PRIORITIZED ISSUES FOR 2024-2034

Poor water quality

ORGANISME
DE BASSIN VERSANT
de la rivière du Nord



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1. Factual description

Surface water

1.1 Watercourse quality monitoring

Physical-chemical monitoring

Data collected within the watercourse quality monitoring program in the Rivière du Nord watershed are available on the *iEau* interactive platform. This program has established various statistics on the concentrations of several contaminants found in watercourses in the zone. In general, stations at the head of the watershed have higher water quality than those at the outflow.

Bacteriological and physical-chemical quality index

The graph below presents the bacteriological and physical-chemical quality index of the five monitoring stations used in the Réseau-Rivières program. A slight reduction in quality has been observed since 2016 in the Rivière du Nord stations. In addition, the results show a minor water quality deterioration from north to south along the Rivière du Nord.

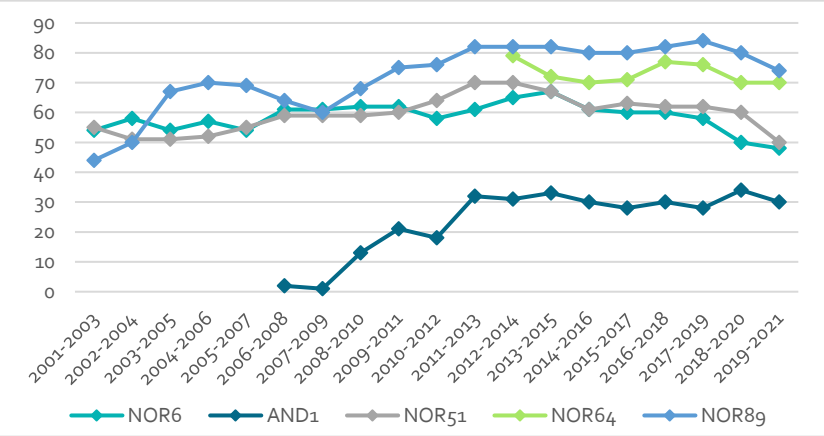


Figure 1. Bacteriological and physical-chemical quality index for 5 stations from 2001 to 2021

Description of water quality index classes (MDDEFP, 2013a) :

Classe A (80-100) : Good quality, generally allowing all uses, including swimming
Classe B (60-79) : Satisfactory quality, generally allowing most uses
Classe C (40-59) : Questionable quality, restricting certain uses
Classe D (20-39) : Poor quality, restricting most uses
Classe E (0-19) : Very poor quality, restricting all uses

Trends

The table below shows the trends from 2007 to 2017 of the various parameters sampled at NOR6, the most downstream station on the Rivière du Nord.

Table 1. NOR6 station trends in concentrations and flow rates according to various water quality parameters

	Fecal coliforms	Total phosphorus	Suspended solids	Total nitrogen	Nitrites-nitrates	Chlorophyl A
NOR6	Increase	Decrease	Increase	Increase	Increase	Decrease

Metals, emerging contaminants, and pesticides monitoring

In 2010, concentrations of metals were sampled six times at NOR6 as part of the Réseau-Rivières program. These data are also available in the Water Atlas (MELCCFP, n.d.-a). Generally, the results are well below chronic aquatic life criteria.

In addition, the emerging contaminants and fish communities monitoring program in the Laurentides was carried out in 2009. Three stations located in the Integrated Water Management Zone (ZGIE) were sampled (upstream and downstream of Saint-Jérôme and downstream of Lachute). The study results enabled certain observations to be made (MELCC, 2018a):

