
# Surface water intake vulnerability analysis report for the Northern village of Akulivik

Water intake number: X2114284

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Prepared by:

**Jessika Pickford, Biol., M.Sc.,** Renewable Resources, Environment, Lands and Parks Department

Revised by:

**Aglaé Telmosse-Boucher**, Renewable Resources, Environment, Lands and Parks Department

**Ilheoma Nkwoji, M. Eng.,** Municipal Public Works Department

**Joachim Villanove,** Renewable Resources, Environment, Lands and Parks Department

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# Introduction

## Mandate

This water intake 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 withdrawal site. 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 2021 federal census, the village of Akulivik has a population of 642 [1]. However, it is considered a Category II water withdrawal, since the number of people served, as defined in the Regulation respecting the quality of drinking water (RQEP, Q-2, r.40), is 450.[2] Given the significant difference between the actual and calculated number of people, the KRG decided to proceed with a vulnerability analysis of Akulivik's water withdrawal. Due to the remote nature of Northern villages, which, it should be noted, can only be reached by air or sea, it's only logical to expect that this alone brings its own share of vulnerability. Even if the population of some communities is fewer than 500 people, in an ideal world, a vulnerability analysis and source protection plan should be carried out for each of the 14 Northern villages.

[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 (Sche ule 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 Akulivik is 3.5 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 surface 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* [2] and the supporting document entitled *Analyses de la vulnérabilité des sources destinées à l'alimentation en eau potable au Québec — Cas particulier du Nunavik* [3] (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 18-22, 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 local knowledge into 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 condition of the drinking water intake.

Three stakeholders from the Northern village of Akulivik were met during the preparation of this VAR.

## General description of the study area

The Northern village of Akulivik is built on the northeast coast of Hudson Bay, on a rocky peninsula at the mouth of the Illukotat River. In 2021, the municipality had 642 inhabitants on a surface area of 75 $km^2$, for a population density of 8.6 people/$km^2$ [1]. The municipality's territory extends from the coast to the 78° 3' 5 W meridian. The area is characterized by rocky outcrops oriented east-west and formed during the last deglaciation.

Akulivik's climate and vegetation zone are representative of tundra [4]. Winters are long and dry, while summers are short and humid [4]. The thaw season generally runs from mid-June to mid-October. Due to the climate and soil type, the plant cover is essentially composed of mosses, lichens, grasses, and a few shrubs. In addition, the Akulivik region lies in a zone of continuous permafrost, with an active layer varying in thickness from 0.5 m to 2 m. The area is home to a number of animal species, mainly Canada goose and caribou.

The 2015–2035 Land Use Designation and Zone Map (see Appendix 1) produced in 2017 by the KRG includes seven land use zones:

- Commercial and Community Services
- Residential
- Transportation and Communications
- Conservation

- Recreational
- Nuna (territory)

The heart of Akulivik lies in the centre of the peninsula, which includes the Tukisiniarvik school, the municipal office, the health centre, and most of the homes. To the west of this area are the fuel tanks and Hydro-Québec buildings. Another part of the village extends eastwards on coastal sediments [4]. This area includes the arena, the landholding corporation office, and the Northern store (see Figure 1). Water withdrawal and treatment facilities are located in this area, with the airport to the east (upstream) of the Illukotat River, a borrow pit to the north, and the village to the west (downstream) (see Figure 2).

