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Flooding in at-risk areas

ORGANISME
DE BASSIN VERSANT
de la rivière du Nord



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1. Factual description

According to the *Act respecting land use planning and development*, for public health and environmental protection reasons, flood zones are among the stress regions that must be defined in Regional County Municipality (RCM)'s Land Use and Development Plans (Chapter A-19.1, Section 5).

Data on historical ice jam and open water flood events are taken from civil security event histories and the mapping of the spring 2023 floods made available by the Ministère de la Sécurité publique (MSP) (Gouvernement du Québec, 2020, 2023).

The major spring floods that took place in several rivers in Québec in 2017 and 2019 highlighted our vulnerability to flooding and left their mark on communities due to the number of flooded homes, blocked roadways, and evacuations. Emergency measures, rescue operations, and disaster relief were also required.

Following the events of spring 2017, the INFO-Crue project was launched by the Québec government. This exhaustive mapping of the province's flood zones and watercourse circulation zones is used to take risk into account during land use planning and the implementation of flood adaptation solutions in the context of climate change. Data collection is still underway.

Certain Integrated Water Management Zone (ZGIE) watercourses are known for their strong reactions during extreme rainfall or climate events, resulting in significant management costs and inconveniencing shoreline residents. From the numerous challenges related to watercourse dynamics and with the aim of finding innovative and integrated approaches emerged a project with a promising management approach: the study on the freedom space of certain stretches of watercourses located within the administrative boundaries of the Argenteuil RCM was carried out in 2016. Flood risk areas (i.e., those with high and moderate flood risks) were therefore characterized for the stretch of the Rivière du Nord between Mirabel and downtown Lachute, the Rivière de l'Ouest, the section of the Ruisseau des Vases in an agricultural area, and the entire stretch of the Rouge River (Saint-André) to the Mirabel border. The purpose of demarcating the freedom space is to preserve the integrity of the watercourse and the functions associated with channel mobility, floodability, and connectivity between the channel and floodplain wetlands. Protecting the freedom space both ensures the safety of citizens by reducing the risks of flooding and erosion and enhances the quality of the environment.

1.1 Physiographic region

In general, the municipalities most vulnerable to flooding within the ZGIE are located in the St. Lawrence Lowlands south of the ZGIE. Indeed, this area has a high population, and several major watercourses flow into the Rivière du Nord. The inflow of water on flat terrain therefore slows its flow velocity, resulting in the swelling and overflow of watercourses. Consequently, in the spring, the Rivière du Nord often triggers floods in the metropolitan Saint-Jérôme region, as well as between Mirabel (Saint-Canut) and Lachute, affecting the latter's downtown area and farmland along the river. In the urban zone of Saint-Jérôme, river flow controls, using the former Woodbridge factory dam, limit the potential consequences of floods.

The Saint-André-d'Argenteuil municipality is also affected by floods, as certain residential areas are located on the banks of the Ottawa River or at the confluence between it and the Rivière du Nord.

In the northern portion of the region, located in the Canadian Shield, flood zones are often located at the meeting points of several rivers (e.g., Sainte-Adèle: Rivière du Nord and Doncaster River) or meandering zones (e.g., Val-Morin).

1.2 Water level and flow

The hydrometric station managed by the Centre d'expertise hydrique du Québec (CEHQ) and the Environment and Climate Change Canada (ECCC) National Hydrometric Program collects data on water levels and flow rates to better

understand the factors that influence them. In the ZGIE, 15 flood monitoring stations are active, including nine on the Rivière du Nord (MSP, 2024).

The average annual flow of the Rivière du Nord at the Saint-Jérôme station (40110) for the 1971-2019 period was approximately 25 m^3/s (MELCC, 2020). The monitoring threshold for Rivière du Nord flooding at the Saint-Jérôme station begins at 150 m^3/s (MSP, 2024). Minor, average, and major flood thresholds are 180, 220, and 260 m^3/s, respectively (MSP, 2024).