- Concentrations of dissolved metals are slightly higher downstream of greater Saint-Jérôme than upstream. They do not, however, exceed the quality criteria.
- Unicellular algae toxicity was practically absent in the samples.
- PCB levels in fish flesh were like the Québec average and below the criteria for the protection of fish-eating fauna.
- Dioxin, furan, and planar PCB concentrations transformed into toxicity for fish-eating mammals and birds have almost always exceeded the criteria for the protection of fish-eating fauna.
- Polybromodiphenylether (PBDE) and polychloronaphtalene (PCN) levels are higher in the flesh of fish caught downstream of urban zones.
- The biotic integrity index of the fish community is average to good.
- The percentage of deformation, fin erosion, lesions, and tumour anomalies is higher and exceeds the 5% threshold downstream of the Saint-Jérôme urban area.
- The concentrations of other emerging contaminants remain low and have never exceed water quality criteria. However, these concentrations tend to be slightly higher downstream of the urban areas of Saint-Jérôme and Lachute.

As for the use of pesticides and their concentration in watercourses, there is little data specific to the OBV rivière du Nord ZGIE. The MELCC indicates that 24 of 38 municipalities in the ZGIE regulate the use of pesticides (MELCC, 2020b).

A study on water quality in the Rivière St. Pierre, a tributary to the Rouge River (Saint-André), shows that of the 58 pesticides analyzed in Ruisseau Foucault, located in a predominantly agricultural area, nine were detected. Nevertheless, none of the concentrations measured exceeded the quality criteria for the protection of aquatic life and contamination prevention (Crago and Dubé, 2010).

Other analyses on pesticides were conducted in the watershed of the Rouge River (Saint-André) as part of the Réseau-Rivières program in 2012 (Giroux, 2015). Over 20 pesticides were detected in the watershed, and 38% of the watershed is farmed with corn and soybeans. Two herbicides (Atrazine and Bentazone) and an insecticide (Clothianidin) were detected in all samples between June and August 2012 (N=11). The quality criteria for the protection of aquatic life was exceeded for the Clothianidin insecticide in 70% of samples.

Eastern Canada Diatom Index (IDEC)

The index ranges from 0 to 100: the higher the value, the higher the biological integrity level and water quality. Table 3 shows the IDEC classification results for some of the Réseau-Rivières stations in the ZGIE. It measures the « ecological distance » separating a polluted environment from a reference environment— this distance being a semi-quantitative measurement of the pollution or deterioration level. Knowledge of the reference environment also allows restoration goals to be set and the efficacy of restoration programs to be measured.

Table 2. Eastern Canada Diatom Index (IDEC) classification results for certain sample stations in the ZGIE

Station	Watercourse	Year	IDEC value (0–100)	IDEC class	Sub-index	Biological integrity	Trophic condition
NOR89	Rivière du Nord	2002	51	B	Neutral	Precarious condition	Oligo-mesotrophic
NOR89	Rivière du Nord	2002	10	D	Neutral	Very poor condition	Eutrophic
NOR89	Rivière du Nord	2003	24	C	Neutral	Poor condition	Meso-eutrophic
NOR89	Rivière du Nord	2019	28	C	Neutral	Poor condition	Meso-eutrophic
NOR64	Rivière du Nord	2019	66	B	Alkaline	Precarious condition	Mesotrophic
NOR51	Rivière du Nord	2002	20	D	Neutral	Very poor condition	Eutrophic
NOR51	Rivière du Nord	2002	3	D	Neutral	Very poor condition	Eutrophic
NOR51	Rivière du Nord	2003	15	D	Neutral	Very poor condition	Eutrophic
NOR51	Rivière du Nord	2003	13	D	Neutral	Very poor condition	Eutrophic
NA	Ruisseau Strong	2012	30	C	Alkaline	Poor condition	Meso-eutrophic
NOR6	Rivière du Nord	2002	4	D	Neutral	Very poor condition	Eutrophic
NOR6	Rivière du Nord	2002	0	D	Neutral	Very poor condition	Eutrophic
NOR6	Rivière du Nord	2003	2	D	Neutral	Very poor condition	Eutrophic
NOR6	Rivière du Nord	2003	0	D	Neutral	Very poor condition	Eutrophic
NOR6	Rivière du Nord	2019	0	D	Neutral	Very poor condition	Eutrophic
NA	Rivière Rouge tributary (Saint-André)	2013	14	D	Alkaline	Very poor condition	Eutrophic
NA	Rivière Rouge tributary (Saint-André)	2013	14	D	Alkaline	Very poor condition	Eutrophic
NA	Rivière Rouge tributary (Saint-André)	2013	12	D	Alkaline	Very poor condition	Eutrophic
NA	Rivière Rouge tributary (Saint-André)	2013	29	C	Alkaline	Poor condition	Meso-eutrophic
AND1	Rivière Rouge (Saint-André)	2012	6	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2013	10	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2014	13	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2015	8	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2016	5	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2017	15	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2018	10	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2019	11	D	Alkaline	Very poor condition	Eutrophic
AND1	Rivière Rouge (Saint-André)	2020	13	D	Alkaline	Very poor condition	Eutrophic
NA	Rivière Rouge (Saint-André)	2019	0	D	Neutral	Very poor condition	Eutrophic