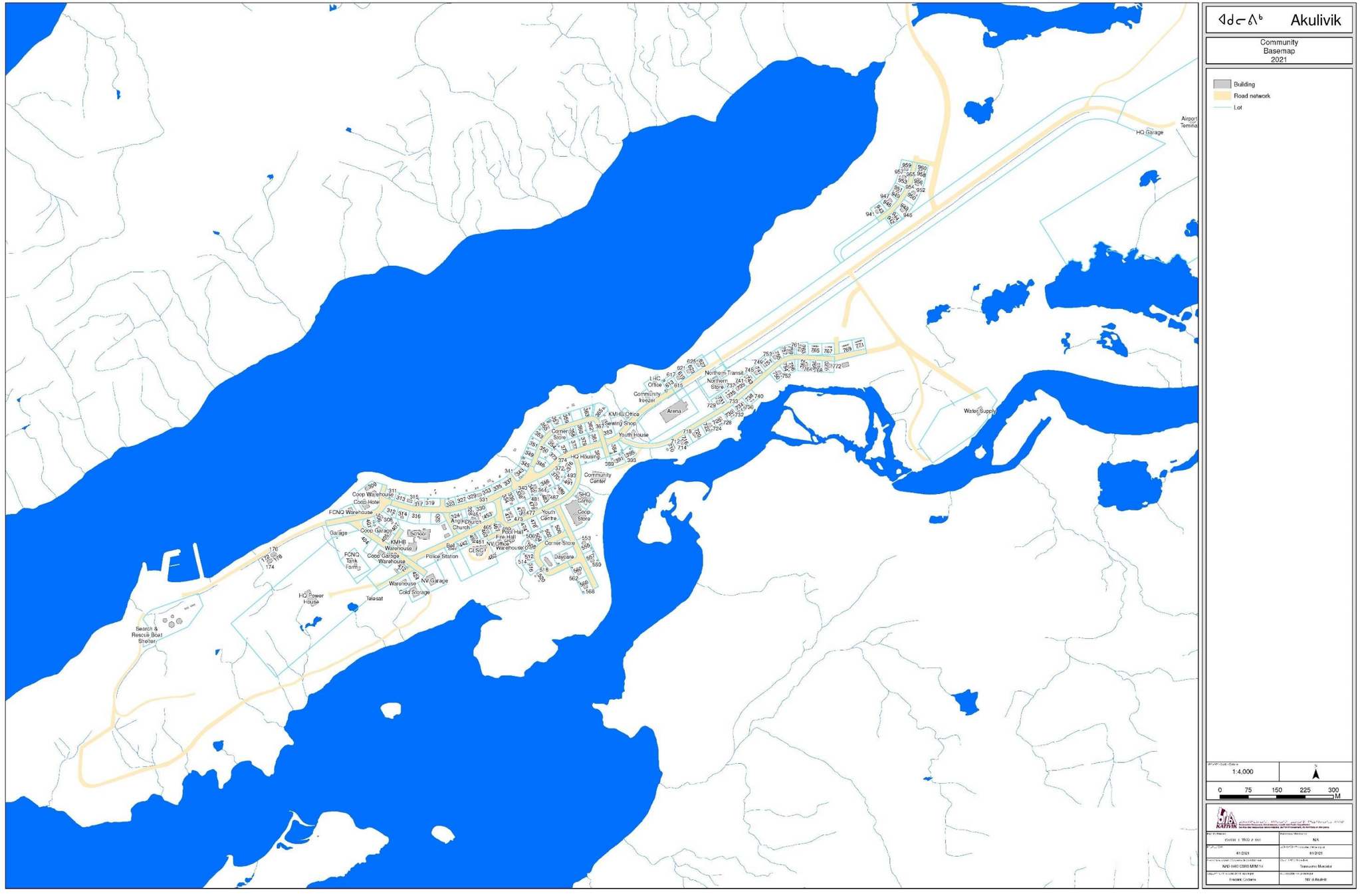


*Figure 1. Map of the Northern village of Akulivik (2021)*


*Figure 2. Localisation map for the Northern village of Akulivik*

# 1. Characterization of water withdrawal

## 1.1 Watershed delimitation of the withdrawal site and brief characterization

The territory of Akulivik is located in the James Bay-Hudson hydrographic region. Drinking water is supplied from the Illukotat River. The river's watershed covers an area of 271 $km^2$ and extends 58 $km^2$ to the northeast [4]. Flooding begins in early June, with freeze-up starting in November. The river flows between the Youville mountains from the northwest to the southeast, emptying into the municipality's south shore. It is estimated that half of the annual runoff from rivers and streams occurs during flood periods, and that low water levels are severe in winter [4].

### 1.1.1 Method used to produce localisation maps

The *Géobase du réseau hydrographique du Québec* (GRHQ) has been identified as the best source of hydrographic data available for the region [5]. 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 [6]. 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.

## 1.2 Description of the withdrawal site and drinking water production facility

### 1.2.1 Description of the withdrawal site

The Northern village of Akulivik draws its drinking water from the Illuktotat River. Water is pumped directly from the river into an outdoor reservoir. Figure 3 shows the caisson housing the water intake pipe that carries raw water from the river to the outdoor reservoir. In the same photo, the reservoir can be seen on the left, with the drinking water treatment plant behind it. The raw water reservoir is continuously filled via the water intake valve. A culvert connects the reservoir to the river, regulating the water level when the reservoir reaches full capacity.

*Figure 3. Protective caisson for the water intake pipe on the bank of the Illukotat River. Photo taken on May 19, 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 depth and critical water levels.

*Table 1. Main characteristics of the withdrawal site.*

| Withdrawal site feature | Description and details |
|---|---|
| Water intake name | Drinking water distribution system, Akulivik |
| Water intake number | X2114284 |
| Production facility number | X0010271 |
| Production facility category | Category 1 (Surface) |
| Geographic coordinates | 78° 10' 4" W, 60° 48' 38" N |
| Type of use | Permanent |
| Type of withdrawal | Concrete caisson located on the river bank from which the outdoor reservoir is filled once a year. |
| Withdrawal depth | Unknown |

| | |
|---|---|
| Distribution | Tank trucks (2 trucks)[3] |
| Population served | 450 people |
| Authorized daily withdrawal rate | 80 $m^3$ |
| Low water level | Unknown |
| Number of the most recent authorization issued by the Ministère | 2011-05-25; 7314-10-01-99125-01/200302127 |

### 1.2.2 Description of drinking water production facility

The Akulivik drinking water treatment plant was built in 1988 and completely upgraded in 2011 (see Figure 4). The water is conveyed from the outdoor reservoir (Appendix 4) to a 5-stage treatment process. The first stage consists of a multimedia filtration system, followed by a 5 µm (micron) filter cartridge. The filtered water is disinfected by chlorination (upstream of the reservoir) and then treated with UV radiation before being stored in an 80 $m^3$ tank. A second chlorination is carried out at the reservoir outlet, just before entering the filling pipe of the tank trucks that distribute the water.

Current reservoir capacity does not meet fire prevention requirements. The installation of a larger reservoir is scheduled for 2026.

The only chemical used for water treatment and stored in the building is sodium hypochlorite. However, there is also a heating oil (diesel) tank attached to the building (see Figure 5).

[3] One of the tank trucks had broken down at the time of drafting this report. A replacement tank truck is expected to be delivered in the autumn.


*Figure 4. Exterior view of the drinking water treatment plant. Photo taken on May 19, 2024.*


*Figure 5. Diesel tank attached to the Akulivik WTP building. Photo taken on May 19, 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 Akulivik, 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.

Figures 6 and 7 **Error! Reference source not found.**show the location of the inner, intermediate, and outer protection areas of the withdrawal site.

