Surface water intake vulnerability analysis report for the Northern village of Inukjuak

Water intake number: X2114289

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KATIVIK

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Introduction

Mandate

This drinking water supply vulnerability analysis report (VAR) is the result of an initiative by the Kativik Regional Government (KRG) to support the Northern villages of Nunavik that have not yet completed the analysis. This initiative is part of a process whereby Quebec municipalities responsible for a Category I water withdrawal (those supplying 500 people or more) are required to carry out a vulnerability analysis of their source. In addition, the Water Withdrawal and Protection Regulation (RPEP, Q-2, r. 35.2), adopted in 2014, stipulates that this process had to lead to the transmission of a VAR before April 1, 2021.

The Kativik Regional Government is a key player in the management of natural resources and environmental protection in Nunavik, and has jurisdiction over the entire territory of Nunavik (Act respecting Northern Villages and the Kativik Regional Government [V-6.1]). The main mandate of the Renewable Resources, Environment, Lands and Parks Department (RRD) is to provide technical services to Northern villages in environmental and urban planning matters. The Municipal Public Works Department plays a crucial role in the supply of drinking water, providing the necessary support for infrastructure maintenance in Nunavik's Northern villages. This puts the supramunicipal body in an ideal position to carry out vulnerability analyses,[1] in conjunction with the water withdrawal authorities in the Northern villages.

According to the calculation based on the Regulation respecting the quality of drinking water (RQEP, Q-2, r. 40), the municipality of Inukjuak serves 1,500 residents,[2] so this is considered a Category I withdrawal. However, it is important to note that the village of Inukjuak will have a population of 1952 in 2021 [1]. This discrepancy between the actual number of people and the number calculated during the vulnerability analysis should be kept in mind.

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[1] The term *vulnerability analysis* is used instead of the specific term *surface water intake vulnerability analysis* for the sake of brevity.

[2] According to the RQEP (Schedule 0.1), the maximum number of people served by a water withdrawal is calculated on the basis of the number of residences multiplied by 2.5 people. Results from the most recent Canadian census show that the average size of private households in Inukjuak is 3.8 people per household.

Objective

The aim of a vulnerability analysis is to identify weak points, problems, and threats that affect or could affect a drinking water supply source. Ultimately, it identifies priorities for action to reduce or eliminate certain threats, and then consolidates the information needed for a protection plan.

The VAR is focused on the following specific objectives:

- Locating the withdrawal site and describing its layout.
- Drawing up a localisation plan of the inner, intermediate, and outer protection zones.
- Validating the vulnerability levels of water used in accordance with section 69 of the RPEP, i.e.,
    - physical integrity of the withdrawal site;
    - vulnerability to microorganisms;
    - vulnerability to fertilizers;
    - vulnerability to turbidity;
    - vulnerability to inorganic substances;
    - vulnerability to organic substances.
- Identifying anthropogenic activities, potential events, and land uses likely to affect the quality and quantity of water withdrawn.
- Assessing the threats associated with the previously identified elements.
- Identifying the probable causes that may explain the levels of vulnerability of specific indicators when vulnerability is medium or high.

To meet ministerial requirements, this VAR is based on the *Guide de réalisation des analyses de la vulnérabilité des sources destinées à l'alimentation en eau potable au Québec* [1] and the supporting document entitled *Analyses de la vulnérabilité des sources destinées à l'alimentation en eau potable au Québec — Cas particulier du Nunavik* [2] (referred to as the *Guide* and the *Supporting document* in this report).

Summary of the field visit

The project manager carried out a field visit between May 15, 2024, and May 18, 2024. This on-site visit had several objectives, including:

1. To inform local stakeholders about the vulnerability analysis, and more specifically about the context for carrying out vulnerability analyses for their municipality, the desired level of involvement in the project, and the information required for the analysis;
2. To gather the information needed for the vulnerability analysis;
3. To gather and incorporate the knowledge of local stakeholders in the vulnerability analysis, including the knowledge of the water treatment plant (WTP) operator;
4. To identify the threats present on the territory, and confirm the presence of threats previously identified;
5. To document the status of CRT Construction and Innavik work sites located in the intermediate and outer zones of the water intake;
6. To document the condition of the drinking water intake.

Nine local specialists were met during the field visit. They were affiliated with the following organizations:

- Northern village of Inukjuak
- Pituvik Sarvaq Power Corporation
- Pituvik Landholding Corporation
- Air Inuit
- Innergex
- CRT Construction

General description of the study area

The Northern village of Inukjuak is built on the north shore of the Innuksuac River, on the eastern shore of Hudson Bay [3]. The village is built on a point that extends into Hudson Bay, near Smith Island. In 2021, the municipality had 1952 inhabitants on 54.9 ha, for a population density of 36 people/km^2. The municipality's territory extends from the coast to meridian 78° 3'2 – 78° 3'5 W. To the south, the municipality is bordered by Mosquito Bay and Gobin Island. Its northern boundary (60° 54' 47" N) is marked by rocky hills [4].

The Inukjuak region lies within the zone of continuous permafrost, although the thickness of the active layer varies (up to 150 m) [4]. It has a tundra climate and vegetation, with an average air temperature of 5.6° and a frost season from October 16 to June 12 [4]. The village of Inukjuak lies beyond the tree line, and shrubs reach a maximum height of 2 m. The area is characterized by long, dry, cold winters and short, cool, wet summers.

The population of Inukjuak is growing rapidly, and this is putting particular pressure on the drinking water treatment and distribution infrastructure. Projections by the Institut de la statistique du Québec show that the total population could reach 2,207 by 2030 [5]. Inukjuak's development plan dates from 2017 (Appendix 1) and does not take into account the government's land-use planning guidelines [2]. This is due to Nunavik's unique legal framework, which means that Quebec's Land Use Planning and Development Act (LUPDA) [3] does not apply north of the 55th parallel. A major redesign of the development plan is currently under development by KRG and the Northern village of Inukjuak.

Figure 1 is a map of the village of Inukjuak, updated by KRG in 2024. Figure 2 shows the municipal boundaries of the Northern village of Inukjuak, as well as the location of the raw water withdrawal site near the Innuksuac River and the water treatment plant in the heart of the village.

