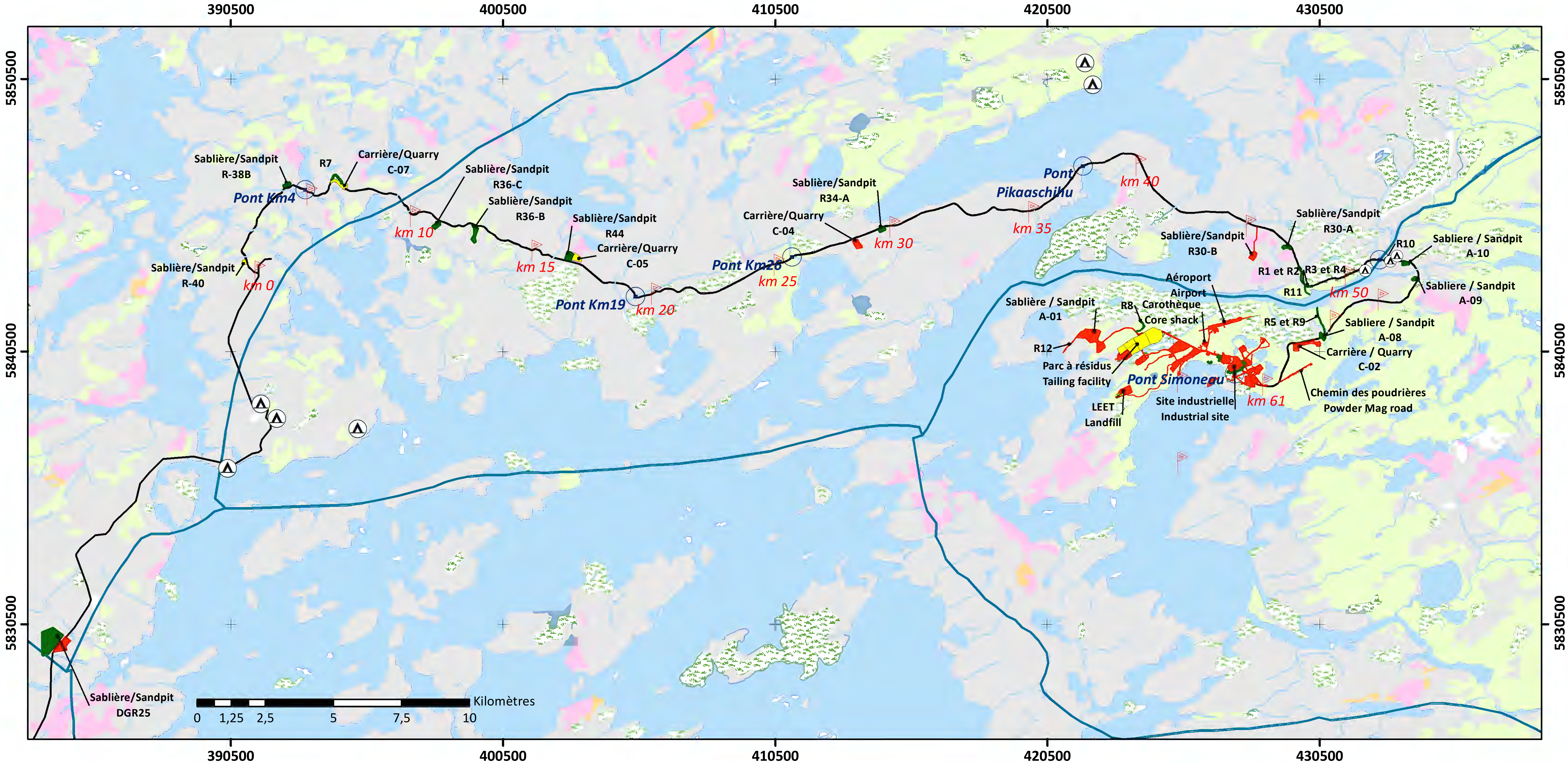
	gangrène et les abcès, comme une boisson énergétique
Rosa acicularis	Pour soulager les menstruations excessives et régulariser le cycle, pour traiter la diarrhée, comme collyre pour traiter la douleur et la cécité causée par le reflet des neiges et contre la toux
Rubus idaeus	Pour traiter la fièvre, l'asthme, contre la diarrhée chez les enfants et les infections cutanées, pour traiter les douleurs dentaires, pour aider les femmes à récupérer après l'accouchement, et diminuer les saignements menstruels, pour traiter le choléra et la dysenterie, comme un tonique et un astringent et pour traiter les problèmes d'estomac
Sagittaria cuneata	Comme cataplasme pour les troubles de la peau, les coupures, les brûlures et les piqûres d'abeilles
Salix bebbiana	Pour traiter la diarrhée, les maux d'estomac et de dents, pour traiter les coupures profondes et fournir de la force
Salix lucida	Pour traiter les plaies dans la bouche, les plaies autour des yeux et les rhumes
Salix planifolia	Pour traiter le diabète
Salix sp.	Pour traiter la paralysie, pour traiter le diabète et les problèmes d'estomac
Sarracenia purpurea	Pour traiter les troubles rénaux et les douleurs lombaires, le diabète, les troubles féminins, tel que l'aménorrhée, pour faciliter l'accouchement, pour traiter la fièvre et les maux de tête, comme un cataplasme sur les coupures, suivant l'accouchement et aider à expulser le placenta, pour traiter les maladies vénériennes, pour traiter le diabète, soulager les troubles de la peau, les coupures, les brûlures et les piqûres d'abeilles
Scutellaria galericulata	Pour traiter la fièvre
Shepherdia canadensis	Pour traiter membres endoloris, l'arthrite et les maux de tête et de visage, comme purgatif et émétique, pour prévenir les fausses couches,

	pour traiter les maladies vénériennes, pour traiter la toux contenant du sang et comme laxatif
Sium suave	Comme un tonique et nettoyer le sang, pour traiter la congestion, les troubles cardiaques, les maux de tête et la fièvre, les maux de gorge, la toux et le rhume, contre le cancer
Solidago multiradiata	Comme tonique
Sorbus americana	Contre le choléra, pour traiter l'arthrite et les douleurs musculaires et pour traiter les maux de gorge et la toux
Sorbus decora	Pour traiter les maux de dos et le diabète
Sphagnum capillifolium	Pour traiter l'érythème fessier, et pour laver le bébé à la naissance, pour soulager les maux de dents et signer les problèmes urinaires, pour traiter la douleur du corps et les douleurs musculaires
Sphagnum fuscum	Appliqué sur les coupures ou les infections de la peau, pour traiter l'érythème fessier, et pour laver le bébé à la naissance, pour traiter le diabète
Symphoricarpos albus	Pour traiter les douleurs dentaires et les maladies vénériennes, comme un diurétique, pour traiter les problèmes rénaux, pour soulager les maux des yeux et traiter une éruption cutanée
*Symphoricarpos occidentalis**	Pour traiter les problèmes rénaux
Symphyotrichum puniceum	Pour traiter l'essoufflement, les problèmes rénaux, les frissons et les sueurs froides, pour faciliter l'accouchement et traiter l'aménorrhée et pour traiter la paralysie faciale
Taraxacum officinale, ***	Comme hépatique, tonique, diurétique et légèrement cholagogue et pour nettoyer le sang
Thuja occidentalis	Pour traiter la pneumonie et les troubles urinaires, comme lavement, pour traiter la paralysie faciale provoquée, pour traiter la douleur générale, pour traiter la congestion, pour traiter les infections de la peau, les coupures et les douleurs abdominales pour traiter l'arthrite et les douleurs musculaires

Triglochin maritima	Pour soulager la diarrhée sanglante
Typha latifolia	Comme un cataplasme sur les brûlures, pour traiter les troubles de la peau, les coupures, les brûlures et les piqûres d'abeilles, pour traiter le diabète et traiter les maux de gorge
Urtica dioica	Après l'accouchement, pour soulager les démangeaisons et l'inflammation causées par un contact avec des plantes et pour traiter l'asthme, pour traiter les troubles de la peau, les coupures, les brûlures et les piqûres d'abeilles, pour traiter la paralysie, la fièvre et les problèmes urinaires et pour traiter l'anémie
Vaccinium angustifolium	Pour traiter le diabète
Vaccinium myrtilloides	Pour prévenir la grossesse, pour prévenir les fausses couches, après l'accouchement, pour déclencher les menstruations ou réduire le flux sanguin lors des menstruations et pour faciliter l'accouchement
Vaccinium vitis-idaea	Pour nettoyer l'estomac, pour traiter le diabète et pour traiter les problèmes urinaires
Valeriana dioica	Pour aider le gain de poids chez un enfant, pour prévenir une fausse couche ou pour soulager la douleur du travail, pour traiter les éruptions cutanées du visage, pour traiter le froid ou la fièvre, comme un tonique très puissant, pour traiter les troubles cardiaques, et prévenir le vieillissement et les rides
Veratrum viride	Dépresseur
Viburnum edule	Pour traiter les maux de gorge et les douleurs dentaires

* Espèces introduites (Canadensys, 2016)
** Espèces envahissantes (Lavoie et al., 2014)