IDEC classification

Neutral sub-index

Class A (71-100):
Very good oligotrophic condition

Class B (46-70):
Good oligo-mesotrophic condition

Class C (21-45):
Poor meso-eutrophic condition

Class D (0-20):
Very poor eutrophic condition

Alkaline sub-index

Class A (71-100):
Very good oligotrophic condition

Class B (46-70):
Good oligo-mesotrophic condition

Class C (26-45):
Poor meso-eutrophic

Macroinvertebrates

In 2016, OBV rivière du Nord carried out a project on the biotic integrity of the Rivière du Nord, as evaluated based on benthic macroinvertebrates (Abrinord, 2016). Three indices were evaluated: the Hilsenhoff index (FBI) and an index of the percentage of organisms intolerant to pollution (% intolerant), which are indicators of pollution tolerance, as well as the Shannon index (H'), which is an index of species diversity and distribution in the sample. In total, 11 sampling stations allowed seven watercourses in the ZGIE to be documented (Table 4).

The VAS15 station on Ruisseau des Vases has the best results for all three indices, making it a model station. The DON9 station on the Doncaster River presents the second-best results. These sites therefore present the greatest biotic integrity. Conversely, the GRA1 (Grand Ruisseau) and OUE9 (Rivière de l'Ouest) stations are the most degraded, with the lowest Hilsenhoff indices and average FBI. However, the Rivière du Nord watershed has an average biotic integrity characterized as good.

Table 3. Rivière du Nord biotic integrity results

Station	Watercourse	Municipality	IQBP 2010-2015[1]	FBI[2]		% intolerant[3]	H'[3]	Observed integrity
VAS15	Ruisseau des Vases	Brownsburg-Chatham	ND	3.55	Excellent	23,48	3.60	Model
MUL8	Rivière aux Mulets	Sainte-Adèle	ND	4.29	Good	3,08	2.23	Intermediate
DON9	Rivière Doncaster	Sainte-Marguerite-du-Lac-Masson	85	4.01	Very good	15,32	3.37	Model
DON27	Rivière Doncaster	Sainte-Lucie	ND	4.32	Good	7,67	2.98	Intermediate
SIM8	Rivière à Simon	Morin-Heights	85	4.92	Good	7,65	2.20	Intermediate
SIM1	Rivière à Simon	Saint-Sauveur	85	4.26	Good	12,59	3.25	Intermediate
OUE9	Rivière de l'Ouest	Brownsburg-Chatham	ND	5.15	Average	5.99	2.22	Degraded
NOR121	Rivière du Nord	Sainte-Agathe-des-Monts	90	4.64	Good	3,95	2.60	Intermediate
NOR66	Rivière du Nord	Saint-Jérôme	71	4.44	Good	9,05	3.06	Intermediate
NOR6	Rivière du Nord	Saint-André-d'Argenteuil	76	4.65	Good	0,94	2.85	Degraded
GRA1	Grand Ruisseau	Piedmont	82	5.15	Average	13,58	2.62	Degraded

[1] IQBP : Three parameters (fecal coliforms, total phosphorus, and SS). Water quality data from 2016 were evaluated to help determine the expected integrity of the stations. [2] Hilsenhoff index: a lower result is desirable. [3] Shannon and % of intolerant organisms indices: a higher result is desirable.