The flow rates of the Rivière du Nord in Saint-Jérôme are three to four times greater than those of the Sainte-Agathe-des-Monts hydrometric station. The average yearly flow rate of the Rivière du Nord hydrometric station is around 8 m^3/s. The monitoring threshold is 40 m^3/s and the minor flood threshold is 44 m^3/s (MSP, 2024).

1.3 Climate

The climate in the ZGIE is distinguished by significant seasonal temperature variations and high precipitation with a relatively standard distribution over the year, throughout the region. The northern area of the watershed receives an average of nearly 100 mm more rain per year than the southern area.

It is estimated that the watershed ecosystems of the Rivière du Nord receive an average of 1091 mm of precipitation per year. Ecosystems capture approximately 36 mm through evapotranspiration, meaning that 1056 mm of water is transported through the region into bodies of water every year (Habitat, 2022).

1.4 Water retention structures

Only 20% of the water retention structures listed in the ZGIE were built for regulation purposes (to maintain watercourse flow or level) and flood control (to control floods or hold back ice).

In all cases, nearly half of the dams in the ZGIE were built between 1960 and 1980. It is therefore safe to say that these decades-old human-made structures may be showing signs of wear and disrepair, raising significant safety and functionality concerns. The risks associated with these aging structures – such as leaks, structural failures, or insufficient retention capacity – may lead to flooding as well as serious repercussions for downstream communities, the surrounding ecosystem, and associated infrastructure.

Beaver dams are also considered water retention structures. They have a scattered presence in the region, but they may have negative impacts, such as flooding and road infrastructure damage (Fortin, Laliberté, and Ouzilleau, 2001; MFFP, 2020).

2. General location

The data collected by the INFO-Crues project will be essential to complete this section. These provisional and regulatory maps will improve the prediction and management of open water flood risks while facilitating land use planning. While awaiting this crucial information, the next section offers a location overview of the diverse types of floods in ZGIE North.

Bodies of water played a central role in the development of the Organisme de bassin versant de la rivière du Nord region, and most municipalities have zones in their region where populations, buildings, and infrastructure are vulnerable to rising waters. In reality, few municipalities can be said to be immune to this danger, especially when taking the various possible types of flooding into account. Sainte-Lucie-des-Laurentides, Sainte-Marguerite-du-Lac-Masson, Val-Morin, Lachute, and Saint-André-d'Argenteuil are the most affected places in the ZGIE according to currently available data.

2.1 Ice jam flooding

In the ZGIE, five ice jam incidents leading to flooding along the Rivière du Nord have been recorded (Gouvernement du Québec, 2020). Similar flood cases related to ice jams also took place on the Simon River, Dalesville River, and Rivière de l'Ouest, as indicated in Table 1.

Table 1. Ice jam floods in the Integrated Water Management Zone (ZGIE) region

Watercourse	Event year	Location
Rivière à Simon	2013	Piedmont
	2018	
Rivière Dalesville	2018	Brownsburg-Chatham
Rivière de l'Ouest	2014	Wentworth-Nord
Rivière du Nord	2008	Sainte-Adèle
	2010	Piedmont
	2016	
	2009	Saint-Jérôme
	2018	

2.2 Open water flooding

Flood zones are contained in the Land Use and Development Plan of the ZGIE RCMs and the Ville de Mirabel. Flood levels with a recurrence of 20 years and 100 years were determined for some sections of the Rivière du Nord and the Ottawa River between 1989 and 2006, first within the mapping program implemented following the *Canada-Quebec convention on mapping, floodplain protection and sustainable water resource development*, then within the *Programme de détermination des cotes de crues* ("flood level determination program") and subsequent studies (MELCC, n.d.-b). The results of this work were submitted to the RCMs and municipalities in question so that they could be integrated into Land Use and Development Plan and urbanization plans. Elsewhere in the region, knowledge of flood zones often remains incomplete.