APPENDIX 3 MAPS OF SITES TO BE RESTORED



Légende / Legend :

Occupation du territoire / of the territory :
- Eau / Water
- Feuillus / Hardwood
- Végétation mélangée / Mixed Vegetation
- Herbacés et végétation basse / Herbaceous and low vegetation
- Résineux / Resinous
- Milieu humide / Wetland

Planification Restauration / Restoration planning :
- Prêt à restaurer / Ready to restore
- À restaurer durant la vie de la mine / During the life of the mine
- À restaurer à la fin de la vie de la mine / End of the life of the mine

Toponymie / Toponymy :
- Camp cri / Cree camp
- Ponts / Bridge
- Kilométrage route / Road mileage
- Territoire de trappes / Traplines
- Chemin d'accès / Access road
- Cours d'eau / Watercourse

Sites à restaurer
Sites to restore

NEWMONT GOLDCORP. Éléonore

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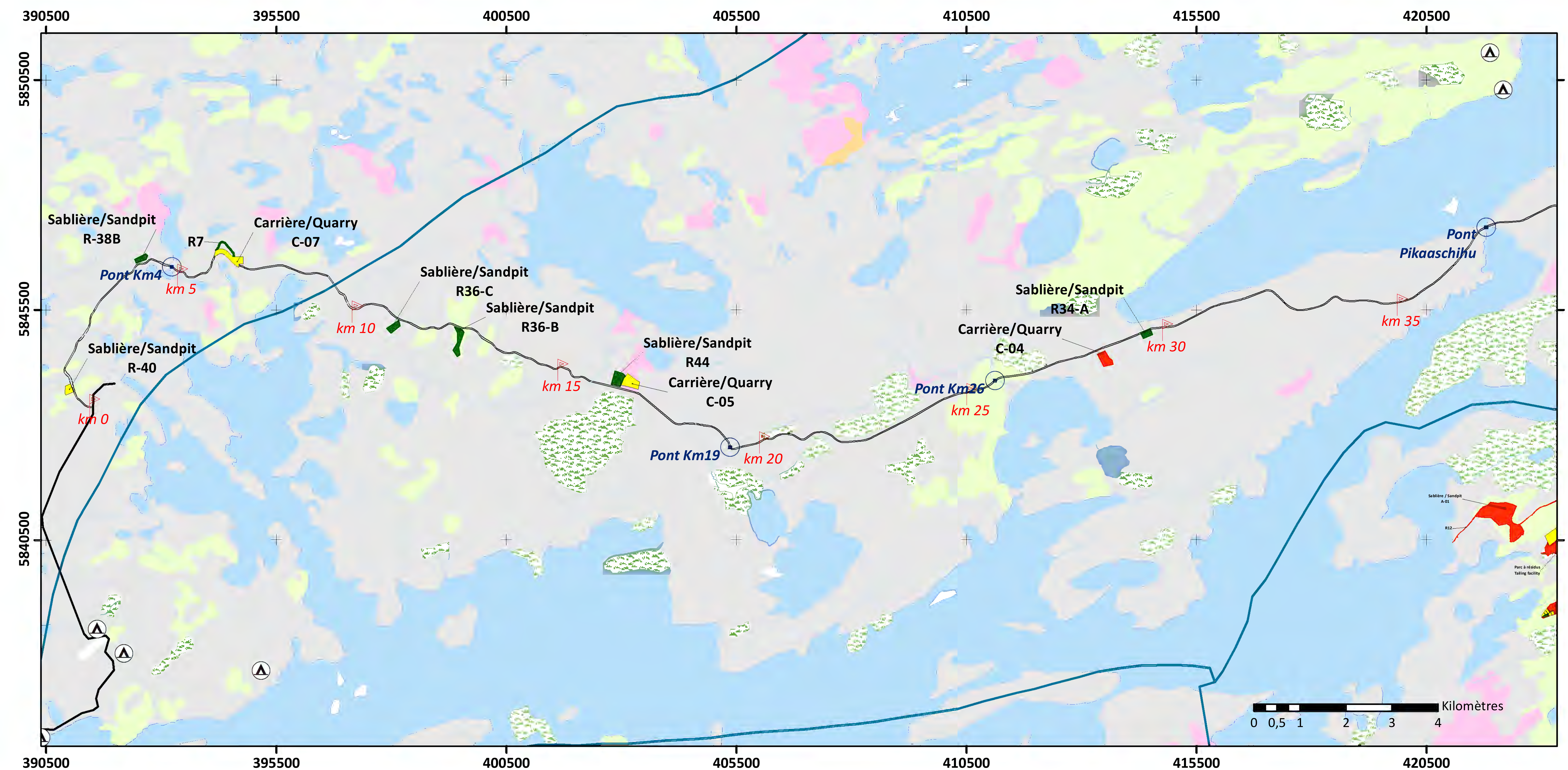

Légende / Legend :

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Sites à restaurer
Sites to restore

NEWMONT GOLDCORP. Éléonore

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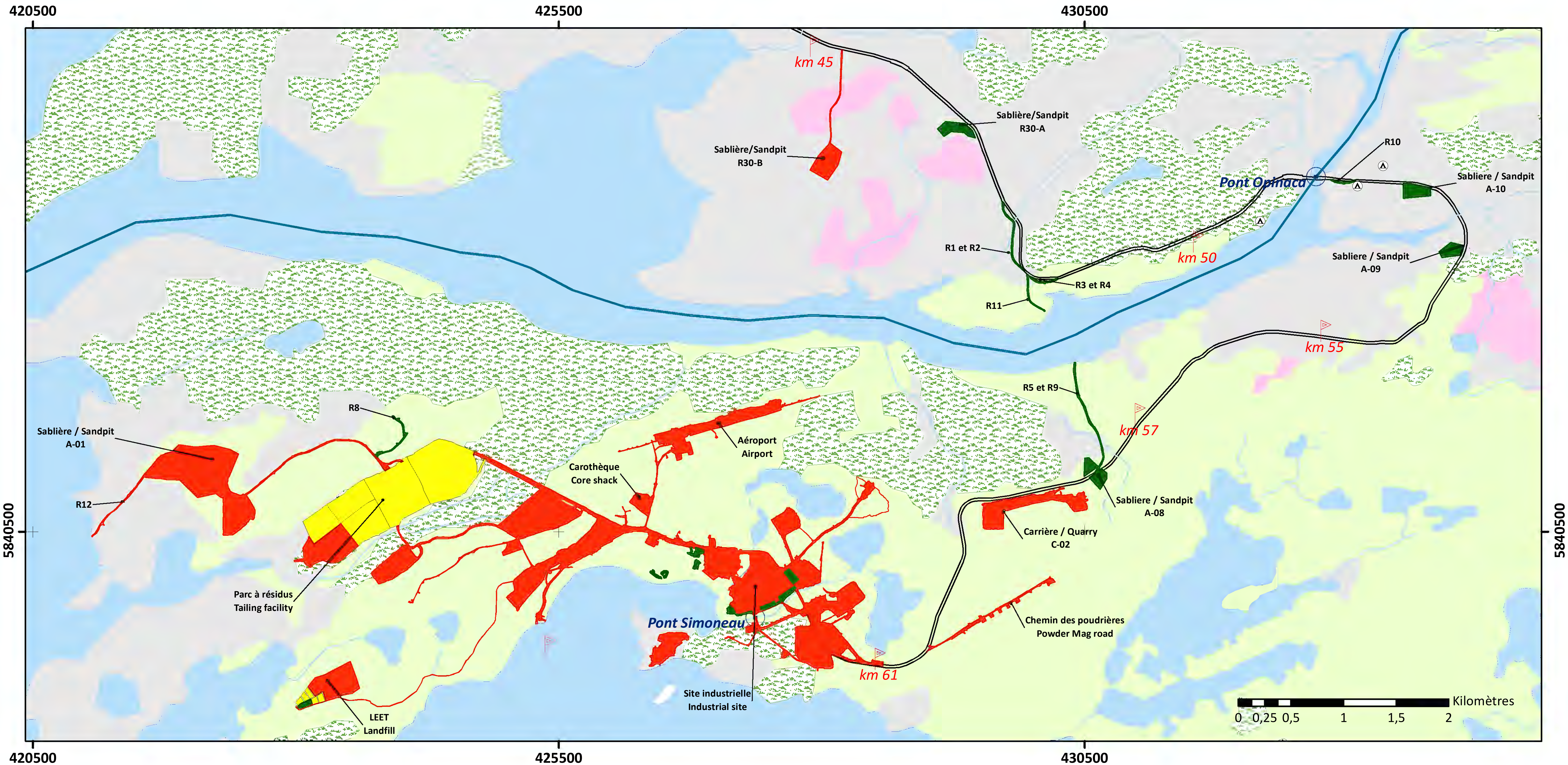

Légende / Legend :

Occupation du territoire / of the territory :

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- Chemin d'accès / Access road
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Sites à restaurer
Sites to restore

NEWMONT GOLDCORP
Éléonore

Coordonnées géo. : NAD83 UTM Zone 18
Document Name: Planification_restauration_zoom
Date : 2019-12-01 07:33:30
Réalisé par : William Fresser

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APPENDIX 4 ECOLOGICAL INVENTORY OF SITES TO BE RESTORED

Inventaire écologique sommaire des sites à restaurer

Dans le cadre de la préparation du plan de compensation des milieux humides

Pour le projet Éléonore de Goldcorp

Par Benoit Limoges

Biologiste consultant

Octobre 2017

Révisé en octobre 2018

Photo page couverture : visite des sites à restaurer avec la famille du maître de trappe. Ici le site à restaurer ayant servi de chemin des poudrières.