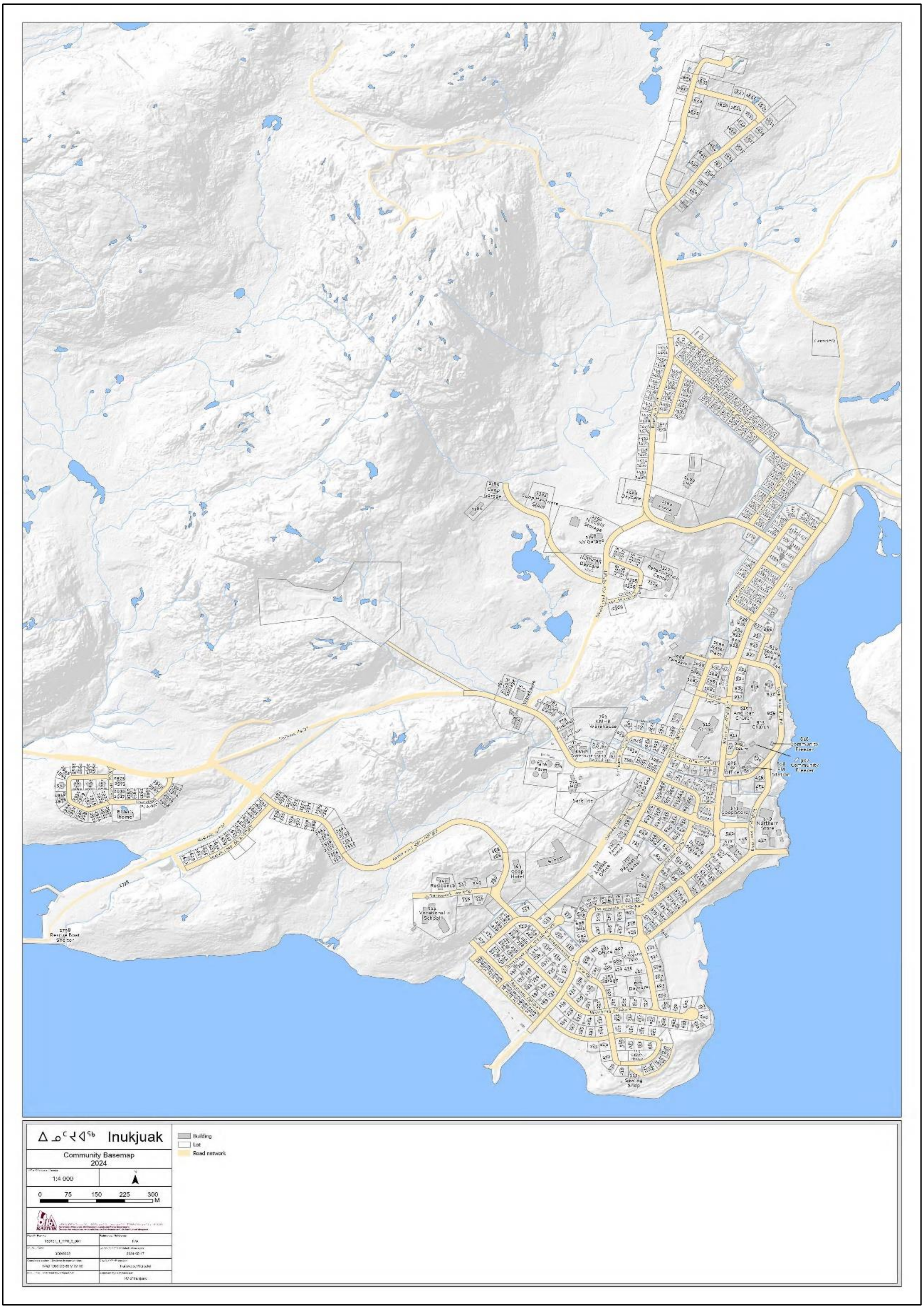
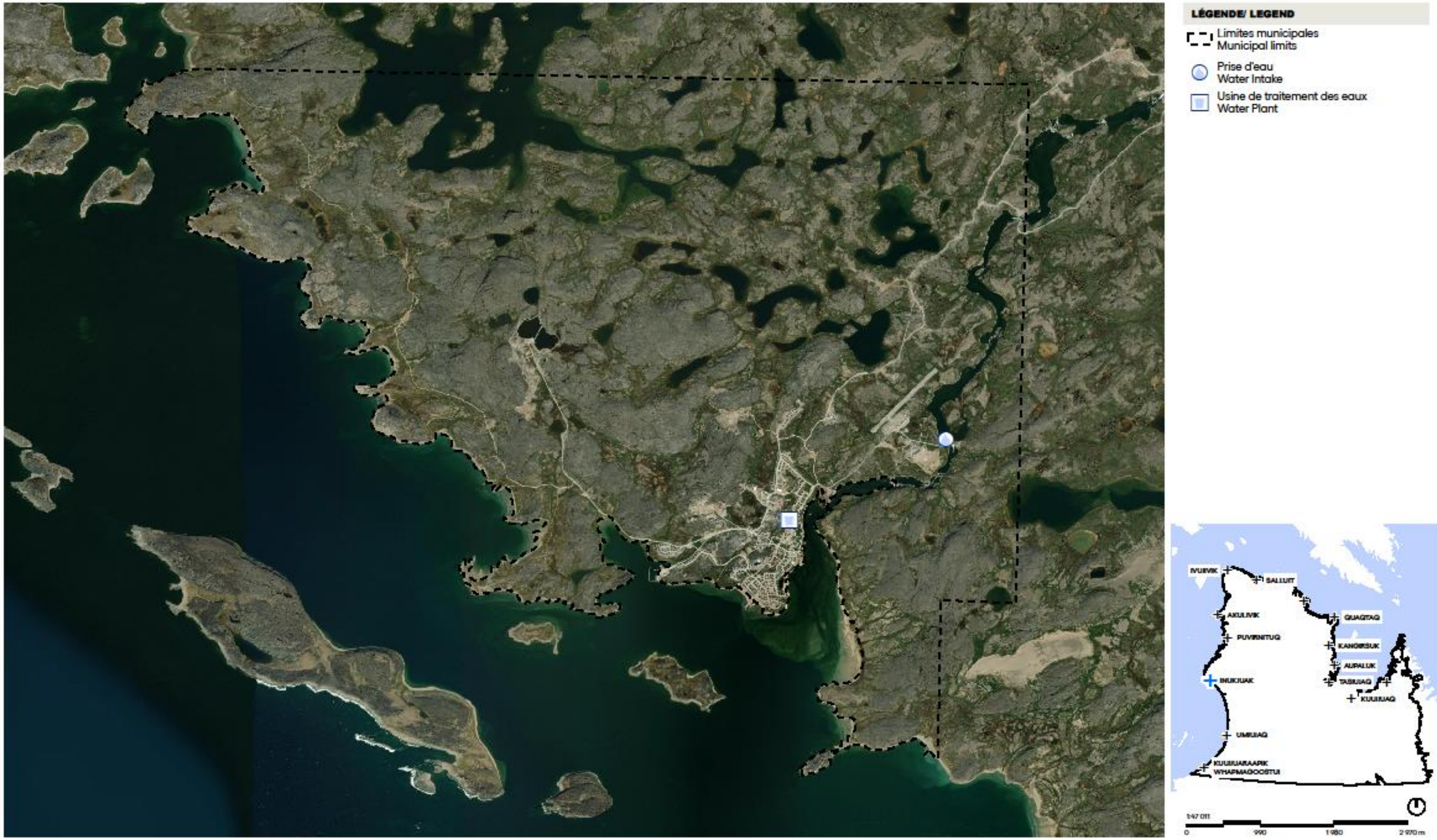


Figure 1. Map of the village of Inukjuak



BC2 | KATIVIK | Village nordique de Inukjuak
Northern Village of Inukjuak

Carte de localisation
Localisation Map

2024-09-03 | **PROJECT 20322301**

Figure 2. Localisation map for the Northern village of Inukjuak

1. Characterization of water withdrawal

1.1 Watershed delimitation of the withdrawal site and brief characterization

The Innuksuac River is located in the James Bay-Hudson drainage region [6]. The map in **Error! Reference source not found.** shows the Innuksuac River watershed and the relative location of the municipality. According to the summary document produced by the CEN [4], the Innuksuac River draws its water from Lake Chavigny and flows 396 km to Hudson Bay. Its watershed covers an area of 10,280 km^2. It is estimated that half of the river's annual volume flows during the June freshet, and the winter months are characterized by significant low flow.

Since 2020, most of the Innuksuac River watershed has been included in the *Rivière-Innuksuac territorial reserve for protected area purposes* (Figure 3) [7]. The legal status of *Biodiversity Reserve* prevents, among other things, all exploration and development activities associated with the forestry and mining industries. The map below illustrates the overlap between the watershed and the protected area (Figure 3). This initiative is a significant protective measure for the municipality's water supply source.

1.1.1 Method used to produce localisation maps

The Géobase du réseau hydrographique du Québec (GHRQ) has been identified as the best source of hydrographic data available for the region [4]. These data were used to determine the position of water bodies and watercourses, as well as their direction of flow. Distances upstream and downstream of the drinking water source were determined using network distance analysis tools. The results of the analysis were used to model the inner and intermediate protection zones. MRNF's 2021 LIDAR data were used to determine the watershed boundaries of drinking water sources, which also correspond to the boundaries of the outer protection zone [5]. Since the extent of the Innuksuac (Inukjuak) River watershed is greater than the coverage of the LIDAR data, the general watershed boundaries (*Bassins hydrographiques multi échelles du Québec*) of the river were used. LIDAR was then used to increase accuracy in the vicinity of the drinking water source and to separate the portion of the watershed downstream from the drinking water source.