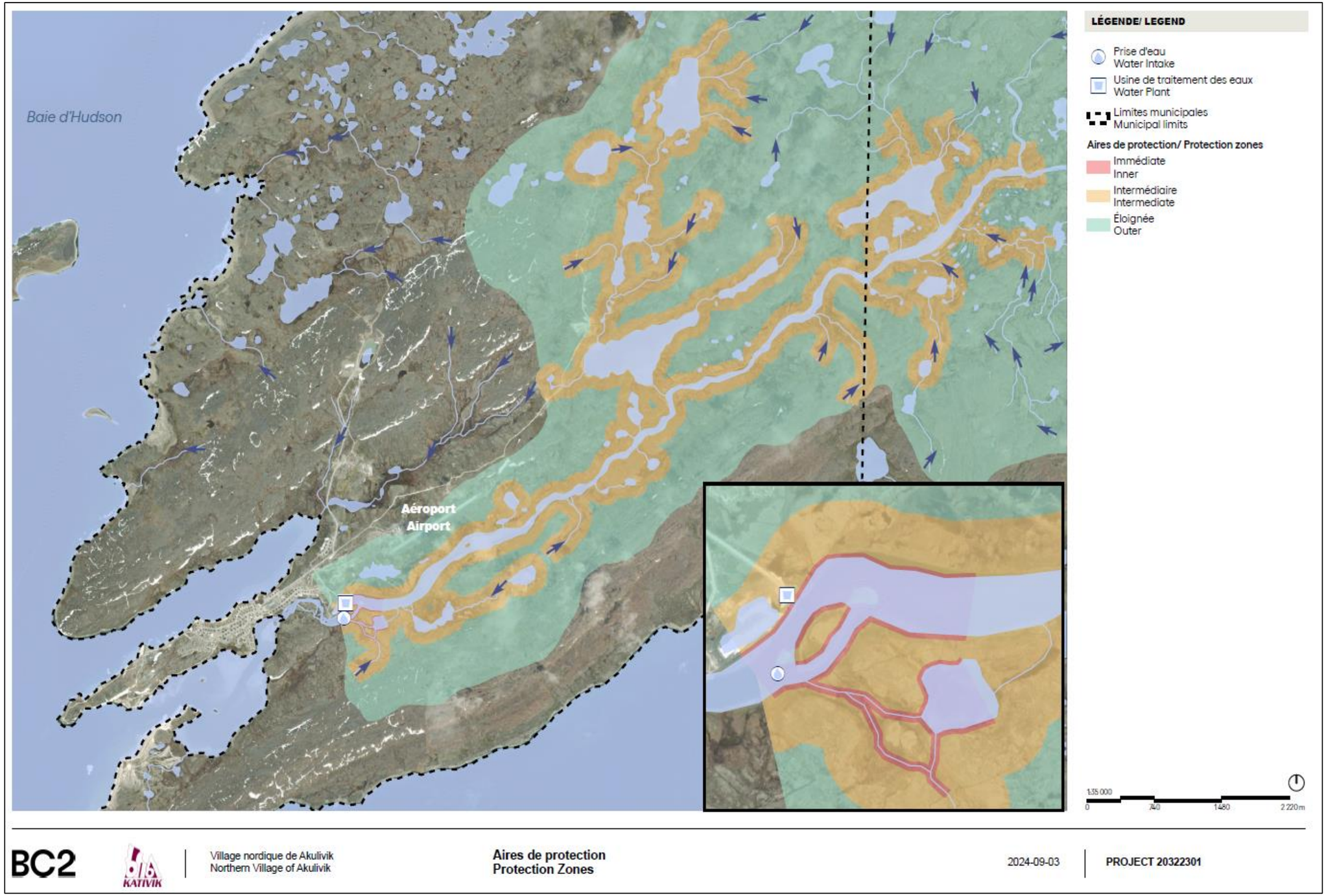


*Figure 6. Inner and intermediate protection zones of the water withdrawal site.*

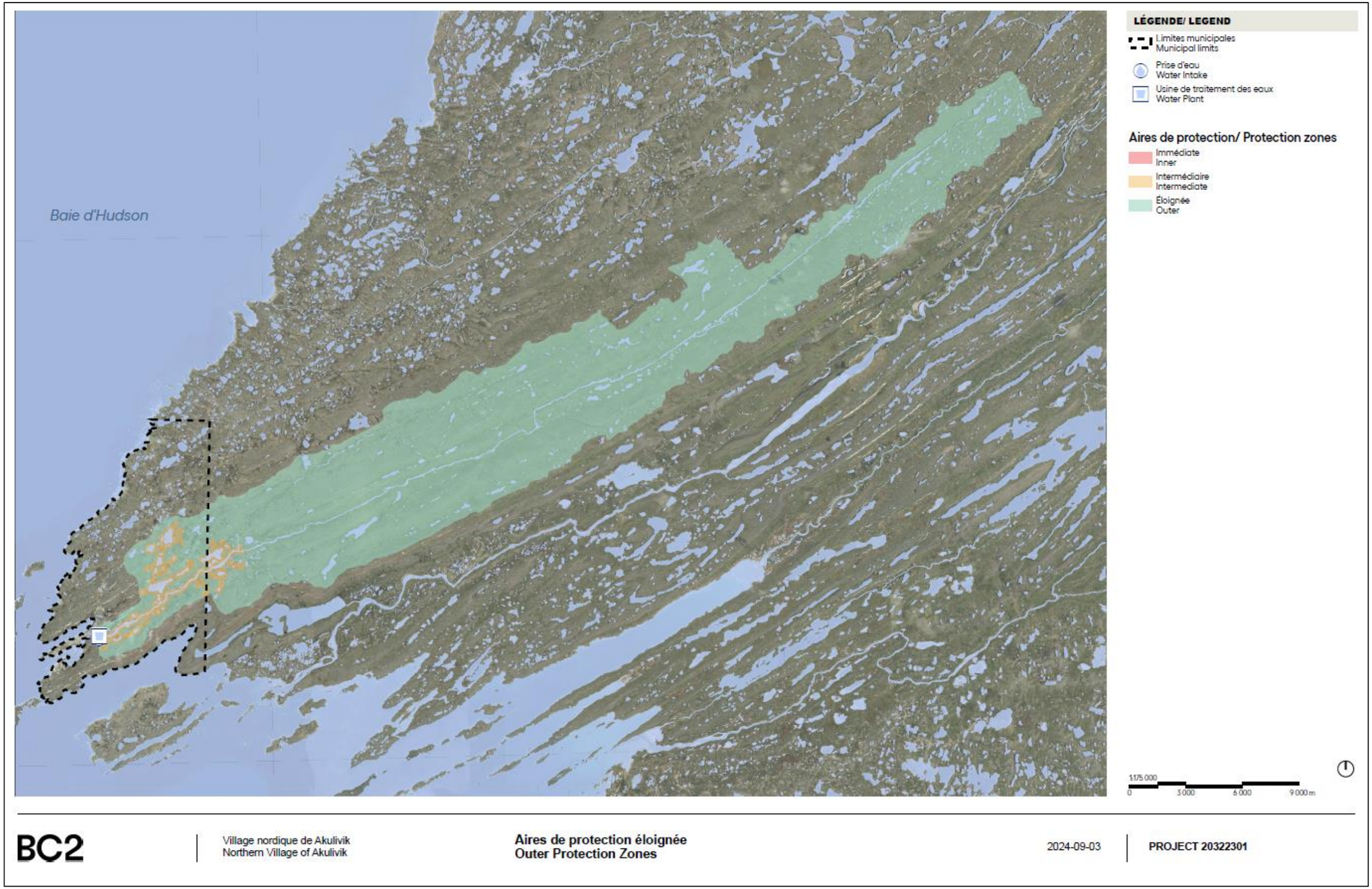


*Figure 7. Outer protection zone (Illukotat River watershed).*

## 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 determined | Justification of the result |
|---|---|---|---|
| Physical integrity of the withdrawal site (A) | Method 3 | Medium | The absence of a record of events, the vulnerability to natural hazards, and the site visit result in a medium rating for physical integrity. |
| Vulnerability to microorganisms (B) | Method 2 | Medium | Periodic detection of *E. coli* in raw water and presence of natural contamination sources in the inner zone. |
| Vulnerability to fertilizers (C) | Method 2 | Low | No algae, cyanobacteria, or aquatic plant blooms. No high-risk activities identified in any of the protection zones. |
| Vulnerability to turbidity (D) | Method 2 | Low | Local experts confirm low turbidity (less than 1 NTU at all times). |
| Vulnerability to inorganic substances (E) | Method 2 | Low | Only one building in the intermediate protection zone. |
| Vulnerability to organic substances (F) | Method 2 | Medium | Presence of potential high-risk and very high-risk events |