Table des matières

Inventaire écologique sommaire des sites à restaurer

1- Objectifs

Afin de développer des plans d'aménagement pour les sites à restaurer, en vue de la compensation :

- connaître leurs conditions biophysiques actuelles,
- en caractériser la flore et sa régénération.

2- Méthodologie

Du 19 au 21 septembre 2017, Marjorie Bujold, biologiste de Goldcorp, Perle Dion-Trudel, stagiaire en environnement chez Goldcorp, et Benoit Limoges, biologiste consultant, sont allés dans chacun des sites à restaurer pour recueillir des informations d'ordre biophysique et les annoter dans les formulaires de terrain présentés à l'Annexe 1. La sablière R36-B a été inventoriée le 25 août 2018. Les données sont surtout d'ordre botanique. La présence de chaque espèce recensée était cochée dans le tableau. La ou les espèces ligneuses dominantes ont été inscrites avec un D, lorsque c'était possible. Cela se veut une estimation du type de régénération potentiel, i.e. vers quel type de communauté végétale le site dégradé pourrait évoluer dans le futur. Le pourcentage de couverture végétale de chaque zone était aussi estimé.

Les autres données recueillies sont :

- Présence de tas d'agrégats,
- Nature du sol de la zone à restaurer,
- Présence d'eau,
- Taille approximative des andains de terre végétale et de mort terrain,
- Taille approximative des tas de débris ligneux,
- Taille approximative des tas de gros rochers,
- Présence de déchets domestiques ou de construction,
- Présence ou signe d'animaux,
- Intérêt du site pour les Cris,
- Usages actuels ou passés,
- Travaux de restauration effectués jusqu'à maintenant,
- Autres remarques.

Ces dernières données ne visent pas directement la caractérisation écologique des sites de restauration, mais plutôt l'obtention des données utiles à la préparation du plan de compensation.

3- Sites à restaurer

Quelque 19 sites potentiels de compensation sont prêts à être restaurés. Il s'agit de :

- 11 sablières dont les activités d'extraction sont terminées,
- 9 segments de chemin d'hiver qui n'ont pas été recouverts par le remblai de la route permanente.

Chaque sablière inventoriée a été divisée en trois sections grossièrement concentriques, soit généralement (Figure 1) :

1. Section déboisée seulement, c'est-à-dire le tour de la sablière à l'intérieur de l'aire d'exploitation;
2. Section décapée, c'est-à-dire qui a été déboisée et dont la terre végétale et parfois le mort terrain a été retiré et poussé en andain;
3. Section excavée, c'est-à-dire là où du matériel granulaire a été extrait et emporté. Cette section a parfois déjà fait l'objet de travaux de reprofilement; elle est alors dénommé « reprofilée ».

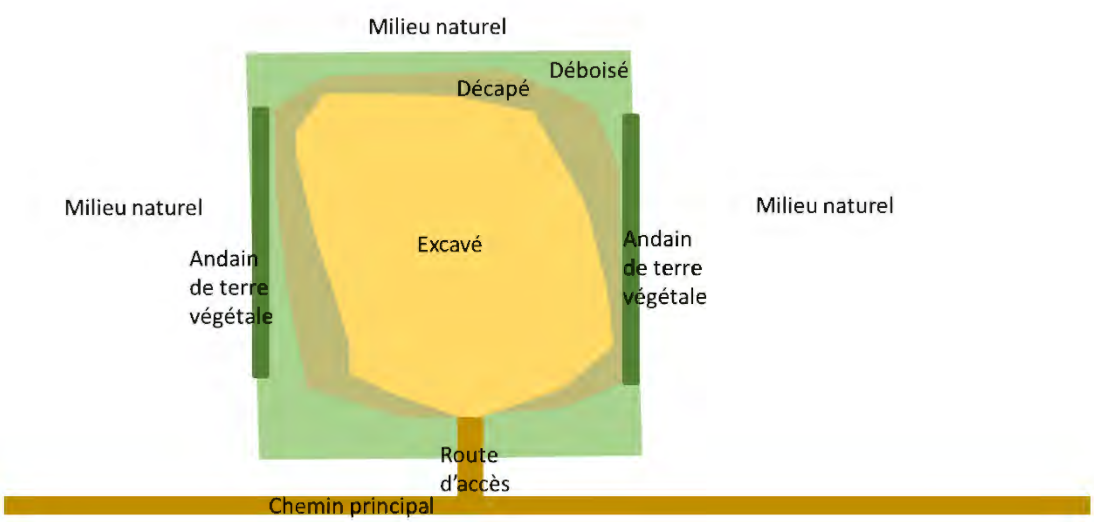

Figure 1 Représentation schématique des différentes sections inventoriées d'une sablière

Pour les segments de route, les deux principales sections sont les suivantes (Figure 2) :

1. Zone ayant été déboisée dans l'emprise de part et d'autre de la route,
2. Le remblai de la route comprenant la surface de roulement et la pente de chaque côté.

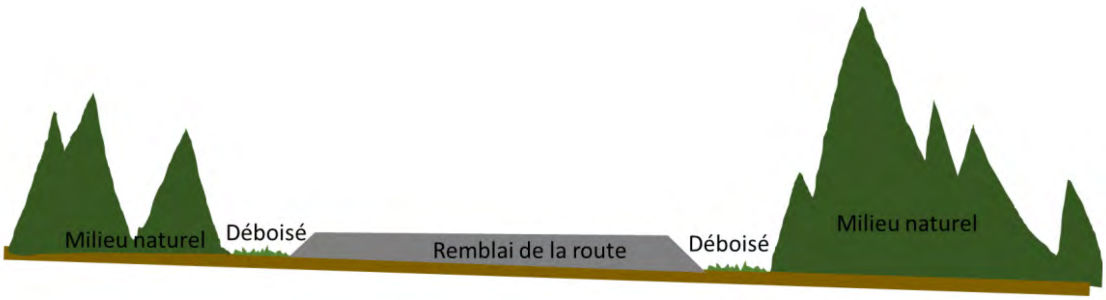

Figure 2 Représentation schématique des différentes sections inventoriées d'un segment de chemin d'hiver

4- Résultats

4.1 Espèces végétales inventoriées

Le Tableau 1 présente les espèces végétales vasculaires inventoriées. Pour celles qui n'ont pu être identifiées à l'espèce, dans certains cas, dans la colonne « Commentaire », on a référé aux espèces déjà identifiées par le passé dans ces habitats. Les Carex, par exemple, n'ont pu être identifiés à l'espèce étant donné que la date de floraison était passée, mais on a inscrit dans le tableau les espèces qui ont déjà été identifiées dans le secteur du projet Éléonore. En effet, toutes les espèces, tant vasculaires, invasculaires qu'animales, ayant été identifiées avec certitude dans les environs du projet minier font l'objet du Registre de biodiversité de Goldcorp.

Quelque 18 nouvelles espèces et nouveaux genres ont été identifiés lors de cet inventaire. On peut les classer dans deux catégories : indigènes et naturalisés. Douze sont des espèces naturalisées qui n'existaient pas sur ce territoire avant le projet Éléonore. Cinq d'entre elles sont considérées nuisibles par Lavoie et al. (2014) ou envahissantes par GISD (2017).

Figure 3 Nouvelle espèce indigène inventoriée, la Corydale toujours-verte

Figure 4 Une espèce naturalisée nouvellement recensée, la Renoncule âcre, considérée nuisible par Lavoie et al. (2014)

4.2 Communautés végétales

Sablières

En ce qui concerne les sablières, les zones déboisées sont généralement composées d'espèces indigènes et elles ont une richesse moyenne de 12 espèces (Tableau 2 et 3). Les zones décapées abritent un mélange d'espèces indigènes et naturalisées avec une richesse moyenne de 12 espèces aussi. Quant aux zones excavées, elles ont une richesse moyenne de 8 espèces et sont composées aussi d'un mélange d'espèces indigènes et naturalisées. On retrouve davantage d'espèces naturalisées (10 espèces) dans les sablières que le long des segments de routes (8 espèces). Toutefois, il faut faire attention en comparant les sablières avec les segments de route, car l'effort d'échantillonnage n'a pas été le même.

Là où il a été possible de détecter une ou des espèces dominantes qui pourraient constituer la couverture végétale de la future régénération, ce sont les espèces suivantes, par ordre décroissant d'occurrence :

1- Aulne crispé (14 occurrences)
2- Pin gris (10)
3- Épinette noire (3)
4- Bouleau à papier (1)
5- Peuplier faux-tremble (1).