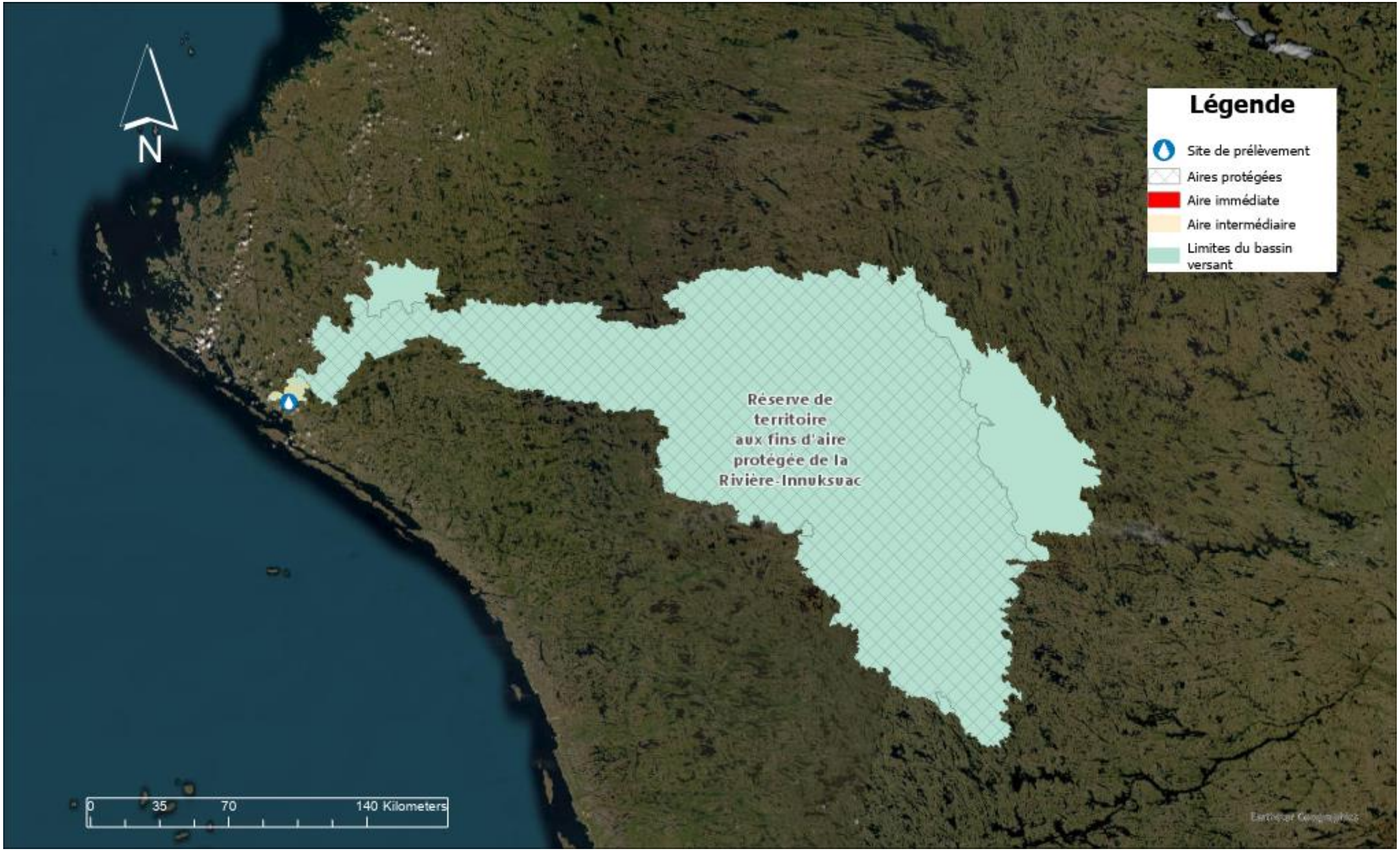


Figure 3. Outer protection zone (Innuksuac River watershed)

1.2 Description of the withdrawal site and drinking water production facility

1.2.1 Description of the withdrawal site

The drinking water withdrawal site is located upstream of the municipality's residential core and downstream of the Innuksuac River (Figure 2). The water is piped to the drinking water treatment plant via a 6-inch-diameter, 3 km-long heated pipeline. The pumping station (Figure 4) is powered by a diesel furnace. Attached to the building is a 10,000 L tank, installed in 2009 (shown in blue on Figure 5). The general condition of the building is good, although some clutter was observed inside the pumping station (Figure 6).

Figure 4. Exterior view of the Inukjuak pumping station. Photo taken on May 16, 2024

Figure 5. Inukjuak pumping station with diesel tank. Photo taken on May 16, 2024

Figure 6. Interior of the pumping station. Photo taken on May 16, 2024

The main characteristics of the withdrawal site are presented in Table 1, and the infrastructure layout is shown in Appendix 2. It was not possible to compile data on authorized withdrawal rates and critical water levels.

Table 1. Main characteristics of the withdrawal site

Withdrawal site feature	Description and details
Water intake name	Inukjuak-Supply
Water intake number	X2114289
Production facility number	X0010358
Production facility category	Category 1 (Surface)
Geographic coordinates	58° 28' 01.36 " N, 78° 04' 03.94 " W
Type of use	Permanent
Type of withdrawal	Submerged strainer
Withdrawal depth	2.4 m
Distribution	Tank truck (4 trucks)
Population served	1500 people
Low-water level	38.7 m [8]
Number of the most recent authorization issued by the Ministère	2009-09-09; 7314-10-01-99085-00/200234839

A 2021 report on the state of the infrastructure [9] points out that a non-negligible quantity of sand is sucked into the supply pipe, exerting additional pressure on the equipment and limiting the flow of water withdrawn. This information was confirmed by the WTP operator, who reported having observed obstruction levels of 50% when flushing the pipe in the autumn. The operator also mentioned that the screen initially installed at the water intake was removed, as it was constantly being obstructed.

1.2.2 Description of drinking water production facility

The Inukjuak drinking water treatment plant was built in 1992 and upgraded in 2013 (**Error! Reference source not found.** and **Error! Reference source not found.**) [9]. The treatment system consists of three granular (activated carbon) filtration systems installed in parallel, followed by filter cartridges. The filtered water is then disinfected with UV lamps. From there, a pipe carries the water to the community tap outside the building, and another pipe carries the water to a second disinfection unit that uses sodium hypochlorite. The treated water is finally stored in three 90 m^3 tanks before being loaded onto tank trucks.

The only chemical stored in this building is sodium hypochlorite.

Figure 7. Inukjuak drinking water production facility (Photo: Google Earth)

Figure 8. South face of drinking water production building with view of oil tank (photo taken on May 16, 2024)

1.3 Localisation plan of protection zones for water used.

The RPEP defines three protection zones that must be delimited for Category 1 surface water withdrawals. For the water withdrawal in Inukjuak, the boundaries of the protection zones are as follows:

Inner protection zone (s. 70): 500 m upstream and 50 m downstream of the withdrawal site, including a 10 m strip of land measured from the high water mark.

Intermediate protection zone (s. 72): 10 km upstream and 50 m downstream of the site, including tributaries and a 120 m strip of land measured from the high water mark.

Outer protection zone (s. 74): The catchment area of the withdrawal site and the portion of the intermediate protection zone located downstream of the withdrawal site. This includes surface water and the entire territory within the boundaries of the catchment area.

Figure 9 shows the location of the protection zones at the withdrawal site. Figure 3 shows the entire outer protection zone.

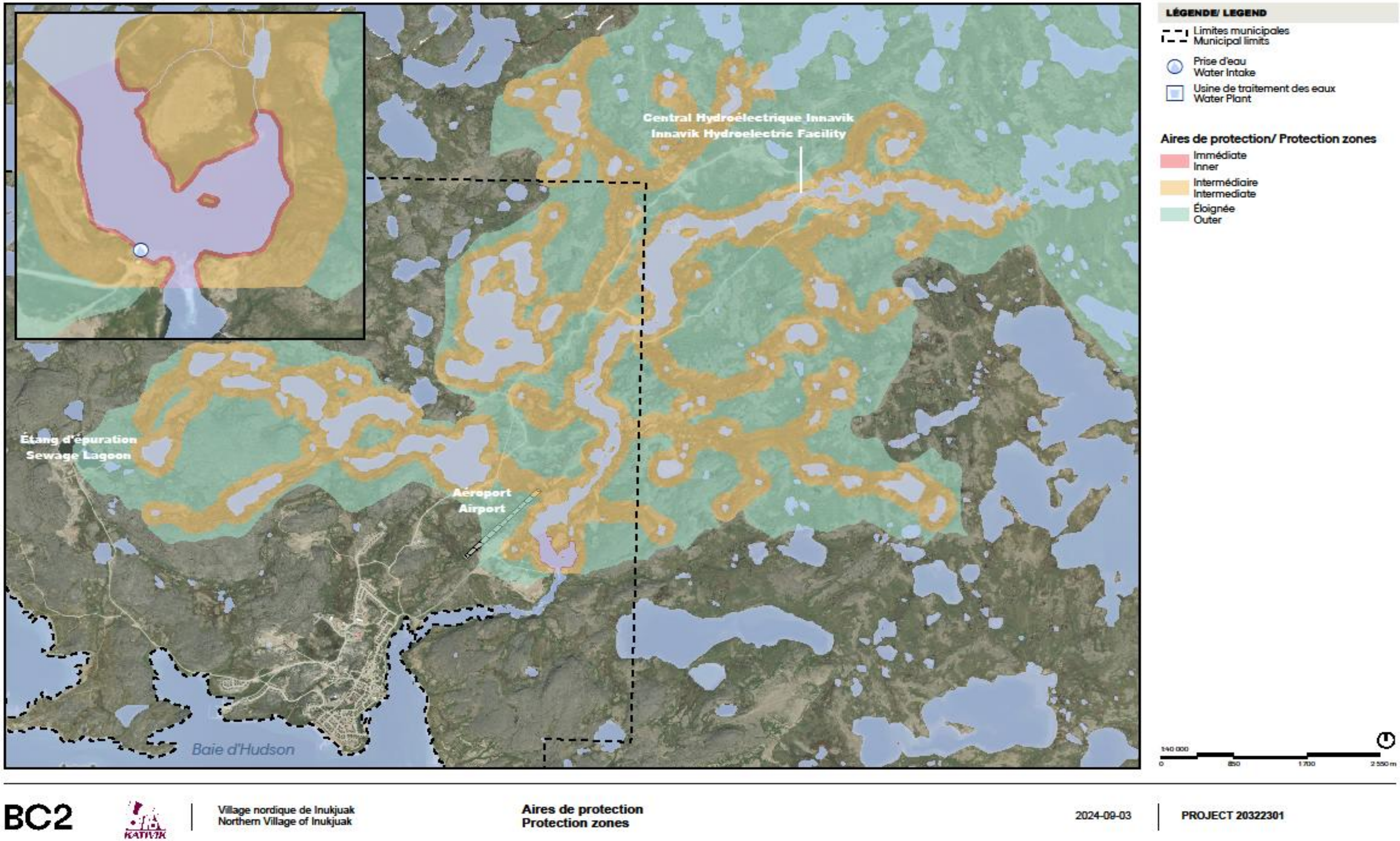


Figure 9. Inner and intermediate protection zones of the water withdrawal site

1.4 Vulnerability levels of water used

The final stage in the characterization of the water withdrawal is the analysis of the vulnerability of the watercourse. In accordance with section 69 of the RPEP, the vulnerability of surface water used for water withdrawals is assessed using six vulnerability indicators, which are rated as having a “low,” “medium,” or “high” level of vulnerability. This section presents the method used for each indicator, and the results obtained (Table 2).