In summer 2019, the Québec government established a decree instituting special intervention zones (ZIS) (MELCC, 2019) in regions flooded during the spring of 2017 and 2019, as well as flood zones with a 0- to 20-year recurrence contained in the RCM's Land Use and Development Plan. Many municipalities along the Rivière du Nord fell within ZIS (Val-Morin, Sainte-Adèle, Saint-Colomban, Mirabel [Saint-Canut], Lachute, Saint-André-d'Argenteuil, and Brownsburg-Chatham). Municipalities bordering the Ottawa River (Grenville-sur-la-Rouge, Brownsburg-Chatham, and Saint-André-d'Argenteuil) were also in these intervention zones. These ZIS aimed to promote more rigorous flood zone management. In March 2022, the new *Régime transitoire de gestion des zones inondables, des rives et du littoral* came into effect, lifting the special intervention zones (Gouvernement du Québec, 2022).

Finally, the MSP created a database of information on flood disasters since 1989 for ZGIE North (Gouvernement du Québec, 2020). Table 2 summarizes the open water flood events in watercourses of interest in the region. Note: floods occurring outside at-risk zones are not always recorded; more flood events than those listed may have occurred.

Table 2. Open water floods in the Integrated Water Management Zone (ZGIE) region by municipality and watercourse

Watercourse	Location	Event year
Rivière du Nord	Sainte-Agathe-des-Monts	2011
	Val-Morin	2017, 2018, 2019
	Val-David	2008, 2017, 2018, 2019
	Sainte-Adèle	1997, 2000, 2005, 2009, 2015, 2017, 2019
	Piedmont	2019
	Prévost	1998, 2009, 2014, 2017
	Saint-Jérôme	1989, 1994, 1998, 2000, 2005, 2009, 2011
	Saint-Colomban	1998, 2005, 2008, 2009, 2011, 2013, 2017, 2019, 2020
	Mirabel	2005, 2008, 2013, 2017, 2018, 2019, 2020
	Lachute	1997, 1998, 2008, 2009, 2017, 2019, 2020
	Saint-André-d'Argenteuil	2017, 2019
Rivière de l'Ouest	Brownsburg-Chatham	2009, 2014, 2019, 2020
	Wentworth-Nord	2019
Rivière à Simon	Morin-Heights	2000, 2004
Rivière aux Mulets	Saint-Adolphe-D'Howard	1986, 2013, 2014, 2017, 2019
Rivière Rouge	Saint-André-d'Argenteuil	2011
Ruisseau Bonniebrook	Saint-Colomban	2018
Rivière Bellefeuille	Saint-Colomban	2010, 2017
Rivière Saint-Antoine	Saint-Jérôme	2009
Le Grand Ruisseau	Saint-Sauveur	2004
Ottawa River	Saint-André- d'Argenteuil	2008, 2016, 2017, 2020
	Brownsburg-Chatham	2019
	Grenville-sur-la-Rouge	2019

3. Cause of the issue

Flooding is the result of a combination of various factors affecting its triggering, duration, and intensity. These factors are related to hydrometeorological elements (precipitation and climate), shape, size, and watershed use, as well as climate change. The main causes by flood type encountered in the ZGIE are presented in Table 3 (Environment Canada [EC], 2013; MSP, 2022). The factors that lead to floods are described further below.