Cela signifie que dans la moitié des cas, la couverture végétale semble évoluer vers des peuplements composés en totalité ou en majorité d'aulne crispé. Dans les autres cas, c'est vers une pinède à pin gris ou une pessière noire que cela semble évoluer. Il n'y a que deux sites où le bouleau à papier ou le peuplier faux-tremble vont occuper une place prépondérante.

Segments de route

Quant aux segments de route à restaurer, on retrouve encore ici davantage d'espèces indigènes dans la zone déboisée avec une richesse moyenne de 10 espèces (

HERBACÉES	A-01-A			A-08-B			A-09			A-10			R-30A			R-34A			R-36-B			R-36C		
	Déboisé	Décapé	Excavé	Déboisé	Remblai	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Reprofilé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé
Achillée millefeuille																		x						x
Anaphale marguerite																								
Aralie hispide (Salsepareille)				x										x							x			
Carex												x									x			x
Épilobe à feuille étroites	x	x		x		x		x				x	x	x		x					x		x	x
Clintonie boréale													x											
Quatre-temps				x		x	x			x		x	x	x			x				x		x	
Corydale toujours-verte									x								x							
Camarine noire										x														
Épigée rampante									x				x											
Prêle "persistant"																		x						
Prêle des champs									x												x			
Prêle des forêts				x			x										x							
Petit thé																								
Marguerite blanche																								x
Linnée boréale								x																
Lotier corniculé				x													x							x
Lycopode innovant													x											
Lycopode dendroïde																								
Lycopode patte de lapin																								
Maianthème du Canada				x																			x	
Pétasite palmé							x										x							
Phléole des prés																								x
Épervière des prés													x											x
Graminée				x	x	x	x	x	x	x		x		x		x					x			
Renoncule âcre																		x						
Thé du Labrador							x			x			x								x			
Petite oseille																	x				x			
Scirpe à ceinture noire		x		x	x		x	x	x					x									x	x
Scirpe	x	x						x	x					x			x							
Potentille tridentée							x						x											
Verge d'or							x																	
Rubanier																x								
Trèfle blanc																		x						
Trèfle rouge																		x						x
Vesce jargeau																	x				x			
Violette																x								
Richesse totale	8	11	3	19	10	3	16	9	13	9	1	7	19	17	0	12	13	6				0	10	15

Tableau 4 et 5). Le remblai de la route contient davantage d'espèces naturalisées et une richesse moyenne de 14 espèces, significativement supérieure à celle de la zone déboisée.

Là où il a été possible de détecter une ou des espèces dominantes sur les segments de route qui pourraient constituer la couverture végétale de la future régénération, cela s'est traduit le plus souvent par les espèces suivantes, par ordre décroissant d'occurrence :

1- Aulne crispé (6 occurrences)
2- Épinette noire (3)

3- Pin gris (2).

Cela signifie que dans la moitié des cas, la couverture végétale semble évoluer vers des peuplements composés en totalité ou en majorité d'aulne crispé. Dans les autres cas, c'est vers une pinède à pin gris ou une pessière noire que cela semble évoluer.

Ce résultat est important pour les maîtres de trappe. En effet, ceux-ci favorisent l'apparition de peuplements qui produisent de la nourriture pour les orignaux, comme le peuplier et le bouleau. Nos résultats montrent que bien peu de sites semblent évoluer naturellement vers de tels peuplements.

4.3 Données biophysiques

Le Tableau 6 présente les diverses données recueillies dans les sablières en marge de l'inventaire botanique. Voici les principaux constats :

- Les sols sont généralement un mélange de sable et de gravier.
- Très peu de tas d'agrégats demeurent dans ces sablières qui sont ainsi prêtes à restaurer, car leur utilisation est terminée.
- Dans la plupart des sites, il y a des flaques d'eau stagnantes qui sont souvent des endroits plus riches en plantes.
- Dans la plupart, il y a des andains de terre végétale qui pourront être étendus afin de redonner une certaine fertilité au sol.
- Certaines sablières ont déjà été reprofilées et certains andains de terre végétale ont été étendus. Elles sont prêtes à planter.
- Dans plusieurs, il y a des empilements de troncs qui pourraient être déchiquetés pour faire des copeaux qui seraient étendus sur le sol afin d'aider à sa structure.
- Il y a aussi plusieurs tas de rochers de type boulder qui peuvent être conservés tel quel comme habitat faunique.
- Certaines pentes abruptes doivent être adoucies afin de respecter les normes du MERN.
- Peu de déchets ont été notés. Mais certains nettoyages devront être faits.
- Peu de signes d'animaux ont été notés.
- Une sablière abrite une colonie d'hirondelle des rivages à préserver.
- Ces sablières ne sont pas utilisées actuellement. Elles servent parfois pour installer des campements temporaires de chasseurs étrangers.
- C'est pourquoi, les maîtres de trappe désirent généralement renaturaliser les sablières pour éviter l'installation de compétiteurs sur leur territoire de trappe.
- La couverture végétale des zones excavées varie de 0 – 50 %, en moyenne 10 %, ce qui démontrer que leur régénération naturelle n'est pas bien engagée ; contrairement aux zones déboisées et décapées, qui sont en général déjà bien régénérées.
- La sablière A-10 a été reprofilée en 2016.

- Les sablières R36-B, R44, R34-A et R30-A étaient en train d'être reprofilées lors de notre inventaire.

Le Tableau 7 présente les diverses données recueillies dans les segments de chemin d'hiver en marge de l'inventaire botanique. Voici les principaux constats

- Les remblais ayant servi de surface de roulement sont généralement un mélange de gravier et de sable.
- Les calvettes qui permettaient aux cours d'eau de traverser les segments de routes ont presque tous été retirés, sauf un. Les cours d'eau ont été stabilisés avec des pierres.
- Les surfaces de roulement ne sont que très peu régénérés naturellement.
- Des travaux de restauration visant à retirer complètement le remblai de certains segments sont prévus en 2017.
- Généralement, les maîtres de trappe Cris veulent voir disparaître complétement ces segments en les reboisant. Leur motivation est que ces sites, tout comme les sablières abandonnées, sont propices à l'installation de chasseurs étrangers.

5- Conclusion

Cet inventaire sommaire a permis de décrire l'état des sites prêts à restaurer qui pourraient servir pour la compensation. Aucun écosystème rare ou fragile n'a été recensé. Au contraire, il a été observé des sites peu régénérés et, lorsque végétation il y a, avec des espèces communes comme l'aulne crispé, l'épinette noire et le pin gris. Rare sont les sablières qui semblent se régénérer vers des peuplements d'arbres feuillus qui pourraient servir d'habitat d'alimentation pour l'orignal, tel que le désirent les maîtres de trappe.

Cet inventaire fournit de nouvelles données sur la biodiversité du secteur du projet Éléonore. On y a appris que plusieurs espèces nouvelles s'installent sur le territoire, notamment des espèces naturalisées dont certaines nuisibles ou envahissantes.

Des données d'ordre biophysique ont été recueillies et elles serviront à préparer les plans de restauration de chacun de ces sites.

Enfin, un atlas photographique des sites à restaurer a été constitué. Des photos de chaque site sont présentées à l'annexe 2.

6- Tableaux

Tableau 1 Liste des espèces vasculaires inventoriées

Arbres		**Commentaire**
Bouleau à papier	*Betula papyrifera*	
Mélèze laricin	*Larix laricina*	
Épinette noire	*Picea mariana*	
Pin gris	*Pinus banksiana*	
Peuplier faux-tremble	*Populus tremuloides*	
Cerisier de Pennsylvanie	*Prunus pensylvanica*	
Arbustes		
Aulne crispé	*Alnus crispa*	
Aulne rugeux	*Alnus rugosa*	
Amélanchier	*Amelanchier sp.*	Nouveau genre. Possiblement *A. Bartramiana*
Bouleau glanduleux	*Betula glandulosa*	
Cassandre caliculé	*Cassandra calyculata*	
Kalmia à feuilles étroites	*Kalmia angustifolia*	
Kalmia à feuille d'andromède	*Kalmia polifolia*	
Myrique beaumier	*Myrica gale*	
Gadellier glanduleux	*Ribes glandulosum*	
Ronce petit murier	*Rubus chamaemorus*	
Framboisier	*Rubus idaeus*	
Saule arbustif	*Salix spp.*	Inclut probablement les espèces suivantes*: Salix bebbiana, S. humilis* et *S. Pyrifolia*
Airelle à feuilles étroites	*Vaccinium angustifolium*	
Airelle des marécages	*Vaccinium uliginosum*	
Viorne trilobée	*Viburnum trilobum*	
Herbacées		
Achillée millefeuille	*Achillea millefolium*	Nouvelle espèce. Espèce naturalisée.
Anaphale marguerite	*Anaphalis margaritacea*	Nouvelle espèce. Espèce naturalisée.
Aralie hispide (Salsepareille)	*Aralia hispida*	
Carex	*Carex spp.*	Inclut probablement les espèces suivantes: *Carex canescens, Carex limosa, Carex oligosperma, Carex tenuiflora* et *Carex trichocarpa*
Épilobe à feuille étroites	*Chamerion angustifolium*	
Clintonie boréale	*Clintonia borealis*	Nouvelle espèce
Quatre-temps	*Cornus canadensis*	
Corydale toujours-verte	*Corydalis sempervirens*	Nouvelle espèce. Syn. *Capnoides sempervirens*
Camarine noire	*Empetrum nigrum*	
Épigée rampante	*Epigea repens*	
Prêle "persistant"	*Equisetum sp.*	Nouvelle espèce. Probablement *E. variegatum*
Prêle des champs	*Equisetum arvense*	
Prêle des forêts	*Equisetum sylvaticum*	
Linaigrette	*Eriophorum sp.*	Inclut probablement les espèces suivantes: *Eriophorum spissum, Eriophorum vaginatum et Eriophorum virginicum*
Petit thé	*Gaultheria hispidula*	
Marguerite blanche	*Leucanthemum vulgare*	Espèce naturalisée.
Linnée boréale	*Linnaea borealis*	