1.4.1 Physical integrity of the withdrawal site

1.4.2 Vulnerability to microorganisms

1.4.3 Vulnerability to fertilizers

1.4.4 Vulnerability to turbidity

1.4.5 Vulnerability to inorganic substances

1.4.6 Vulnerability to organic substances

Table 2. Vulnerability levels of surface water used for withdrawal according to six indicators

Indicator assessed	Method	Level of vulnerability	Justification of the result
Physical integrity of the withdrawal site (A)	Method 3	High	At least three service breakdown events have occurred in the last five years.
Vulnerability to microorganisms (B)	Method 2	Medium	No facilities likely to dump pathogenic microorganisms or indicators of fecal contamination into the watercourse.
Vulnerability to fertilizers (C)	Methods 2, 3	Low	No algae or cyanobacteria blooms. No potential sources of ammonia nitrogen in the protection zones.
Vulnerability to turbidity (D)	Methods 1, 2	Medium	Seasonal adjustment in spring, high flow in the Innuksuac River, absence of a screen at the water intake, and absence of a turbidity log; vulnerability is rated as medium.
Vulnerability to inorganic substances (E)	Method 2	Low	

Vulnerability to organic substances (F)	Method 2	Low	The surface area occupied by the activity sectors concerned is less than 20% of the intermediate protection zone.

1.4.1 Physical integrity (Indicator A)

The *Guide* specifies two methods for assessing the physical integrity of the withdrawal site. The first is based on the number of events affecting the physical integrity of the withdrawal site over the last five years. The main source of information is the record of events kept by those responsible for Category I surface water withdrawals, as specified in section 22.0.4 of the RQEP. The second method is based on a hydrological analysis and must be carried out by a professional in the field.

In addition to these two methods, a third approach adapted to the context of Nunavik was proposed in the *Supporting document*. This approach draws on the collective memory of Northern communities and the knowledge of WTP operators in Northern villages. To highlight this third approach, which includes the knowledge of local stakeholders, it was favoured for the estimation of the physical integrity of withdrawal sites.

The highlights of the municipal stakeholders' meeting are as follows:

- There is no record of events, although they did keep one several years ago.
- In 2022, diesel fuel (heating oil) ran out at the pumping station while a blizzard prevented any maintenance operations. During this event, all the pipes between the pumping station and the WTP froze, preventing the supply of raw water to the WTP. This resulted in a service disruption that lasted a few days.
- In 2022, a water pipe was punctured during maintenance work on a culvert. This resulted in a service disruption that lasted about one week.
- In 2021, the pumping station ran out of fuel. According to the individuals consulted, road conditions made fuel delivery impossible.
- Another pipe freeze event in 2011 was mentioned, but not considered in this analysis.

These details are also presented in Table 3. In light of this information, the vulnerability of the physical integrity of the withdrawal site is considered **high**.

Table 3. Probable causes of the high level of vulnerability of the withdrawal site

Identified problem	Vulnerability indicator with which this problem is associated	Identification of causes	Type of cause
Mechanical breakdown	Physical integrity of the withdrawal site (A)	Frozen pipes	Natural
Mechanical breakdown	Physical integrity of the withdrawal site (A)	No screen at water intake (supply pipe)	Anthropogenic
Out of fuel	Physical integrity of the withdrawal site (A)	Weather conditions (blizzard preventing fuel delivery)	Natural

1.4.2 Vulnerability to microorganisms (Indicator B)

Surface water can be vulnerable to contamination by pathogenic microorganisms, which are a major source of gastroenteritis and many waterborne diseases. Under section 22.0.2 of the RQEP, those responsible for supply systems serving more than 1,000 people south of the 55th parallel are required to take periodic samples of raw water and measure their E. coli bacterial concentration. Northern villages, however, are not subject to this requirement.

Microbiological analyses carried out by WTP operators are limited to the weekly detection of E. coli and total coliforms using Colilert®. The results are presented as presence/absence, so Method 1 cannot be used to estimate vulnerability to microorganisms. However, since those responsible for the Northern villages send their results to the KRG for compilation and distribution, we enhanced Method 2 by incorporating the interpretation of qualitative results. Thus, a heterogeneous database covering the period 2022–2024 was analyzed, and positive test results for the presence of E. coli were reported in winter 2024 (February 29 and March 7). Total coliforms are also detected fairly regularly throughout the year.

In Quebec, residual chlorine must be at least 0.3 mg/L in the water supplied (RQEP, Q-2, r. 40). However, the data consulted indicated a residual chlorine content of less than 0.3 mg/L at the tank truck loading arm during the two E. coli occurrences. This observation falls outside the scope of the source's vulnerability, since it is a water treatment issue. However, extra vigilance is warranted when fecal coliforms are detected.

The second element considered when assessing vulnerability to microorganisms is the impact of spring flooding on raw water quality. Spring flooding generally coincides with the passage of migratory birds (snow geese and Canada geese), so particular vigilance is exercised at this time of year, when the chlorine dose is adjusted to take account of the increased presence of microorganisms in the water.

Finally, according to the *Guide* [1], “the level of vulnerability is considered low if, in the catchment area of the withdrawal site, there is no conurbation served by a combined or pseudo-domestic sewer system, no livestock establishment, no food processing industry, or any other establishment likely to discharge pathogenic microorganisms or indicators of fecal contamination into the watercourse. “(…) In the other cases, the level of vulnerability is considered to be medium.”

Although the above-mentioned threats do not occur in inner or intermediate protection zones, the threat posed by migratory animals should not be overlooked.

Therefore, **the level of vulnerability to microorganisms is considered medium.**

1.4.3 Vulnerability to fertilizers (Indicator C)

Since the Northern village of Inukjuak is located north of the 55th parallel, the regulations do not require monitoring of total phosphorus in raw water. Vulnerability assessment methods 2 and 3 should therefore be applied.

Method 2 is based on the number of events associated with algal, cyanobacterial, or aquatic plant blooms, and suspected increases in ammonia nitrogen. No proliferation events were observed at the withdrawal site. In addition, regular measurements of ammonia nitrogen have shown no impact from blasting activities.

The level of vulnerability to fertilizers is considered low.

1.4.4 Vulnerability to turbidity (Indicator D)

Operators of distribution systems supplied with surface water and that are located north of the 55th parallel are exempt from the requirements of section 22.0.2 of the RPEP, which calls for continuous monitoring of raw water turbidity and recording of the value obtained every four hours. However, the Inukjuak WTP is equipped with a continuous turbidimeter, and the WTP operator confirms routinely checking raw water turbidity several times a day, especially in spring during seasonal floods.

Considering the fact that a seasonal adjustment must be made in the spring, the high flow of the Innuksuac River, the absence of a screen at the water intake, and the lack of a turbidity log, **the level of vulnerability is considered medium**.

Table 4. Probable causes of medium vulnerability to turbidity

Identified problem	Vulnerability indicator with which this problem is associated	Identification of causes	Type of cause
High spring turbidity	Vulnerability to turbidity (D)	Spring flooding, high risk of surge in the intermediate zone	Natural

1.4.5 Vulnerability to inorganic substances (Indicator E)

Under section 14 of the RQEP, 11 inorganic substances are subject to quality standards. They are antimony, arsenic, barium, boron, cadmium, chromium, cyanides, fluorides, mercury, selenium, and uranium. Annual monitoring of these substances is mandatory for all systems serving more than 20 people. Nitrates and nitrites must be measured on a quarterly basis.

As the available data set does not include 5 consecutive years for each of the target substances, method 2 was used. Method 2 uses the proportion of land area occupied by industrial, commercial, and agricultural activities to estimate the source's vulnerability to inorganic contaminants.

The buildings included in the intermediate protection zone are the water withdrawal site (pumping station), the Air Inuit Cargo garages, and the Innavik Hydro facilities, i.e., the hydroelectric plant with its dam and a backup thermal generating station. A main gravel road runs alongside the river, sometimes crossing the intermediate protection zone. In addition, a bridge is located approximately 8 km from the water intake (straight line water route is 6 km long). On the opposite bank, there's an ATV trail maintained by the *Hunter support group*. The buildings occupy 0.02% of the land surface of the intermediate protection zone.

The level of vulnerability is considered low.

1.4.6 Vulnerability to organic substances (Indicator F)

The municipality of Inukjuak is exempt from monitoring the organic substances listed in section 19 of the RQEP, since it supplies fewer than 5,000 people. As such, no data are available. Method 2, identical to that used previously (Indicator E), is therefore used to assess the source's level of vulnerability to organic substances.