### 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.
- No events that may have compromised the water intake have occurred in the last five years.
- During the site inspection, it was observed that sections of the discharge pipe were not insulated, and could be vulnerable to freezing.
- Work is planned to increase the size of the drinking water reservoir.

By exploring the vulnerability of the supply site to natural hazards, it becomes apparent that certain processes related to the ice-rich permafrost located in the inner zone, including thermokarst subsidence, could compromise the physical integrity of the drinking water pumping and treatment facilities (see permafrost map in Appendix 3). The analysis of actual and potential climatic hazards also highlights the possibility of flash floods in the inner zone of the withdrawal site, and the almost certain probability of the occurrence of climatic hazards (blizzards, ice storms, and windstorms) [4]. These two elements increase the vulnerability of supply facilities, since access to the withdrawal site and WTP could be compromised (blizzards, ice storms), and physical damage to infrastructure could occur (flash floods, blizzards, ice storms) (see infrastructure design plan in Appendix 4).

**Although no compromising events were mentioned during interviews with local stakeholders, the absence of a logbook of events, the vulnerability to natural hazards, and the site visit result in a medium rating for physical integrity.**

*Table 3. Probable causes of the medium level of physical integrity 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) | Thermokarst subsidence | Natural |
| Mechanical breakdown | Physical integrity of the withdrawal site (A) | Flash flooding | 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 water 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 2022 and 2024. 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 in the water distributed when the presence of *E. coli* was reported. 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 possible influx of pathogenic microorganisms due to permafrost thawing combined with flash floods and the passage of animals. Therefore, particular vigilance is exercised at this time of year, when treatment efficiency (filters, UV lamps, and chlorination) must be optimal to protect the public against 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. "*

**For all these reasons, the vulnerability to microorganisms of the water used is considered medium.**

*Table 4. Probable causes of medium vulnerability to microorganisms.*

| Identified problem | Vulnerability indicator with which this problem is associated | Identification of causes | Type of cause |
|---|---|---|---|
| Presence of fecal coliforms in raw water | Vulnerability to microorganisms (B) | Presence of migratory animals | Natural |
| Presence of pathogens in raw water | Vulnerability to microorganisms (B) | Water contamination due to permafrost thawing | Natural |

### 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.

**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. Method 2 for assessing vulnerability to turbidity takes advantage of the experience of on-site personnel and other relevant information. During meetings with local and regional stakeholders, it was confirmed that turbidity at the water intake varies only slightly (less than 1 NTU at all times) but increases in the spring. This is partly due to the fact that raw water is stored in an outdoor reservoir before being sent to the WTP, allowing for sedimentation.

**The level of vulnerability to turbidity is considered low.**

### 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 only building located in the intermediate protection zone is the drinking water withdrawal and treatment facility, which covers less than 1% of the intermediate protection zone.

**The level of vulnerability is considered low.**

### 1.4.6 Vulnerability to organic substances (Indicator F)

The municipality of Akulivik 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 recommended to assess the source's level of vulnerability to organic substances. Fuel storage near the buildings (associated with Nunavik's specific context of supply), in particular the WTP tank located at the junction of the inner and intermediate zones, is considered a non-negligible source of vulnerability to organic substances. The two elements presented in Table 5, fuel handling and storage at the WTP and the airport, are of particular concern, especially since the spill response capacity of the Northern village of Akulivik is inadequate. For these reasons, **the level of vulnerability to organic substances is considered medium.**

*Table 5. Probable causes of medium vulnerability to organic substances.*

| Identified problem | Vulnerability indicator with which this problem is associated | Identification of causes | Type of cause |
|---|---|---|---|
| Fuel storage and handling at the water treatment plant | Vulnerability to organic substances (E) | Presence of water treatment plant in the intermediate zone | Anthropogenic |
| Fuel storage and handling at Akulivik northern airport | Vulnerability to organic substances (E) | Presence of the Akulivik northern airport | Anthropogenic |

# 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

Water withdrawal facilities are located upstream of the village, and very little anthropogenic activity takes place in the protection zones. Only three activities were recorded: the Akulivik northern airport, the drinking water withdrawal and treatment facilities, and traditional hunting and fishing activities (Table 6).

*Table 6. Anthropogenic activities occurring in the inner and intermediate protection zones of the Northern village of Akulivik drinking water withdrawal site.*

| Anthropogenic activity | Protection zone in which the activity takes place | Contaminant or group of contaminants considered | Determined risk |
|---|---|---|---|
| Fuel storage and handling at the water treatment plant | Inner protection zone | Organic substances (fuel) | High |
| Presence of the Akulivik northern airport | Intermediate protection zone | Organic and inorganic substances (ethylene glycol, fuel, dust control fluids) | High |
| Winter snowmobile traffic on frozen water bodies | Intermediate protection zone | Organic substances (fuel) | High |
| Presence of UTE | Intermediate protection zone | Organic substances (fuel) | Medium |
| Hunting and fishing activities | Intermediate protection zone | Microorganisms | Medium |
| Hunting and fishing activities | Outer protection zone | Microorganisms | Medium |
| Winter snowmobile traffic on frozen water bodies | Outer protection zone | Organic substances (fuel) | Medium |

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

Potential events that could pose a threat to the quality of the water withdrawn are associated with normal fuel handling and storage activities associated with the buildings identified (Table 7Table 7).