Table 3. Main causes by flood type in the Québec region

Flood type		Descriptions of causes
Water body flood	**Flash flood (sudden)**	Caused by heavy rainfall over a short period of time, such as violent storms
	Open water flood (slow)	Caused by: - Melting snow cover - Heavy precipitation - Saturation of frozen ground impeding water infiltration (increases runoff) Occurs when the quantity that needs to drain exceeds the normal capacity of the water environment, which leads to an overflow as the water slowly rises Influenced by the configuration of the watershed and its degree of artificialization
River ice and jams	**Ice jam**	Occurs during periods of ice and winter thaws or during spring thaws when mild temperatures weaken river ice cover. Created when ice is temporarily restricted in its movements, causing water to overflow upstream. The sudden break of the jam may cause floods downstream. Ice may be blocked by the morphology of the watercourse or be frost-welded to the shore. Elements such as bridge pillars, islands, sharp turns, shallow water, a sudden reduction in slope, and the strangling of the watercourse may increase the probability of jam formation.
	Frazil ice jam	Caused by the accumulation of frazil, which limits water flow by adhering beneath layers of ice, on riverbeds, or on bridge pillars, forming what is known as a "hanging dam" or a "frazil jam"
	Debris jam/beaver dam	Created by the accumulation of debris or wood across a watercourse leading to flooding A beaver dam may produce effects similar to those of debris jams.
Rainwater or sewer system backup		The result of an overflow from a pipeline grid in an urban setting that is overloaded with water during strong rainfall or due to mild winter temperatures or spring thawing. Infrastructure flooding may also result from a sewer system backup. Indeed, snowmelt, heavy rainfall, or a jam may cause the water level to rise in the sewer network and cause an overload. Wastewater then rises into buildings through floor drains, taps, toilets, etc. These flood events are not recorded, despite the significant sanitation risk.
Rising water table		Caused by significant water seepage (strong rainfall or snowmelt) or during the flood of a neighbouring body of water. The water table then rises to the ground surface or exceeds its level.
Runoff		Occurs when water cannot or can no longer infiltrate the ground or flows directly into infrastructure without passing through rivers. Its volume can become substantial due to the following factors: - Highly saturated ground - Highly impervious soil - Rapid snowmelt - Heavy rainfall - Sharp basin slope - Sparsely vegetated ground surface If the snow accumulation is above average and the thaw rapid, the risk of strong runoff and subsequent flooding increases (Freshet).
Water regulation structure breakdown		Caused by a water regulation structure malfunction (mechanical breakdown, physical breakdown, bad management or planning, etc.). These structures encompass all constructions used to temporarily or permanently alter water behaviour, such as: - Dams; - Flood protection dams; - Pumping stations; - Check valves for storm and sanitary sewers; - Aboiteaus.

3.1 Hydrometeorological elements

- **Precipitation**
  Whether in liquid or solid form, this is the predominant meteorological variable in the triggering of floods caused by the overflow of a watercourse (Buffin-Bélanger, Maltais, and Gauthier, 2022). Parameters such as quantity, intensity, duration, covered area, and rainfall path determine the runoff that reaches a river, influencing the land's capacity for rain absorption (Environment Canada [EC], 2013). Spring or autumn precipitation, strong storms, and post-tropical storms are all causes of flooding.
- **Evapotranspiration**
  Evapotranspiration also plays a crucial role. The intensity of precipitation and its synchronization or lack thereof with evapotranspiration causes watercourse flow rates to fluctuate (Buffin-Bélanger et al., 2022). The quantity of water that runs off into the region corresponds to the total volume of water obtained through precipitation, from which the quantity of water absorbed by vegetation is subtracted. Low vegetation cover associated with strong precipitation may therefore increase the risk of flooding.
- **Temperature**
  Ice increases the impermeability of soil when it already contains humidity, which reduces its infiltration capacity. Moreover, snow accumulates during the winter then, during snowmelt or thaws, surface water flows rapidly over the frozen ground toward watercourses. The presence of thick ice on rivers also influences floods and ice jams. The climate also determines the impact of winter ice on rivers as well as its thaw (Environment Canada [EC], 2013).

3.2 Watershed disturbances

Watershed disturbances and land use may trigger the acceleration of surface water flow as it modifies the land's infiltration capacity and the way that water flows to its surface. This change in flow velocity can lead to significant consequences to the region's water system, increasing the risk of flooding and erosion (diagnostic report – *Bank Erosion*) (Buffin-Bélanger et al., 2022). The main watershed disturbances likely to trigger floods include the following:

- Topographic changes
- Soil sealing and urbanization (diagnostic report – *Bank Erosion*)
- The destruction of natural environments, such as wetlands and water environments
- The modification of riverbeds and the linearization of watercourses
- The installation of agricultural or roadway drainage ditches

Although these factors are generally constant, the form, surface area, soil type, and topography of the watershed also influence the quantity of water that reaches a river (Environment Canada [EC], 2013). The various geomorphological features, such as the characteristics of rivers from upstream to downstream, are particularly important themselves, as they help determine the type of flood likely to occur along a given stretch of river. They also offer an evaluation of the stability of this section to possible floods and, consequently, its propensity for mobility. In alluvial plains, floods are generally more frequent and more harmful due to the often extensive development and use of this type of environment (Buffin-Bélanger et al., 2022).