According to the spatial analysis, the percentage of the intermediate protection zone occupied by the sectors concerned is 0.02%.

The level of vulnerability is therefore considered low.

However, it is worth noting an important point about the scope of this analysis. In Inukjuak, all buildings in the inner, intermediate, and outer protection zones are equipped with diesel tanks. Although the current method cannot quantify this threat, it is recommended that tank inspections be carried out and spill kits be made available to the public.

2 Inventory of factors likely to affect the water used

Section 75 of the RPEP requires that the vulnerability analysis include a complete inventory of factors likely to affect the quality or quantity of the water used. The list of potential threats must include anthropogenic activities (sites and establishments that release or are likely to release contaminants into the water intake; section 2.1), potential events associated with anthropogenic activities (unpredictable situations representing a risk to surface water; section 2.2), land uses (land uses that could lead to contamination of the source or a reduction in the quantity of water available; section 2.3). To provide the best reflection of the actual situation, natural hazards and sources of natural contamination are also inventoried.

In addition to identifying threats to water quality and quantity, the vulnerability analysis method proposed by MELCCFP also includes an estimate of the risk associated with each threat. Risk estimation is based on a qualitative assessment of the severity of the impact of a threat, and an estimate of the frequency of contamination (or probability, in the case of potential events).

2.1 Results of the inventory of anthropogenic activities and assessment of the threats they represent

The inventory includes twelve distinct anthropogenic activities, seven of which are located in the inner and intermediate protection zones (Table 5). In these zones, four anthropogenic activities are associated with a high level of risk. The most imminent is certainly the raw water supply station and its fuel tank located just a few metres from the water intake. In addition, activities associated with the energy sector, such as the hydroelectric dam and the backup thermal generating station, represent contamination risks for the water source, especially since they are associated with increased traffic on the road running alongside the river. Detailed results of the analysis can be found in Table A8-2, provided as an attachment.

Table 5. Anthropogenic activities occurring in the inner, intermediate and outer protection zones of the Northern village of Inukjuak drinking water withdrawal site

	Anthropogenic activity	**Description of the anthropogenic activity**	**Protection zone in which the activity takes place**	**Contaminant or group of contaminants considered**	**Determined risk**
1	Presence of raw water supply station	Presence of a building housing the water supply pump that transports raw water to the WTP.	Inner protection zone	Organic and inorganic substances (fuel)	High
2	Presence of the Inukjuak northern airport	Typical air transport activities.	Intermediate protection zone	Turbidity, organic and inorganic substances (ethylene glycol, fuel, dust control fluids)	High
3	Presence of the Innavik hydroelectric plant	Presence of a dam in operation since 2022 about 6 km from the water intake.	Intermediate protection zone	Organic substances (lubricating oil)	Medium
4	Presence of a road	A road runs along the northwest bank of the Innuksuac River between the village and the hydroelectric dam. There's a side road about 3 km from the intake that allows all-terrain	Intermediate protection zone	Turbidity, organic substances (fuel), inorganic substances (de-icing salts, fuel)	Medium

		vehicles to cross the river on a bridge and head for the Nuna.			
5	Hunting and fishing activities	Traditional hunting and fishing activities. Skinning.	Intermediate protection zone	Microorganisms	Medium
6	Operation of a sand and gravel depot	Piles of gravel, rock, and sand are stored about 5 km from the water intake, near the dam.	Intermediate protection zone	Turbidity, organic and inorganic substances (fuel)	Low
7	Wastewater treatment ponds	The sewage treatment ponds are located on the north-western edge of the village.	Outer protection zone	Microorganisms	Low
8	Launching of motor boats	Launching of motor boats upstream of the dam for hunting and fishing activities.	Outer protection zone	Organic and inorganic substances (fuel)	Low
9	Winter traffic of snowmobiles on frozen bodies of water	Winter traffic of snowmobiles on frozen bodies of water for hunting and fishing activities.	Outer protection zone	Organic and inorganic substances (fuel)	Low
10	Presence of an aerological station	Presence of an aerological station consisting of a building and an antenna.	Outer protection zone	Organic and inorganic substances (fuel)	Very low
11	Presence of a meteorological station	A meteorological station is located at the boundary of the intermediate and remote area.	Outer protection zone	Organic and inorganic substances (fuels and batteries)	Very low

For a more in-depth analysis of the risks inherent in the anthropogenic activities identified, consult the following documents:

- Inukjuak Backup Thermal Generating Station - Environmental and social impact assessment statement, available on the Kativik Environmental Advisory Committee website (https://www.keqc-cqek.ca/en/projets/construction-of-a-backup-generating-station-project-on-the-nordic-village-of-inukjuak-territory/)
- Website of the company responsible for the hydroelectric plant: HOME | innavikhydro
- Innavik Hydroelectric Project - Environmental and social impact assessment statement, available on the Kativik Environmental Advisory Committee website (https://www.keqc-cqek.ca/en/projets/innavik-hydroelectric-project/)

2.2 Results of the inventory of potential events and assessment of the threats they represent

The inventory of potential events associated with anthropogenic activities identified a total of 15 potential events in the three protection zones, most of them were associated with chemical and fuel spills (Table 6). In fact, due to the existing infrastructure and infrastructure under construction, fuel transport, handling, and storage operations are commonplace in the inner and intermediate protection zones of the source.

Table 6. Results of the inventory of potential events and assessment of the threats they represent

	Potential event	**Anthropogenic activity associated with the potential event**	**Protection zone in which the activity takes place**	**Contaminant or group of contaminants considered**	**Determined risk**
1	Fuel spill	Presence of the Inukjuak northern airport	Intermediate protection zone	Organic and inorganic substances (ethylene glycol, fuel, dust control fluids)	High
2	Dam failure	Presence of the Innavik hydroelectric plant	Inner protection zone	Turbidity, organic and inorganic substances (lubricating oil,	Medium

				insulating oil, diesel fuel, ethylene glycol)	
3	Dam failure	Presence of the Innavik hydroelectric plant	Intermediate protection zone	Turbidity, organic and inorganic substances (lubricating oil, insulating oil, diesel fuel, ethylene glycol)	Medium
4	Fuel spill at the dam	Presence of the Innavik hydroelectric plant	Intermediate protection zone	Organic and inorganic substances	Medium
5	Fuel spill	Presence of a road	Intermediate protection zone	Organic and inorganic substances (fuel), microorganisms	Medium
6	Dumping of animal carcasses	Hunting and fishing activities	Intermediate protection zone	Microorganisms	Medium
7	Oil spill at the dam	Presence of the Innavik hydroelectric plant	Intermediate protection zone	Organic and inorganic substances	Low
8	Chemical spills on the construction site	Construction of the backup thermal generating station	Intermediate protection zone	Organic and inorganic substances (fuel)	Low
9	Fuel spill	Presence of a materials depot	Intermediate protection zone	Organic and inorganic substances (fuel)	Low
10	Fuel spill	Operation of a quarry	Intermediate protection zone	Organic and inorganic substances (fuel)	Low
11	Fuel spill	Launching of motorboats	Intermediate protection zone	Organic and inorganic substances (fuel)	Low

12	Fuel spill	Winter snowmobile traffic on frozen water bodies	Intermediate protection zone	Organic and inorganic substances (fuel)	Low
13	Fuel spill	Presence of an aerological station consisting of a building and an antenna.	Outer protection zone	Organic and inorganic substances (lubricating oil, insulating oil, diesel fuel, ethylene glycol)	Low
14	Fuel spill	Presence of a meteorological station.	Outer protection zone	Organic and inorganic substances (lubricating oil, insulating oil, diesel fuel, ethylene glycol)	Low
15	Wastewater flows to withdrawal site	Wastewater treatment ponds	Outer protection zone	Microorganisms, fertilizers	Low

Two potential natural events were identified at Inukjuak: the presence of migratory animals and the thawing of permafrost (Table 7). In fact, ice-rich permafrost (unstable to thawing) is found in the inner protection zone (see Appendix 3).

Table 7. Results of the inventory of potential events of natural origin and assessment of the threats they represent

Potential event	**Protection zone in which the activity takes place**	**Contaminant or group of contaminants considered**	**Determined risk**
Presence of migratory animals	Inner protection zone	Microorganisms	High
Presence of migratory animals	Intermediate protection zone	Microorganisms	Medium

Water contamination due to permafrost thawing	Inner protection zone	Microorganisms, turbidity, organic and inorganic substances	Medium
Water contamination due to permafrost thawing	Intermediate protection zone	Microorganisms, turbidity, organic and inorganic substances	Low

2.3 Land-use inventory results

The Inukjuak development plan dates from 2017 (see Appendix 1). However, the KRG is actively working with several Northern villages to update their development plans, including that of Inukjuak. This update allows for the inclusion of new land uses, including the redefinition of drinking water source protection zones. In the 2017 plan, the protection zone was 60 m around the water intake and does not take into account the rest of the water body.