Lotier corniculé	*Lotus corniculatus*	Nouvelle espèce. Espèce naturalisée. Envahissante selon le GISD (2017)
Lycopode innovant	*Lycopodium annotinum*	
Lycopode dendroïde	*Lycopodium dendroideum*	Nouvelle espèce
Lycopode patte de lapin	*Lycopodium lagopus*	Nouvelle espèce
Maianthème du Canada	*Maianthemum canadensis*	
Petit atocas	*Oxycoccus microcarpus*	
Pétasite palmé	*Petasites frigidus*	
Phléole des prés	*Phleum pratense*	Nouvelle espèce. Espèce naturalisée.
Épervière des prés	*Pilosella caespitosa*	Syn. *Hieracium pratense* et *H. Ceaspitosum.* Espèce naturalisée.
Graminée	*Poaceae sp.*	
Renoncule âcre	*Ranunculus acris*	Nouvelle espèce. Espèce naturalisée. Nuisible selon Lavoie et al. (2014)
Thé du Labrador	*Rhododendron groendlandicum*	
Petite oseille	*Rumex acetosella*	Nouvelle espèce. Nuisible selon Lavoie (2014). Envahissante selon le GISD (2017)
Scirpe à ceinture noire	*Scirpus atrocinctus*	
Scirpe	*Scirpus spp.*	
Potentille tridentée	*Sibbaldia tridentata*	
Silène enflé	*Silene vulgaris*	Nouvelle espèce. Espèce naturalisée. Syn. *S. cucubalus*
Smilacine trifolié	*Smilacina trifolia*	
Verge d'or	*Solidago sp.*	Nouveau genre. Probablement *S. lepida*
Rubanier	*Sparganium sp.*	
Tanaisie vulgaire	*Tanacetum vulgaris*	Nouvelle espèce. Espèce naturalisée.
Trèfle blanc	*Trifolium repens*	Espèce naturalisée. Nuisible selon Lavoie et al. (2014). Envahissante selon le GISD (2017)
Trèfle rouge	*Trifolium pratense*	Nouvelle espèce. Espèce naturalisée.
Canneberge commune	*Vaccinium oxycoccos*	
Vesce jargeau	*Vicia cracca*	Nouvelle espèce. Espèce naturalisée. Nuisible selon Lavoie et al. (2014)
Violette	*Viola sp.*	Nouveau genre

Tableau 2 Espèces vasculaires ligneuses recensées dans les 11 sablières prêtes à restaurer

	A-01-A			A-08-B			A-09			A-10			R-30A			R-34A			R-36-B			R-36C			R-38B			R-44			DG-R25-O		
	Déboisé	Décapé	Excavé	Déboisé	Remblai	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Reprofilé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé
ARBRES																																	
Bouleau à papier													x	x									x	x	D	x	x						
Mélèze laricin	x	x		x	x				x					x							x					x			x			x	
Épinette noire	x	x	x	x	x		x		x				D	x		x	x				x				D	x	x	x	x	x	x		D
Pin gris	x	D	x	D	D		D	x	D	D			x	x		x					x		D	x	D	x	x	x	x	x	x	x	D
Peuplier faux-tremble		x		x			x		x				x			D					D		x			x		x	x	x	x	x	
Cerisier de Pennsylvanie				x	x						x		x	x		x					x				x	x		x	x				x
ARBUSTES																																	
Aulne crispé	x	D	x	D	D				D	x				D		D	x	D			D			D	D	x	D	D	D		x		D
Bouleau glanduleux				x			x			x			x	x		x									x		x		x			x	x
Cassandre caliculé				x	x		x										x				x				x	x						x	
Kalmia à feuilles étroites	x	x		x			x		x	x		x	x			x							x		x	x	x	x				x	
Kalmia à feuille d'andromède																					x					x							
Gadellier glanduleux													x	x			x				x			x		x		x		x	x	x	
Ronce petit murier					x																												
Framboisier					x			x					x	x							x		x	x	x	x		x	x	x		x	x
Saule arbustif		x		x			x	x	x	x		x	x	x			x				x			D	x	x	x			x	x	x	
Airelle à feuilles étroites	x	x					x	x				x	x	x		x					x		x				x	x	x	x	x	x	x
Airelle des marécages				x																													

Tableau 3 Espèces vasculaires herbacées recensées dans les sablières prêtes à restaurer

HERBACÉES	A-01-A			A-08-B			A-09			A-10			R-30A			R-34A			R-36-B			R-36C			R-38B			R-44			DG-R25-O		
	Déboisé	Décapé	Excavé	Déboisé	Remblai	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Reprofilé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé	Déboisé	Décapé	Excavé
Achillée millefeuille																		x						x									
Anaphale marguerite																																x	
Aralie hispide (Salsepareille)				x										x							x											x	
Carex												x									x			x	x	x				x			
Épilobe à feuille étroites	x	x		x		x		x				x	x	x		x					x		x	x		x	x		x	x			x
Clintonie boréale													x																				
Quatre-temps				x		x	x			x		x	x	x			x				x		x		x			x	x			x	
Corydale toujours-verte									x								x								x								
Camarine noire										x																							
Épigée rampante									x				x																x				
Prêle "persistant"																		x															
Prêle des champs									x												x				x								
Prêle des forêts				x			x										x									x			x			x	
Petit thé																													x				
Marguerite blanche																								x									
Linnée boréale								x																									
Lotier corniculé				x													x							x					x				
Lycopode innovant													x													x							
Lycopode dendroïde																												x					
Lycopode patte de lapin																																x	
Maianthème du Canada				x																			x									x	
Pétasite palmé							x										x																
Phléole des prés																								x	x								
Épervière des prés													x											x									
Graminée				x	x	x	x	x	x	x		x		x		x					x				x		x			x		x	
Renoncule âcre																		x							x								
Thé du Labrador							x			x			x								x								x		x		
Petite oseille																	x				x						x						
Scirpe à ceinture noire		x		x	x		x	x	x					x									x	x	x	x	x	x	x				
Scirpe	x	x						x	x					x			x								x	x							x
Potentille tridentée							x						x																			x	
Verge d'or							x																										
Rubanier																x																	
Trèfle blanc																		x															
Trèfle rouge																		x						x	x								
Vesce jargeau																	x				x												
Violette																x																	
Richesse totale	8	11	3	19	10	3	16	9	13	9	1	7	19	17	0	12	13	6				0	10	15	20	19	12	12	17	10	8	18	9

Tableau 4 Espèces vasculaires ligneuses recensées dans les segments de route prêts à restaurer

	R-1-2		R-3-4		R-5	R-6		R-8		R-9		R-10		R-11	R-12	
	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Remblai de la route	Décapé	Remblai de la route
ARBRES																
Bouleau à papier						x	x				x					
Mélèze laricin	x				x						x					
Épinette noire	x	D		x	x	x		x	x		x	x	x	x	D	D
Pin gris	x	x		x	x	x	x	x	D		x			x	D	x
Peuplier faux-tremble									x		x		x	x		
Cerisier de Pennsylvanie	x			x			x	x							x	
ARBUSTES																
Aulne crispé		x			x	x	D	x	D		D		D		D	D
Aulne rugeux					x						x				x	
Amélanchier								x	x							
Bouleau glanduleux	x			x	x	x					x		x	x		
Cassandre caliculé	x				x			x	x					x		
Kalmia à feuilles étroites	x	x		x	x	x		x					x		x	
Myrique beaumier														x	x	x
Gadellier glanduleux											x			x		
Ronce petit murier					x											
Framboisier							x				x			x	x	
Saule arbustif	x	x		x		x	x	x	x		x	x	x	x	x	D
Airelle à feuilles étroites	x	x		x									x	x	x	
Airelle des marécages						x	x	x								
Viorne trilobée											x					

Tableau 5 Espèces vasculaires herbacées recensées dans les segments de route prêts à restaurer