*Table 7. 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 |
|---|---|---|---|---|
| Fuel spills during storage or filling of the diesel tank connected to the building | Fuel storage and handling at the water treatment plant | Inner protection zone | Organic and inorganic substances (fuel) | High |
| Fuel spills during normal operations | Presence of the Akulivik northern airport | Intermediate protection zone | Organic and inorganic substances (fuel) | High |

| | | | | |
|---|---|---|---|---|
| Fuel spills during normal operations | Fuel storage and handling at the water treatment plant | Intermediate protection zone | Organic and inorganic substances (fuel) | Medium |
| Spillage of dust suppressant | Presence of the Akulivik northern airport | Intermediate protection zone | Organic and inorganic substances | Medium |
| Dust deposition during aircraft take-off and landing | Presence of the Akulivik northern airport | Intermediate protection zone | Turbidity | Low |
| Fuel spills | Winter snowmobile traffic on frozen water bodies | Intermediate protection zone | Organic and inorganic substances (fuel) | Low |
| Dumping of animal carcasses | Hunting and fishing activities | Intermediate protection zone | Microorganisms | Low |

Two potential natural events have been identified in the inner and intermediate protection zones of the Akulivik water withdrawal site: the presence of migratory animals and the thawing of permafrost (Table 8). In fact, ice-rich permafrost (unstable to thawing) is found in the inner and intermediate protection zones (see Appendix 3).

*Table 8. 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, inorganic substances | Low |
| Water contamination due to permafrost thawing | Intermediate protection zone | Microorganisms, turbidity, inorganic substances | Very low |

There is little documentation on the real impact of thawing permafrost on river regimes and hydrological flows. Although Akulivik is located in a zone of continuous permafrost, several major forces associated with climate change could compromise the amount of water available. The vulnerability of this withdrawal site is likely to be exacerbated by the lack of knowledge about the expected behaviour of the supply source over the next few years. The possible interaction between changing precipitation patterns, rising average temperatures, and geocryological conditions could have the effect of reducing the supply potential of the Illukotat River.

### 2.3 Land-use inventory results

The Master plan presented in Appendix 1 sets out the overall direction envisaged for the Northern village of Akulivik. 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, northern village Master plans target lands within municipal boundaries, often similar to the boundaries of Category 1 lands (JBNQA).

Part of the outer protection zone overlaps the protected territory of the Monts de Puvirnituq National Park Reserve (see Appendix 5).[4] This initiative helps to limit industrial activities (e.g., mining) that could pose a risk to the quality or quantity of water withdrawn.

## 3. Identifying the probable causes of established problems

The probable causes of the medium level of vulnerability obtained for Indicators A 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, water quality data are substantially less abundant than south of the 55th parallel. Some data simply do not exist, while others can be difficult to locate. There are two main reasons for this:

[4] MELCCFP – Protected areas in Quebec (March 31, 2024, version)

1. The RQEP contains exceptions and exemptions for northern villages. 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 the vagaries of the weather. As a result, samples taken in accordance with the rules of the art may not arrive at the laboratory on time, and may therefore be disregarded. Some regulatory analyses may therefore be incomplete, making historical analyses impossible.

The approach proposed in the supporting Guide is designed to overcome this lack of data and enables local knowledge to be put to good use, not least in the analysis of the physical vulnerability indicator for the sampling site.

The methods 1 and 2 proposed in the Guide and the adaptations proposed for Nunavik offer sufficient alternatives to enable the RAV to be carried out, even in the absence of regulatory data.

The lack of knowledge about the potential impacts of climate change on water quality and quantity is a major issue, and increases the uncertainty associated with estimating the probability of the 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 at Akulivik. Figure 8, which shows the annual proportion of raw water bacteriological analyses carried out for each northern village, illustrates this point well [7]. Akulivik's bacteriological testing rate has been increasing since 2021. Since these results make up the bulk of the raw water quality database for source water, it is difficult to perform statistical or trend analyses.

**Bacteriological Analysis – Colilert Sampling Results:**

| | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|
| | 50 weeks | 52 weeks | 50 weeks | 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 8. Annual proportion of bacteriological analyses carried out for each Northern village. Excerpt from the Municipal Public Works Department Activity Report (May 2024) [7].*

# 5. Conclusion and recommendations

The analyses carried out show that the Northern village of Akulivik is in a favourable position when it comes to its drinking water supply. Vulnerability indicators are low, with the exception of physical and microbiological vulnerability, for which vulnerability is medium.

Very few anthropogenic activities have been identified on the territory, and potential events are comparable to those of other Northern villages for which vulnerability has been analyzed. In this respect, the presence of the diesel tank between the WTP building and the withdrawal site is a major concern. In fact, the tank is located just a few metres from the supply source and the outdoor reservoir. A spill at this location could have very serious consequences for the local population.

It was pointed out during the interviews that a lake located to the northeast of the Northern village has already been used as an emergency supply source during shortages. This emergency supply source should be better characterized and given special status to preserve its physical integrity.

Lastly, a project to document the impact of airport activities could be considered to rigorously document risks and implement effective mitigation measures.