The vast majority of protection zones are located on Category 2 and Category 3 lands (JBNQA). Management of these lands is the responsibility of the KRG and the Quebec government. In fact, development plans for Northern villages target Category 1 lands within municipal boundaries only (JBNQA). The presence of a protected area covering the Innuksuac River watershed is conducive to protecting the source of supply (Table 8), since the legal status of *Biodiversity Reserve* prevents all exploration and development activities associated with natural resource industries.

Potentially conflicting land uses are limited to anthropogenic activities permitted on the territory, in particular energy-related activities (hydroelectric dam and backup thermal generating station).

Table 8. Land use contributing to protection

Land use	Protection zone affected by land use	Land use representing a risk or contributing to protection
Rivière-Innuksuac territorial reserve for protected area purposes	Outer protection zone (area beyond the intermediate protection zone)	Land use contributing to protection

3 Identification of the probable causes of problems revealed by medium- or high-level vulnerability indicators

The probable causes of medium and high vulnerability levels for Indicators A, B, and D were identified in Section 1. In the case of the physical integrity of the withdrawal site, it should be noted that the problems identified are exacerbated by the complexity of parts supply logistics (air and sea transport only), the lack of local expertise, and the shortage of skilled labour.

4 Missing data

In Nunavik, there is substantially less water quality data than south of the 55th parallel. Some data simply do not exist, while others can be difficult to find.

There are two main reasons for this:

1. There are exceptions and exemptions for Northern villages in the RQEP. These exemptions inevitably lead to the absence of data.
2. Transporting water samples for analysis is a complex logistical task in northern environments since air transport is dependent on weather conditions. This means that samples taken in accordance with best practices may not arrive at the laboratory on time, and may be discarded. Some regulatory analyses may therefore be incomplete, making historical analyses impossible.

The approach proposed in the *Supporting document* is designed to overcome this lack of data, and enables local knowledge to be put to good use, including in the analysis of the withdrawal site physical integrity indicator.

Methods 1 and 2 proposed in the *Guide* and the adaptations proposed for Nunavik include sufficient alternatives to complete the VAR, even in the absence of regulatory data.

The lack of knowledge about the potential impact of climate change on water quality and quantity is a major challenge, and increases the uncertainty associated with estimating the probability of an event. In all cases, a conservative approach based on knowledge of the local context was applied.

Finally, the information gathered to estimate vulnerability to microorganisms highlighted the complexity of this issue in Inukjuak. Figure 10, which shows the annual proportion of raw water bacteriological analyses carried out for each northern village, illustrates this point well. The rate of bacteriological testing in Inukjuak is excellent, but several factors can lead to a test not being carried out. Since these results make up the bulk of the raw water quality database for the supply sources, it is difficult to perform statistical or trend analyses.

Bacteriological Analysis – Colilert Sampling Results:

	2021 50 weeks	2022 52 weeks	2023 50 weeks	2024 18 weeks
Kangiqsualujjuaq	95%	92%	82%	94%
Kuujjuaq	98%	98%	98%	100%
Tasiujaq	81%	87%	88%	94%
Aupaluk	79%	90%	92%	94%
Kangirsuk	84%	96%	88%	89%
Quaqtaq	65%	96%	82%	83%
Kangiqsujuaq	93%	88%	80%	89%
Salluit	91%	71%	92%	100%
Ivujivik	63%	98%	98%	50%
Akulivik	49%	85%	74%	89%
Puvirnituq	77%	75%	66%	89%
Inukjuak	86%	73%	90%	94%
Umiujaq	79%	85%	60%	61%
Kuujjuarapik	98%	98%	96%	100%
Average Nunavik	**81%**	**89%**	**85%**	**88%**

Figure 10 Annual proportion of bacteriological tests carried out for each northern village. Extract from Municipal public works department activity report (May 2024) [8]

5 Conclusion and recommendations

The northern village of Inukjuak is one of the most densely populated in Nunavik, and its dynamic local character has led to the development of a number of projects. Documentation relating to the environment, climate change, transportation, the built environment, and traditional Inuit culture was available to support the completion of the VAR. The scope of these reference documents goes beyond that of the VAR, but the information they contain could be useful when updating the VAR, or when developing a protection plan.

Energy-related projects in the region inevitably increase the vulnerability of the Innuksuac River to anthropogenic activities and potential events. For example, the presence of a hydroelectric dam and a backup thermal generating station in the intermediate protection zone represents a threat to water quality and quantity. However, site visits in May 2024 revealed that the on-site management teams are aware of Nunavik's environmental vulnerability, and the implementation of preventive measures and emergency plans is prioritized.

The physical integrity of the withdrawal site (Indicator A) should be a priority when developing a protection plan. The presence of a diesel tank poses an imminent threat to the quality of the water withdrawn. Several options for mitigating this threat are possible, including training the employees responsible for filling the tank, making municipal stakeholders aware of the problems that could arise from oil contamination, managing the oil supply better, using hydroelectricity to power the water withdrawal infrastructure, relocating the tank and generators (if applicable), implementing a leak management plan specific to the withdrawal site, and sharing resources between the Northern village, the dam team, and the backup thermal generating station team. These proposals are just a few examples of the wide range of possible mitigation measures.

The level of vulnerability for the other indicators was exacerbated by the absence of an emergency response plan for the identified threats. The low population density along the Innuksuac River greatly reduces the threat posed by anthropogenic activities and land use. However, there are many potential sources of oil spills, and local management of this risk would significantly help to decrease the water source's vulnerability to contamination.