	R-1-2		R-3-4		R-5	R-6		R-8		R-9		R-10		R-11	R-12	
HERBACÉES	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Déboisé	Remblai de la route	Remblai de la route	Décapé	Remblai de la route
Achillée millefeuille											x					
Anaphale marguerite		x														
Aralie hispide (Salsepareille)				x											x	
Carex				x				x					x		x	
Épilobe à feuille étroites		x		x	x		x	x	x				x		x	
Clintonie boréale														x		
Quatre-temps											x		x	x	x	
Corydale toujours-verte							x									
Épigée rampante					x											
Prêle des champs		x														
Prêle des forêts		x		x							x		x			
Linaigrette		x												x		
Petit thé					x											
Linnée boréale											x					
Lotier corniculé													x			
Lycopode innovant					x						x					
Petit atocas														x	x	
Pétasite palmé											x					
Phléole des prés							x				x		x		x	
Graminée		x				x	x	x	x		x		x		x	
Thé du Labrador					x			x						x	x	
Petite oseille	x	x					x									
Scirpe à ceinture noire		x		x	x		x	x			x	x		x	x	
Scirpe	x	x							x			x				
Potentille tridentée											x			x		
Silène enflé															x	
Smilacine trifoliée								x							x	
Verge d'or															x	
Tanaisie vulgaire															x	
Trèfle blanc							x				x					
Canneberge commune					x			x								
Vesce jargeau							x				x		x			
Richesse totale	15	0	12	16	9	15	16	10	0	24	4	15	17	23	5	15

Tableau 6 Caractéristiques biophysiques des sablières

No de sablière	A-01-A	A-08-B	A-09	A-10	R-30A	R-34A	R-36B	R-36C	R-38B	R-44	DG-R25-O
Nature du sol décapé	Gravier - sable loameux	Sable loameux	Sable graveleux	Sable graveleux	Sable graveleux	Sable graveleux	Gravier, sableux et moraine sableuse	Gravier et sable	Gravier et sable	Sable graveleux	Gravier et sable
Présence de tas d'agrégats											Trois petits tas faits récemment
Présence d'eau	Flaques d'eau temporaires	Flaques d'eau temporaires	Flaques d'eau temporaires	Grande flaque au milieu de la sablière		Étang avec rubaniers semble un habitat faunique		Flaques d'eau temporaires	Flaques d'eau temporaires	Flaques d'eau temporaires	
Volume estimé de terre végétale en andain	3000 m^3 mélangé avec mort terrain dans des andains bien définis tout autour du site	16 000 m^3, dont une partie provenant d'A08-A. Une partie récemment utilisée pour étendre sur R5			Il reste 2-3 petits andains de terre végétale qui pourraient être étendue là où il n'y en a pas.	Un gros tas d'un volume approximatif de 5000 m^3	Andain d'environ 900 m^3	Environ 100 m^3 de terre végétale en andain.	Terre végétale pas en andain. Étendue du côté Ouest.	Quatre andains de 130 m de long, pour un volume totale de 10 000 m^3 de terre végétale	
Volume estimé de mort terrain en andain							Environ 400 m^3	Mélange de mort terrain et terre végétale d'un volume approximatif de 3000 m^3			
Volume estimé de tas de troncs	Un peu au travers des andains			Au sud-ouest, il y a une zone couverte de copeaux: à éparpiller car c'est trop épais	Il y a deux tas de troncs à chipper d'un volume approximatif de 1000 m^3.		900 m3		600 m^3 de troncs + déchets de coupe récupérables pour faire des copeaux		
Volume estimé de tas de rochers	30 m^3						Bcp de grosses roches 8000 m3	Deux tas: 60 m^3 et 1000 m^3	Deux tas: 600 m^3 et 1600 m^3	Un tas de 150 m^3	
Pentes à reprofiler	Longueur: 300 m, hauteur: 10 m. Du côté Est, il est possible de reprofiler sans toucher au milieu naturel		Longueur: 50 m, hauteur: 10 m. Étant déjà bien révégétée, pas besoin de reprofiler cette pente.	Longueur: 100 m; hauteur 20 m. Sablière déjà reprofilée, mais je crois que la pente dépasse ce qui est admis.				Longueur : 400 m, hauteur 10 m.	Deux pentes: 1- Longueur: 50 m, hauteur, 5 m. 2- Longueur: 70 m, hauteur: 10 m.		

Déchets	Déchets domestiques présents + autres matériau industriel	Blocs de ciment, métal et gros tuyaux compactés					Rond de feux avec canne provenant des chasseurs	Bancs de bois			
Signes d'animaux	Hirondelles de rivage ont niché dans la cavité centrale. Environ 100 terriers.	Crapaud vivant						Trace d'ours noir	Trace d'orignal		Fèces et traces d'orignal
Usages actuel ou passé	Sert actuellement à l'entreposage						Présence de chasseurs à l'automne			Peu d'extraction fait dans ce site, comparé à la grandeur qui a été déboisée et décapée. Au nord, il y a une grande zone déboisée et décapée séparée en 4 parties par les 4 andains.	
% de couverture végétale: zone déboisée	100%	100%	100%	100%	100%	100%		Absent	100%	100%	100%
% de couverture végétale: zone décapée	25%	25%	70%	Absent	80%	50%		25%	60%	70%	70%
% de couverture végétale: zone excavée	1%	1%	5%	0%	0%	0%	100%	5%	50%	5%	35%
Travaux de restauration	Laisser la falaise de sable à l'entrée pour la nidification des hirondelles		Un certain terrassement semble avoir été fait.	Reprofilé en 2016	Vient tout juste d'être reprofilée. Environ 2% de la superficie est couvert de terre végétale.	Est en train d'être reprofilée.	Reprofilage déjà fait			Prévu d'être reprofilé en 2017	Restauration naturelle dans la zone excavée qui est en grande partie couverte de petits arbres

Tableau 7 Caractéristiques biophysiques des segments de route

	R-1-2	R-3-4	R-5	R-6	R-8	R-9	R-10	R-11	R-12
Nature du sol remblayé	Gravier	Sable graveleux	Récemment couvert de terre végétale de A-08-B	Gravier	Gravier.	Gravier	Sable graveleux. Gros rochers d'un côté pour soutenir le remblai.	Sable	Sable graveleux. Érosion du chemin vers le réservoir.
Présence d'eau	Un ruisseau sépare R1 de R2	Un ruisseau sépare R3 de R4					Milieu humide adjacent.	Section près de la route, en voie de se régénérer un milieu humide.	Partie inférieure se transforme en bande riveraine
Déchets	Segments de géogrille dépassent. Il y a un tuyau qui traine.			Structure de cabane et déchets à proximité	Cordes et planches	Planches	Un peu	Un peu	Caissons de bois
% de couverture végétale: zone déboisée	100%	100%		100%	100%	100%	100%	100%	
% de couverture végétale: zone décapée									50%
% de couverture végétale: zone remblayée	10%	10%	0%	1%	1%	60%	10%	Section nord: 100%. Section sud: 15%	5%
Travaux de restauration	La calvette a été enlevée et le ruisseau a été stabilisé avec des roches. En 2017 prévu retirer le remblai.	La calvette a été enlevée et le ruisseau a été stabilisé avec des roches. En 2017 prévu retirer le remblai.	Terre végétale étendue. Rochers bloquent l'entrée. Prêt à planter	Déblayer le remblai ou l'ameublir. Bloquer l'accès avec rochers.	5 tas de gravier à étendre ou à retirer.	Retirer la structure de cabane et la calvette située à 150 m de la rivière.			
Intérêt pour les Cris	Reforester	Reforester					Reforester	Reforester	Reforester

7. Références

Global Invasive Species Database, 2017. Downloaded from http://www.iucngisd.org/gisd/search.php on 04-10-2017.

Lavoie, C., G. Guay et F. Joerin, 2014. Une liste des plantes vasculaires exotiques nuisibles du Québec : nouvelle approche pour la sélection des espèces et l’aide à la décision. Écoscience 21 (2): 1–24.

Annexe 1 Formulaires de terrain

Code du site :	Sablière	Route	Gravière	Autre

Tas d’agrégats présents	
Nature du sol décapé	
Nappe phréatique	

Terre végétale H : Largeur : Longueur :	Terre végétale H : Largeur : Longueur :	Terre végétale H : Largeur : Longueur :	
Mort terrain H : Largeur : Longueur :	Mort terrain H : Largeur : Longueur	Mort terrain H : Largeur : Longueur :	
Débris ligneux H : Largeur : Longueur :	Débris ligneux H : Largeur : Longueur :	Débris ligneux H : Largeur : Longueur :	
Rochers H : Largeur : Longueur :	Rochers H : Largeur : Longueur :	Rochers H : Largeur : Longueur :	
Pentes à reprofiler Longueur : Hauteur :	Pentes à reprofiler Longueur : Hauteur :	Pentes à reprofiler Longueur : Hauteur :	

Déchets domestiques		Gros déchets	

Animaux

Espèces	Signe	Activité	Endroit

Intérêt cri	
Usages actuel ou passé	
Périphérie correspond à carte écoforestière	
Travaux effectués	

Autres remarques :	% de couverture végétale des trois zones : Déboisé Décapé Excavée