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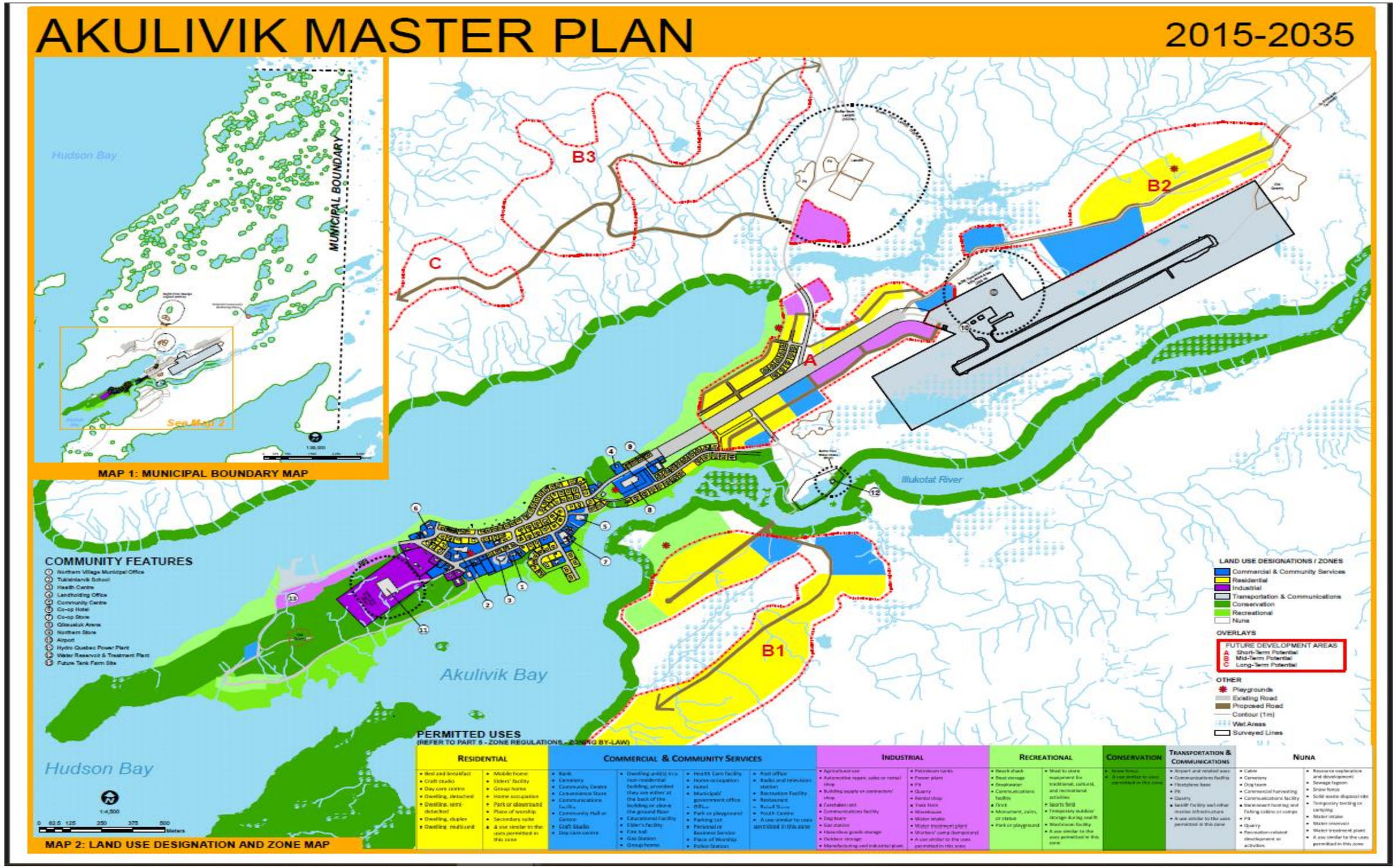
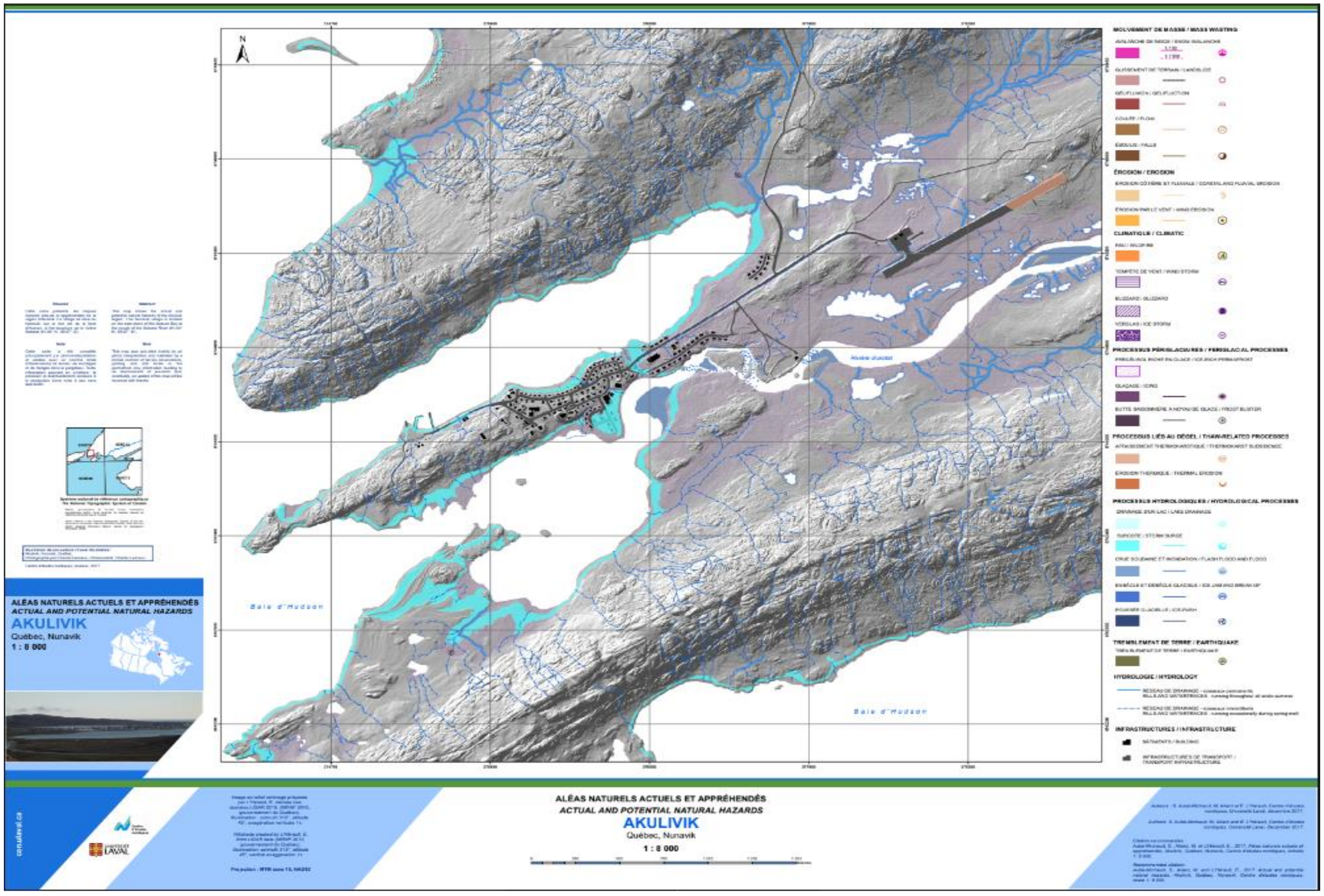
[6] MINISTÈRE DES RESSOURCES NATURELLES ET DES FORÊTS, "LiDAR - Modèles numériques (terrain, canopée, pente) [Jeu de données]," Données Québec.