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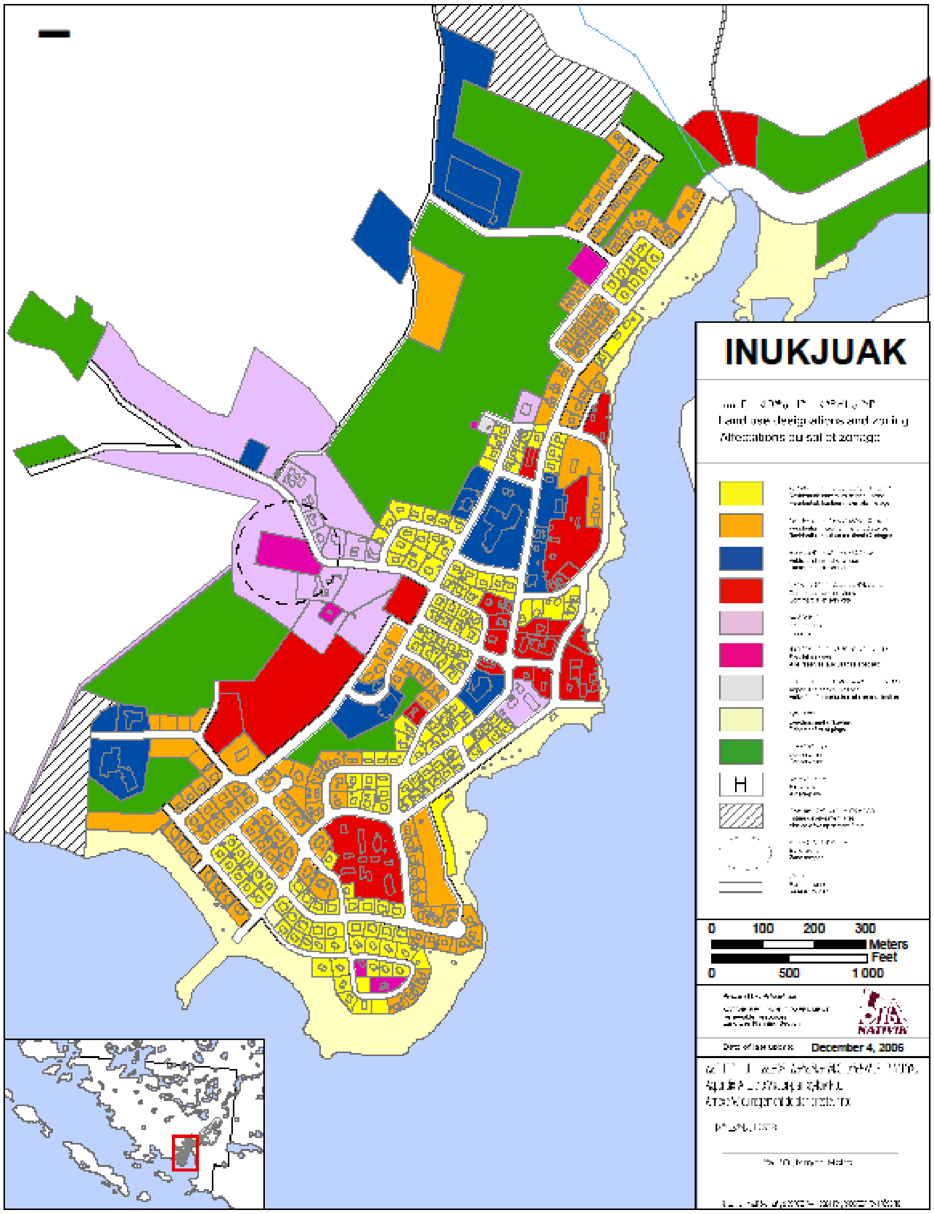
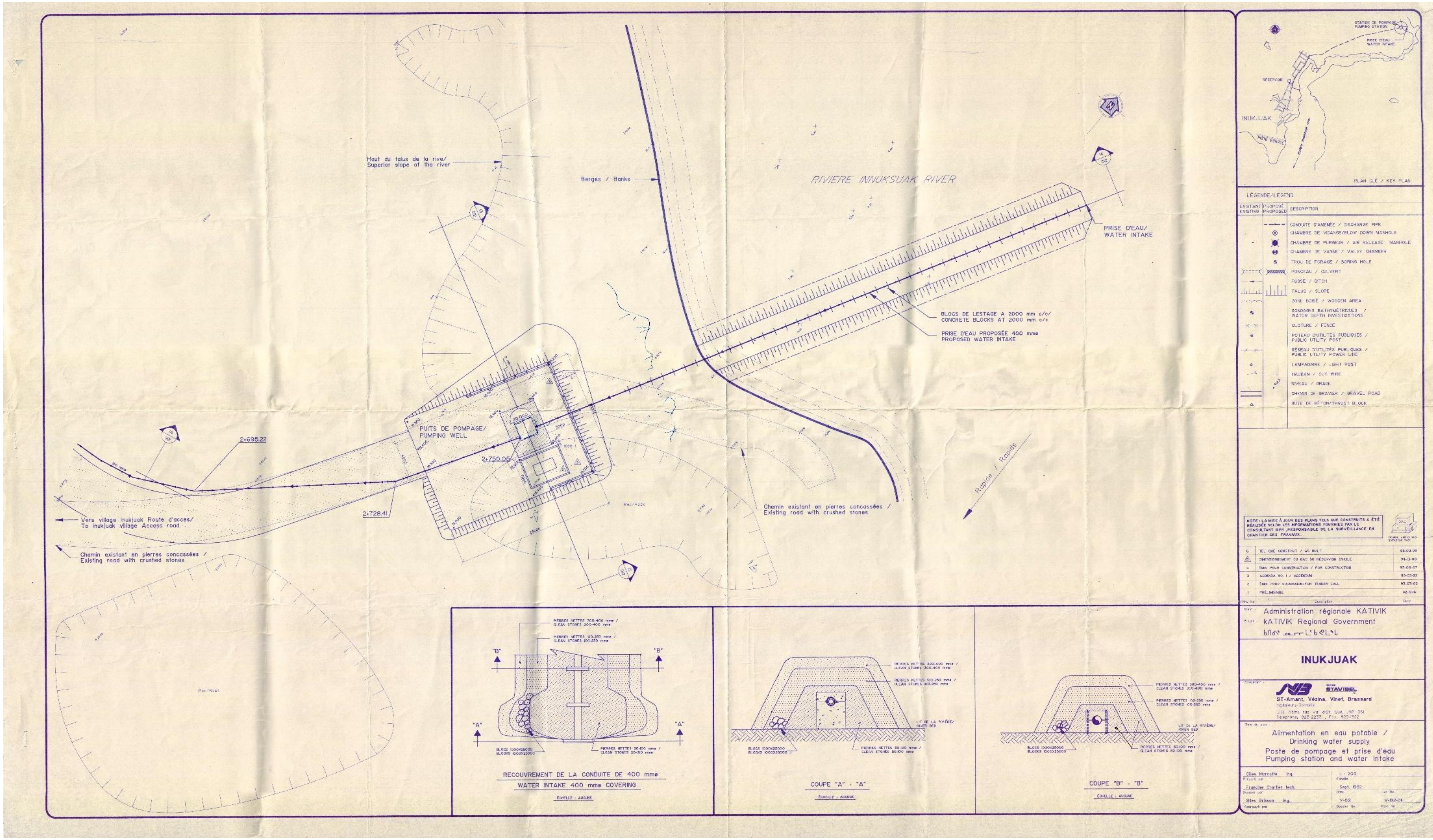
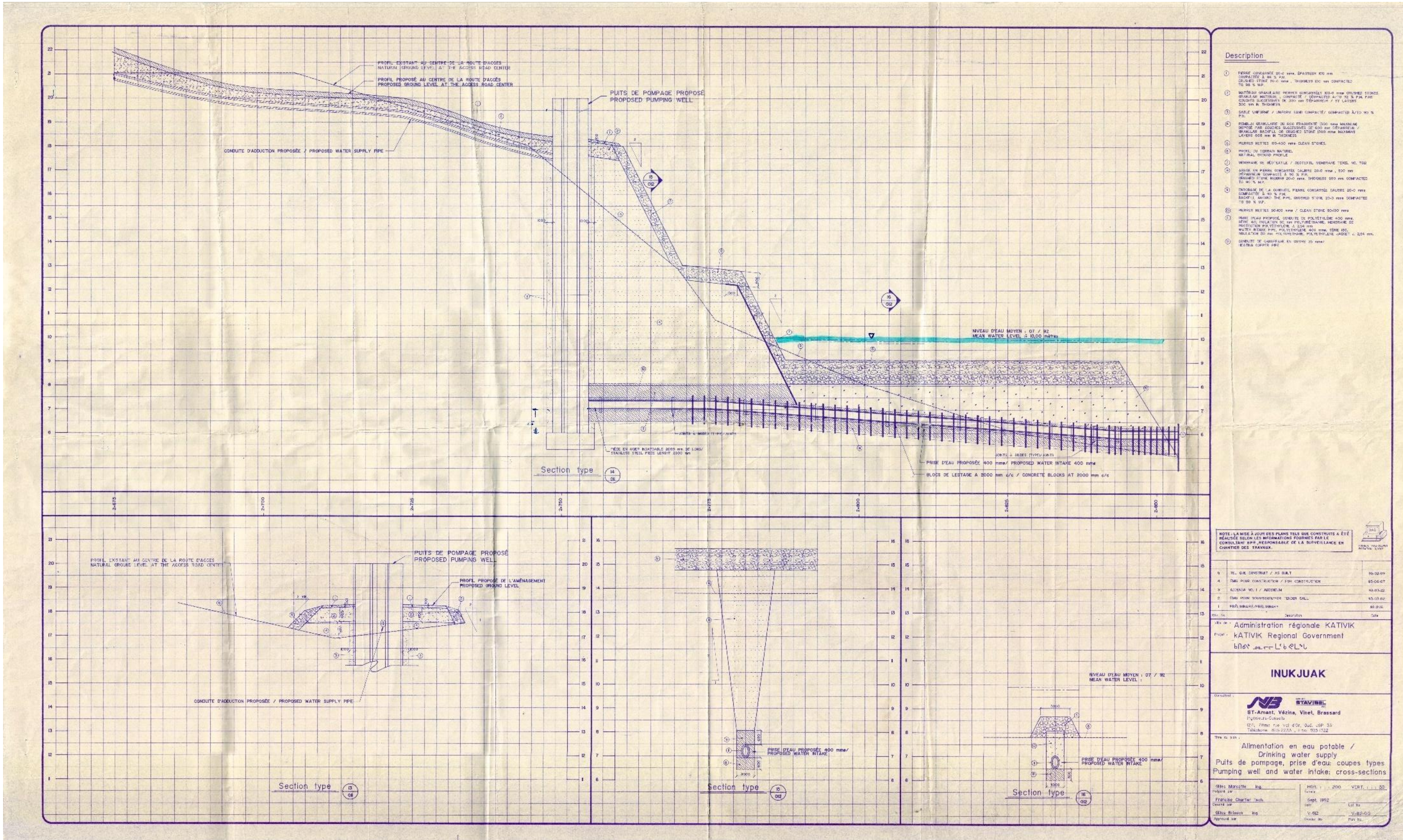
Appendix 1. Development plan for the Northern village of Inukjuak (2017)