HERBACÉES		Code de site		
		Zone déboisée	Zone décapée	Zone excavée
Anémone à cinq folioles	*Anemona quinquefolia*			
Salsepareille	*Aralia hispida*			
Carex blanchâtre	*Carex canescens*			
Carex limosa	*Carex limosa*			
Carex oligosperme	*Carex oligosperma*			
Carex tenuiflore	*Carex tenuiflora*			
Carex lacustre	*Carex trichocarpa*			
Cassandre caliculé	*Cassandra calyculata*			
Épilobe à feuille étroites	*Chamerion angustifolium*			
Potentille palustre	*Comarum palustre*			
Savoyane	*Coptis trifolia*			
Quatre-temps	*Cornus canadensis*			
Drosera à feuille ronde	*Drosera rotundifolia*			
Camarine noire	*Empetrum nigrum*			
Épigée rampante	*Epigea repens*			
Prêle des champs	*Equisetum arvense*			
Prêle des forêts	*Equisetum sylvaticum*			
Linaigrette dense	*Eriophorum spissum*			
Linaigrette à large gaine	*Eriophorum vaginatum*			
Linaigrette de Virginie	*Eriophorum virginicum*			
Eupatoire maculé	*Eutrochium maculatum*			
Petit thé	*Gaultheria hispidula*			
Comandre livide	*Geocaulon lividum*			
Gesse des prés	*Lathyrus pratensis*			
Marguerite blanche	*Leucanthemum vulgare*			
Linnée Boréale	*Linnaea borealis*			
Lycopode innovant	*Lycopodium annotinum*			
Maianthème du Canada	*Maianthemum canadensis*			
Myriophylle	*Myriophyllum sp.*			
Petit atocas	*Oxycoccus microcarpus*			
Pétasite palmé	*Petasites frigidus*			
Épervière des prés	*Pilosella caespitosa*			
Graminée	*Poaceae sp.*			
Thé du Labrador	*Rhododendron groendlandicum*			
Sarracénie	*Sarracenia purpurea*			
Scheuchzérie des marais	*Scheuchzeria palustris*			
Scirpe à ceinture noire	*Scirpus atrocinctus*			
Potentille tridentée	*Sibbaldia tridentata*			
Smilacine trifolié	*Smilacina trifolia*			
Rubanier	*Sparganium sp.*			
Trèfle blanc	*Trifolium repens*			
Canneberge commune	*Vaccinium oxycoccos*			

ARBRES		Code de site Zone déboisée	Zone décapée	Zone excavée
Sapin beaumier	*Abies balsamea*			
Bouleau à papier	*Betula papyrifera*			
Mélèze laricin	*Larix laricina*			
Épinette noire	*Picea mariana*			
Pin gris	*Pinus banksiana*			
Peuplier faux-tremble	*Populus tremuloides*			
Cerisier de Pennsylvanie	*Prunus pensylvanica*			
ARBUSTES				
Aulne crispé	*Alnus crispa*			
Aulne rugeux	*Alnus rugosa*			
Andromède glauque	*Andromeda glaucophylla*			
Andromède	*Andromeda polifolia*			
Bouleau glanduleux	*Betula glandulosa*			
Bouleau nain	*Betula pumila*			
Noisetier à long bec	*Corylus cornuta*			
Kalmia à feuille étroite	*Kalmia angustifolia*			
Kalmia à f. d'andromède	*Kalmia polifolia*			
Myrique beaumier	*Myrica gale*			
Gadellier glanduleux	*Ribes glandulosum*			
Gadellier amer	*Ribes triste*			
Ronce p. murier (chicouté)	*Rubus chamaemorus*			
Framboisier	*Rubus idaeus*			
Saule de Bebb	*Salix bebbiana*			
Saule humble	*Salix humilis*			
Saule baumier	*Salix pyrifolia*			
Sureau noir	*sambucus nigra*			
sorbier d'Amérique	*Sorbus americana*			
Airelle à feuille étroites	*Vaccinium angustifolium*			
Airelle fausse-myrtille	*Vaccinium myrtilloides*			
Airelle des marécages	*Vaccinium uliginosum*			
Airelle v. d'Ida, gr. rouge	*Vaccinium vitis idea*			
Viorne trilobée (pimbina)	*Viburnum trilobum*			
AUTRES				

ANNEXE 2 ATLAS PHOTOGRAPHIQUE

A-01-A **De gauche à droite : zone décapée, andain de terre végétale, zone déboisée et milieu naturel**	
A-01-A **Cavité centrale avec colonie d'hirondelles de rivage**	

A-08-B **Cette sablière est pratiquement totalement recouverte d'une couche de terre végétale d'une épaisseur de 4 m. Une partie a été prélevée récemment pour couvrir R-5**	
A-08-B **On voit ici que la terre végétale, déjà passablement végétalisée, a été entreposée dans la partie excavée dont on voit le bord et le milieu naturel adjacent.**	

A-09 **Cette sablière est séparée de la route principale par une zone déboisée et un mince rideau de forêt naturelle.**	
A-09 **Au fond, on voit la pente qui s'est déjà passablement revégétée.**	

A-10 **Sablière reprofilée de manière à créer un milieu humide au centre**	
A-10 **Couche de 10 cm de copeaux à étendre sur l’ensemble du site**	

R-30A **Sablière où le maître de trappe voudrait construire un étang pour la chasse à l'oie**	
R-30A **Andain de terre végétale qui pourrait être étendu sur le substrat nu**	

R-34A **Sablière récemment reprofilée avec un creux au milieu qui pourrait se transformer en milieu humide.**	
R-34A **Étang qui s'est formé en bordure de la sablière : un petit habitat faunique avec rubanier**	

R-36B **Empilements de bois**	
R-36B **Vue aérienne**	

R-36C **De droite à gauche, la section décapée, la pente à reprofiler et la zone excavée.**	
R-36C **Cette sablière se draine dans un torrent en partie empierré pour éviter l'érosion.**	

R-38B **Cette sablière se caractérise par un manque de structuration des dépôts en place, qui sont bordés par une pente abrupte offrant une belle vue.**	
R-38B **Pile de troncs qui pourraient être déchiquetés pour faire des copeaux à étendre sur aider à structurer le sol**	

R-44 **Cette sablière se caractérise par une série d'andains de terre végétale parallèles qui sont séparées par des zone décapées n'ayant pas été excavées.**	
R-44 **À gauche et à droite, les andains de terre végétale**	

DG-R25-O **La partie centrale a été l'objet de travaux plus récents qui ont laissé trois tas de gravier sur place.**	
DG-R25-O **Régénération naturelle en aulne crispé d'une autre section**	

R-1-2 **Segment de chemin d'hiver maintenant inutilisé**	
R-1-2 **De droite à gauche, le ruisseau qui sépare les deux segments de route, l'enrochement mise en place lors de l'enlèvement de la calvette, une section déblayée de la surface de roulement qui se naturalise peu à peu, puis le segment R2 au substrat nu.**	

R-3-4 **Segment de chemin d’hiver plus ou moins parallèle à la route permanente, que l’on voit au fond à droite**	
R-3-4 **Petit cours d’eau qui sépare R3 de R4.**	

R-5-9 **Entrée de R5, qui vient d'être recouvert de terre végétale provenant de la sablière limitrophe A-08-B et d'être bloquée par des gros rochers**	
R-5-9 **Segment de R9**	

R-6 **Vue aérienne de R6 et de la carrière C-07**	
R-6 **Le remblai n'est pas tellement naturalisé car ce segment de chemin d'hiver est encore accessible en véhicule.**	

R-8 **En avant plan, l’ancien chemin des poudrières, derrière, un des quatre emplacements, chacun doté d’un tas de gravier**	
R-10 **Segment de chemin d’hiver situé à l’entrée du territoire de trappe VC29 (affiche de bienvenue au fond)**	

R-11 **Section nord de R-11, déjà naturalisée par des plantes de milieux humides**	
R-11 **Section sud, moins bien naturalisée car plus sèche et bien drainée car en sable, pas de remblai.**	

<table>
<tr><td>R-12
Ce chemin d’accès à Barge-3 n’est plus accessible aux véhicules depuis peu.</td><td></td></tr>
<tr><td>R-12
Barge 3 en érosion</td><td></td></tr>
</table>

APPENDIX 5 INFORMATIONS ON SANDPITS

Dans cette annexe, on a inséré des informations supplémentaires pour certaines sablières. La plupart des informations qui suivent proviennent des demandes de CA. Elles concernent souvent les conditions qui prévalaient avant l'implantation de la sablière.

DG-R25

À l'extrême ouest du territoire à l'étude, située de part et d'autre de la route de Sarcelle, la sablière DG-R25 a été construite en 2007 par la SEBJ pour le projet des centrales Eastmain-1-A et Sarcelle, et de la dérivation Rupert (Figure 5). Elle a été agrandie en 2008, à la suite d'une demande de CA hors norme, puisqu'une partie de l'agrandissement se situait en-deçà de la limite de 75 m d'un plan d'eau. En effet, elle est bordée à l'est par deux petits plans d'eau de 0,1 et 0,45 ha qui se drainent de façon diffuse vers un petit lac d'une superficie d'environ 2,7 ha, lequel se déverse vers le réservoir Opinaca. Les eaux des étangs sont typiques des petits plans d'eau eutrophes de la région.

Une section de la portion est (DG-R25-E agrandissement) est encore en utilisation tandis que la partie ouest (DG-R25-O) a commencé à être restaurée. En effet, après avoir été très utilisée (Figure 6), elle est maintenant fermée et a été reprofilée par la SEBJ.