[7] Municipal Public Works Department, "Activity Report, February to May 2024," Kativik Regional Department, Kuujjuaq, QC, 2024.

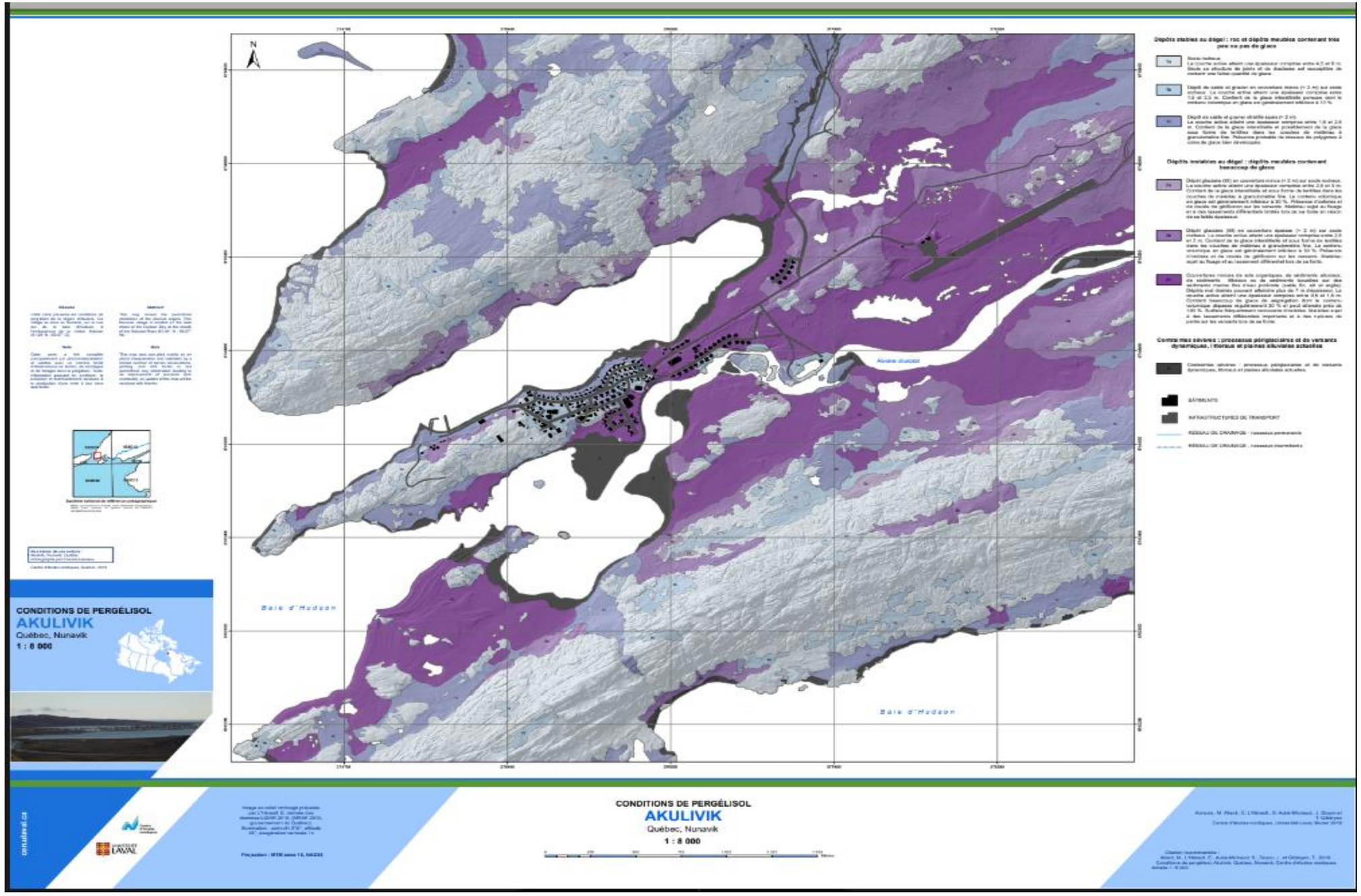
Appendix 1 Land Use Designation and Zone Map for the Northern Village of Akulivik



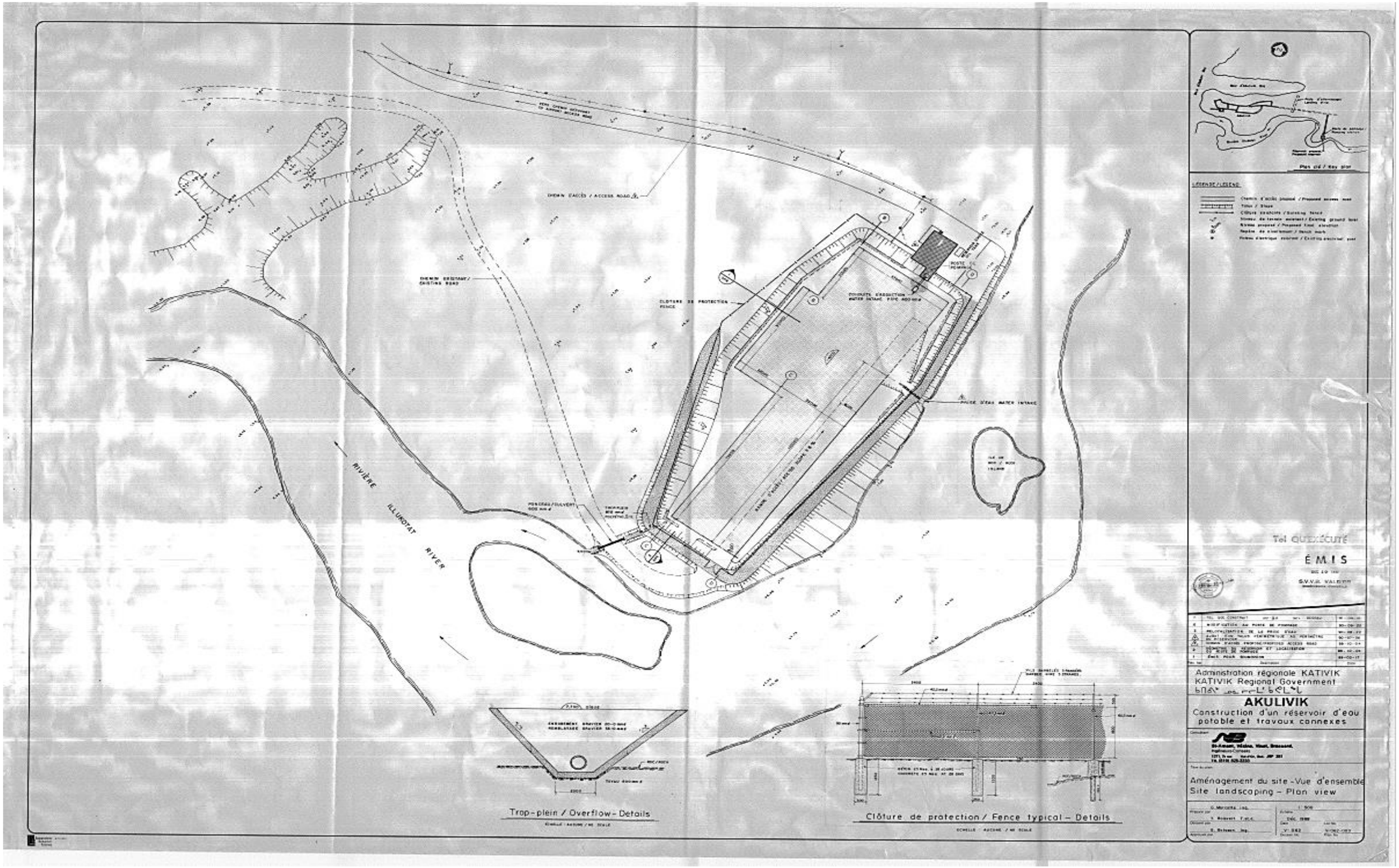
## Appendix 2 Map of actual and potential natural hazards