3.3 Climate changes

According to the climate change adaptation study "Les défis et perspectives pour la région des Laurentides" (2020) carried out by Ouranos, we should expect modified watercourse flow rates in the region. Flooding in ZGIE North can be summarized in the following points:

- Rise in freeze/thaw episodes leading to increases in average winter flow rates in rivers from 2041 to 2070 (strong consensus)
- Increased winter liquid precipitation due to rising winter temperatures
- Rising temperatures
- Increase in heavy precipitation events (frequency and intensity) that may influence runoff, wastewater overflow, water levels, peak flow rates, etc.
- Recent simulations suggest a reduction in spring floods in the southern Laurentides due to less intense spring flooding. However, runoff floods may be more frequent due to an increase in intense rainfall episodes during the summer and autumn (Ouranos, 2020)

4. Main consequences

Floods can have numerous impacts on the material sphere as well as the environmental, social, and economic spheres. Indeed, they may cause significant damage to dwellings, infrastructure, farmland, and ecosystems. They may also disturb the well-being and health of the population, disrupt essential services, and lead to substantial costs for governments, businesses, and affected citizens. Spring floods generally have a larger impact due to the wider expanse of the flood zones. However, spring or autumn floods have a greater shoreline erosion potential. The following section presents the main consequences of floods in the ZGIE. The consequences vary greatly depending on the magnitude of the flooding; flood preparation and response; the presence and concentration of populations, goods, and infrastructure; and risk mitigation measures.

4.1 Environmental

- Intensification of erosion and soil runoff
- Ground and surface water quality degradation due to the input of contaminants and pollutants (sewer backup)
- Contribution to the natural dynamic regulating numerous ecosystems. Among other things, floods replenish certain wetlands, naturally clean riverbeds, and maintain the wet conditions of shoreline habitats. However, exceptional floods may lead to the destruction of certain habitats due to erosion.
- Pollution caused by the accumulation of debris, garbage, chemicals, agricultural waste, etc.

4.2 Economic

For institutions (governments and municipalities)

- The annual cost of the floods in Québec in 2017 and 2019 represented $360M and $438M, respectively, according to the MSP
- Expenses associated with implementing emergency measures and evacuations
- Building and infrastructure repair expenses
- Likely decrease in tourist attraction due to damaged tourism facilities and difficult access
- Investment in flood prevention and management: dam construction, drainage infrastructure, risk management policy, immunization work, etc.
- Decreased value of affected properties, which impacts the tax pool of municipalities

For flood victims

- Loss of land as well as material damage to buildings, land, and personal property
- Costs of temporary housing, moving, storage, and severance payments when it is impossible to rebuild the residence
- Loss of income due to work absences
- Loss of agricultural production and destruction of harvests on farmland
- Indirect costs of impacts on the physical and mental health of flood victims
- Increased insurance costs for individuals and businesses in at-risk zones
- Decreased value of affected properties
- Interrupted or reduced commercial and industrial activities
- Investment in immunization work

4.3 Social

- Impacts on physical health:
    - Chronic diseases, infectious diseases, injuries, hypothermia, accidents, drowning, death, etc.
    - Asthma and respiratory problems associated with mold and humidity
- Impacts on mental health: stress, anxiety, depression, post-traumatic stress, long-term sense of insecurity, etc.

- Damage to public safety:
    - Disruption of essential and basic services such as potable water, electricity, transportation, and communication systems
    - Increased risk of landslides
    - Disrupted availability and speed of emergency services (ambulance, firefighters, police)
    - Depending on their magnitude, floods may affect the safety of people, homes, and infrastructure

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