Figure 5 Vue aérienne des deux sections de la sablière DG-R25, de part et d'autre de la route de Sarcelle, en 2008

Figure 6 La sablière DG-R25-E en 2011

Des mesures d’exploitation et de restauration particulières avaient été planifiées pour la section hors norme (Figure 7). Des mesures de mitigations particulières permettent l’exploitation du dépôt jusqu’à 30 m des milieux hydriques, tout en maintenant le plancher d’exploitation à 1 m au-dessus de la nappe d’eau (cote 233). Dans la portion du dépôt située à moins de 75 m du milieu hydrique, on prévoyait planter des semis d’aulne crispé à une densité moyenne de 4500 plants/ha. Cette densité de plantation accrue permettrait une fermeture plus rapide du couvert végétal dans les zones situées plus près des milieux hydriques. Le reste de la sablière serait planté à une densité moyenne de 3000 plants/ha.

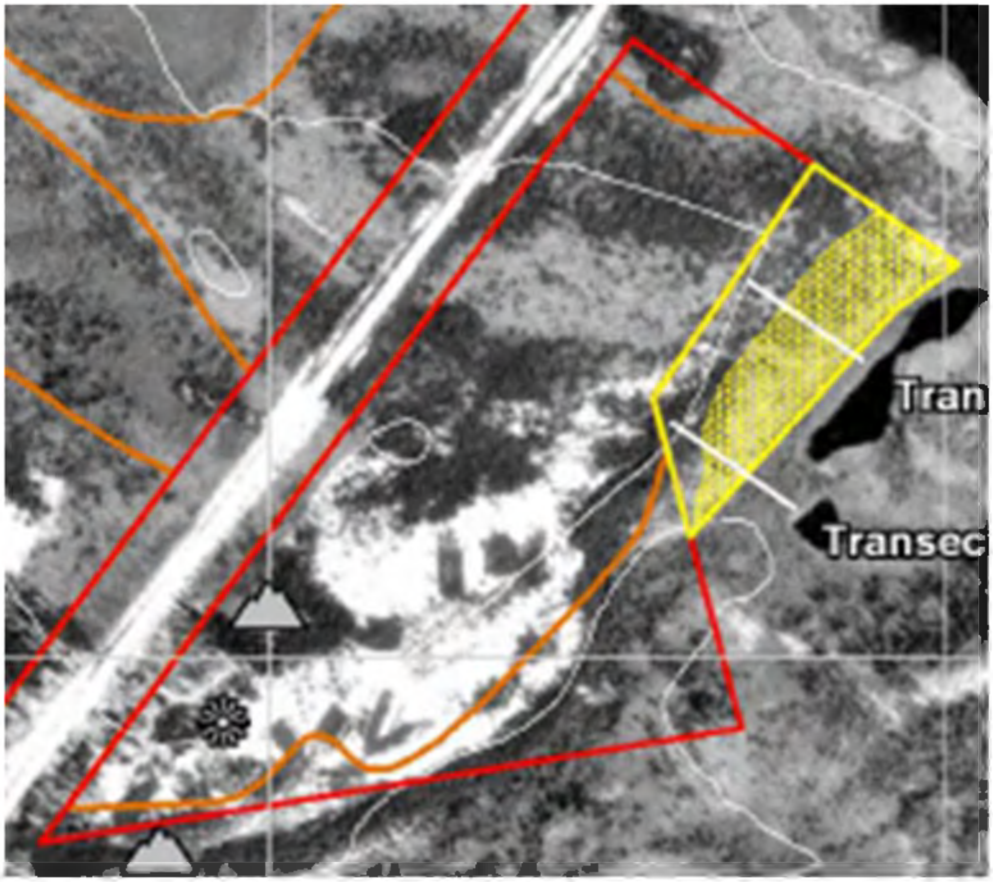

Figure 7. Gros plan sur la sablière DG-R25-E avant l'agrandissement. La ligne jaune entoure l'agrandissement autorisé en 2008 et le tramé jaune, la section hors norme.

Il y a actuellement des discussions entre MOL et Hydro-Québec. Après avoir été cédée à MOL, cette sablière pourrait retourner à la société d'état.

R-38-B

C'est la seule sablière prête à restaurer qui soit située dans le territoire de trappe VC22 et qui ait été construite par MOL.

R-36-B

Le banc d'emprunt R-36B se trouve au km 12 de la route permanente. Le ruisseau le plus près est situé à 78 m. Des milieux humides se trouvent dans les alentours de la sablière, mais celle-ci n'empiète sur aucun d'eux, le plus près se trouvant à 32 m. Le site de la sablière était couverte par un brulis, donc très peu d'arbres ont dû être coupés. La sablière est située sur le territoire de trappe VC 28. Une aire de chasse à l'orignal se trouve à proximité de la sablière. Le chemin d'accès à la sablière a une emprise de 15 m et une surface de roulement d'environ 8 m sur une longueur d'environ 30 m.

Figure 8 Vue aérienne de l'emplacement de la sablière R-36-B

R-44

La sablière R-44 se trouve au km 16 de la route permanente, à proximité de la carrière C-05. Le cours d'eau le plus près se situe à environ 229 m. Des milieux humides se trouvent dans les alentours de la sablière, mais celle-ci n'empiète sur aucun d'eux, le plus près se retrouvant de l'autre côté de la route à environ 192 m. Aucun camp, ni aucun site archéologique n'ont été observés à moins de 2 km de la sablière. La sablière se trouve sur le territoire de trappe VC 28, et à la limite d'une zone valorisée par les autochtones. Un sentier de motoneige se trouve à plus de 2 km de la sablière. Le chemin d'accès a une emprise de 15 m, une surface de roulement d'environ 8 m et une longueur d'environ 50 m.

Il y a eu un gros feu dans ce secteur à l'été 2018.

Figure 9 Vue aérienne de l'emplacement de la sablière R-44

R-34A

Aucune information particulière.

R-30A

Aucune information particulière.

A-10

La sablière A-10 est situé à l'extrémité nord-est du site industriel, situé à mi-chemin entre la rivière Opinaca et le cours d'eau #21. Avant la construction de la sablière, le site était couvert d'une végétation forestière de type pessière noire à pin gris dont l'humus est mince (2 à 5 cm).

A-09

Avant sa construction, le site était recouvert d'une végétation de type pessière noire à éricacées.

A-08

Avant sa construction, le site était couvert d'un brûlis en régénération de pin gris.

A-01-A

Avant la construction, le site était caractérisé par la présence de peuplements résineux de pin gris et d'épinette noire. Le déboisement requis était estimé à 11 ha. Elle est située près d'une aire de chasse à l'oie de la zone de chasse VC29.

Figure 10 Vue aérienne de la sablière A-01-A

Figure 11 Une colonie d’hirondelles de rivages y est présente.

APPENDIX 6 PRIORITY OF ECOLOGICAL SERVICES (BOIS-CHARLEBOIS,2018)

Service écosystémique et espèces	Nombre de mentions lors des entrevues	En diminution ou à surveiller sur Eeyou Istchee
Services écologiques d'approvisionnement		
Nourriture		
Bernache du Canada	11	Oui
Orignal	10	Oui
Bleuet	8	Non
Touladi	8	Oui
Castor	7	Oui
Caribou	7	Oui
Brochet	6	Non
Doré	5	Non
Lièvre	5	Oui
Ours	5	Non
Corégone	4	Non
Esturgeon	4	Oui
Tétras du Canada	3	Non
Canneberge	2	Non
Camarine	2	Non
Gélinotte huppée	2	Non
Chicouté	1	Non
Lagopède des saules	1	Non
Porc-épic	1	Non
Écureuil	1	Non
Baleine	1	Non
Framboise	1	Non
Fraise	1	Non
Barbotte	1	Non
Cisco	1	Non
Meunier noir	1	Non
Matériaux		
Orignal	10	Oui
Castor	7	Oui
Caribou	7	Oui
Lièvre	5	Oui
Ours	5	Non
Vison	4	Non
Lynx	3	Non
Loutre	3	Non
Martre	3	Non
Rat musqué	2	Non
Loutre	2	Non
Renard arctique	1	Non
Renard	1	Non

Service écosystémique et espèces	Nombre de mentions lors des entrevues	En diminution ou à surveiller sur Eeyou Istchee
Porc-Épic	1	Non
Belette	1	Non
Loup	1	Non
Eau douce	11	Oui
Bois de chauffage		
Bouleau blanc	2	Oui
Épinette noire	2	Non
Pin gris	1	Non
Plantes et animaux médicinaux		
Bernache du Canada	11	Oui
Castor	7	Oui
Ours	5	Non
Cèdre	2	Non
Thé du Labrador	1	Non
Sphaigne	1	Non
Voie de déplacement	2	Non
Services écologiques de régulation et socio-culturels		
Purification de l'eau	Oui	Oui
Activités traditionnelles	Oui	Oui
Potentiel récréatif	Oui	Non
Attachement au lieu et paysage	Oui	Non
Régulation du climat	Non	Oui
Production primaire	Non	Non
Formation des sols	Non	Non
Cycle des nutriments	Non	Non
Résilience des écosystèmes	Non	Non
Purification de l'air	Non	Non
Dégradation des matières organiques	Non	Non
Pollinisation et dispersion des semences	Non	Non