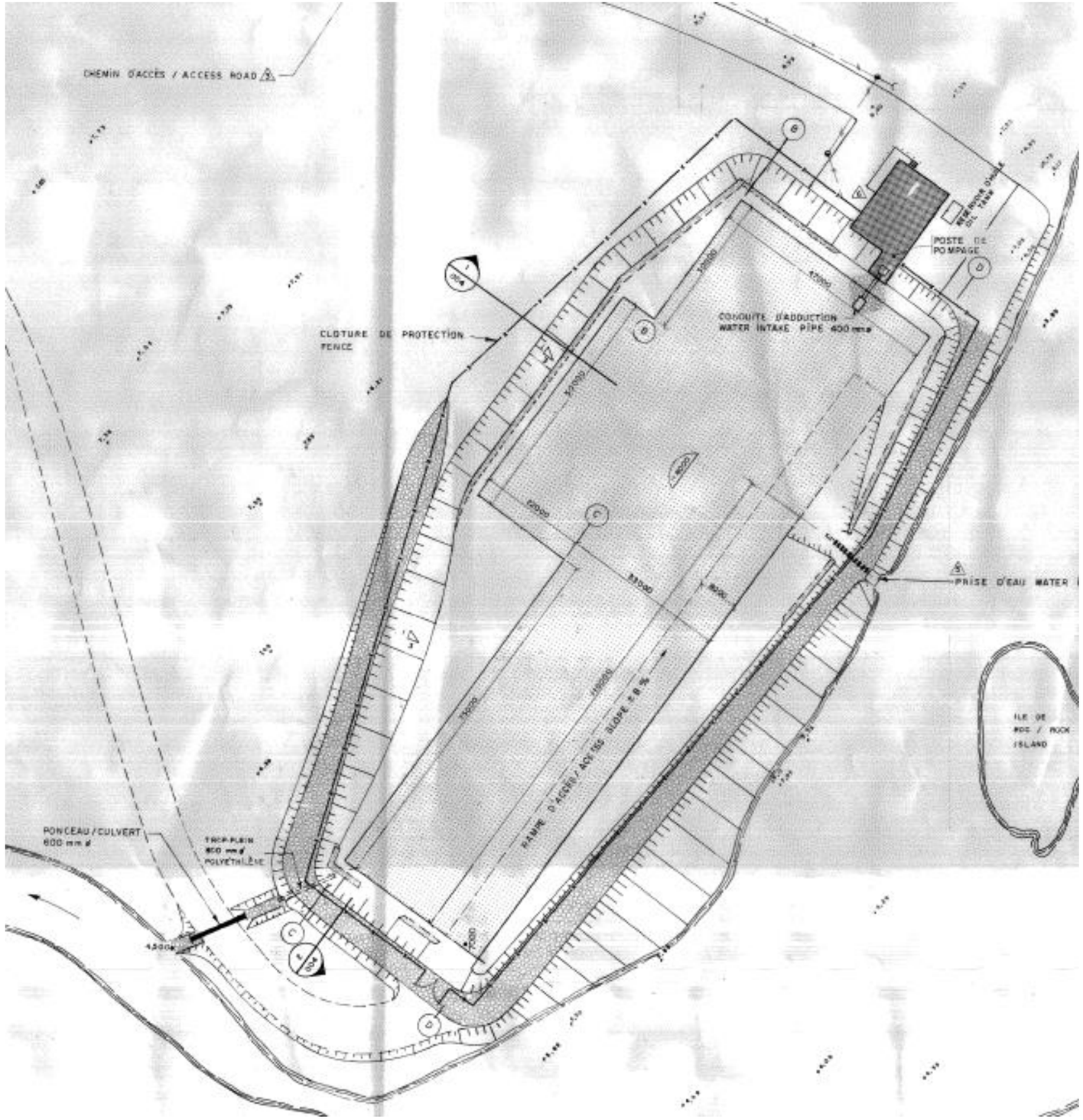


## Appendix 3 Map of permafrost conditions



## Appendix 4 Design plan for outdoor reservoir




CHEMIN D'ACCÈS / ACCESS ROAD
CLÔTURE DE PROTECTION
FENCE
CONDUITE D'ADDUCTION
WATER INTAKE PIPE 400 mm ø
POSTE DE
POMPAGE
PRISE D'EAU WATER
ILE DE
ROC / ROCK
ISLAND
RAMPE D'ACCÈS / ACCESS SLOPE
PONCEAU / CULVERT
600 mm ø
TROP-PLEIN
POLYÉTHYLÈNE

Appendix 5 Location of Monts-de-Puvirnituq National Park Reserve