Appendix 2. Layout of water withdrawal infrastructure




PROFIL EXISTANT AU CENTRE DE LA ROUTE D'ACCÈS
NATURAL GROUND LEVEL AT THE ACCESS ROAD CENTER
PROFIL PROPOSÉ AU CENTRE DE LA ROUTE D'ACCÈS
PROPOSED GROUND LEVEL AT THE ACCESS ROAD CENTER
PUITS DE POMPAGE PROPOSÉ
PROPOSED PUMPING WELL
CONDUITE D'ADDUCTION PROPOSÉE / PROPOSED WATER SUPPLY PIPE
NIVEAU D'EAU MOYEN : 07 / 92
MEAN WATER LEVEL : 10,00 mètres
PRISE D'EAU PROPOSÉE 400 mmø / PROPOSED WATER INTAKE 400 mmø
BLOCS DE LESTAGE À 2000 mm c/c / CONCRETE BLOCKS AT 2000 mm c/c
Section type
PROFIL PROPOSÉ DE L'AMÉNAGEMENT
PROPOSED GROUND LEVEL
PRISE D'EAU PROPOSÉE 400 mmø/
PROPOSED WATER INTAKE
Description
PIERRES NETTES 100-400 mm CLEAN STONES.
PROFIL DU TERRAIN NATUREL
NATURAL GROUND PROFILE
PIERRES NETTES 50-400 mm / CLEAN STONE 50-400 mm
NOTE : LA MISE À JOUR DES PLANS TELS QUE CONSTRUITS A ÉTÉ RÉALISÉE SELON LES INFORMATIONS FOURNIES PAR LE CONSULTANT BPR, RESPONSABLE DE LA SURVEILLANCE EN CHANTIER DES TRAVAUX.
5 TEL QUE CONSTRUIT / AS BUILT
4 ÉMIS POUR CONSTRUCTION / FOR CONSTRUCTION
3 ADDENDA NO. 1 / ADDENDUM
2 ÉMIS POUR SOUMISSION/FOR TENDER CALL
1 PRÉLIMINAIRE/PRELIMINARY
Description
Date
Administration régionale KATIVIK
KATIVIK Regional Government
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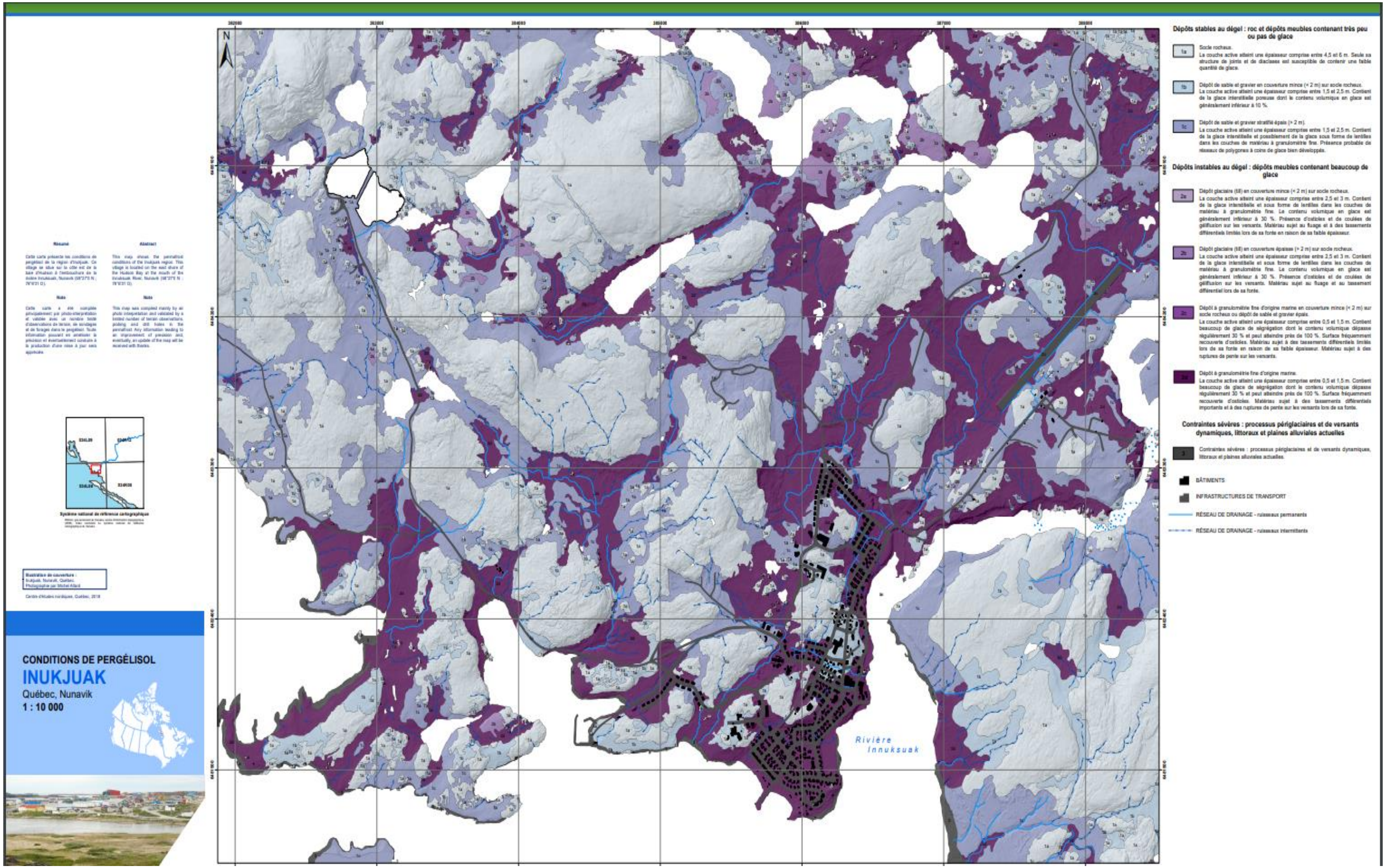
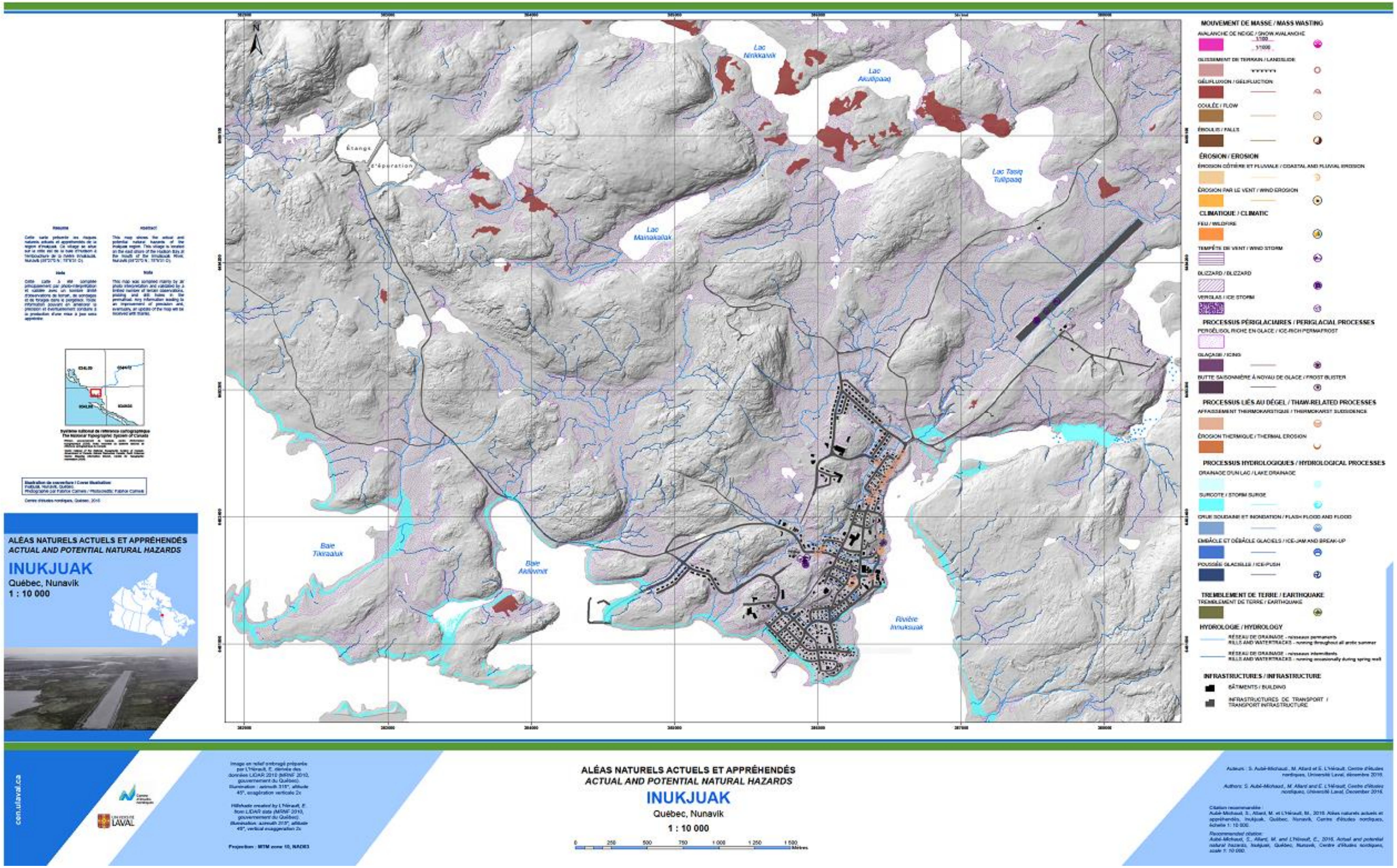
INUKJUAK
STAVIBEL
ST-Amant, Vézina, Vinet, Brassard
Ingénieurs-Conseils
Alimentation en eau potable /
Drinking water supply
Puits de pompage, prise d'eau: coupes types
Pumping well and water intake: cross-sections
Gilles Marcotte ing.
Francine Chartier tech.
Gilles Brisson ing.
HOR. 1 : 200 VERT. 1 : 50
Sept. 1992
V-62
V-62-02

Appendix 3. Permafrost conditions - Inukjuak



Appendix 4. Actual and potential natural hazards - Inukjuak



Appendix 5. Rivière-Innuksuac territorial reserve for protected area purposes