Analysis of chloride concentrations related to the spreading of winter de-icers

The study carried out within the Écoroutes hivernales project conducted in Val-Morin, Val-David, and Sainte-Lucie-des-Laurentides suggests the influence of human activities on wetland and aquatic environment water quality. The specific conductivity measurements of 377.91 µS/cm and 432.60 µS/cm in Ruisseau Lachapelle far exceed the scale of natural values (10 µS/cm to 40 µS/cm). Furthermore, chloride concentrations exceed the reference threshold for natural concentrations (10 mg/L) by an average of 8.6 times. These high values are explained by the fact that Ruisseau Lachapelle drains a part of the region crossed by Highway 15 and Route 117, where large quantities of de-icing salt are spread each year (Abrinord, 2023).

The study also showed a significant influx of chloride salts through one tributary of Lac Ménard located in Sainte-Lucie-des-Laurentides. Chloride concentrations are indeed far above 10 mg/L, and specific conductivity measurements indicate a small influx of dissolved salts with an average of 69.95 µS/cm (Abrinord, 2023). This major contamination originates from the Sainte-Lucie-des-Laurentides used snow disposal site and road salt warehouse, while the chloride concentration is 28 to 56 times larger than the natural value. While these concentrations are elevated in a small intermittent watercourse, it is pertinent to note that they exceed all protection criteria for chronic exposure every time (Abrinord, 2023).

1.2 Lake quality monitoring

Volunteer Lake-Monitoring Program (VLMP): Lake conditions

In the ZGIE (3,354 lakes), 146 lakes were monitored by the Volunteer Lake-Monitoring Program (VLMP) for at least one year between 2004 and 2019 (MELCC, 2020a).

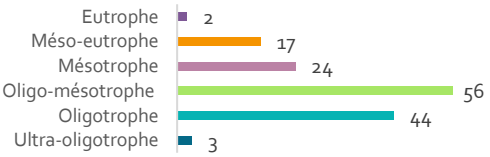


Figure 2. Condition of 146 lakes monitored by VLMP

Beyond these annual follow-ups, vulnerability to nutrients and the level of attainment of allowable phosphorus inputs for the lakes of the four Regional County Municipalities (RCMs) in the Laurentides were evaluated. To leave the trophic condition of a lake undisturbed, the phosphorus concentration must not exceed 1.5 times the natural concentration of the lake. This natural concentration corresponds to the input calculated according to a scenario where the land occupation is natural (forest or wetlands) throughout the watershed. This study revealed that 18 lakes larger than 0.25 km² in the Rivière du Nord watershed exceeded quality criteria. Among the lakes that are less vulnerable to nutrient inputs, 22 lakes receive phosphorus inputs at the acceptable limit (Blais and Bazoge, 2005).

Cyanobacteria

In total, 46 lakes in the ZGIE experienced cyanobacteria episodes at least once between 2004 and 2017 (MELCC, 2018b). VLMP results show that phosphorus concentrations in lakes are related to cyanobacteria. In fact, some of the lakes with the most problematic phosphorus concentrations had one or more cyanobacteria proliferation episodes over the past seven years. For example, the Caron, Colette, Crooks, Johanne, Saint-François, and à la Truite lakes are among the most problematic in terms of phosphorus levels (MELCCFP, n.d.-b).

Groundwater

The groundwater knowledge projects carried out in the Laurentides and Les Moulins RCMs and completed in 2022 allowed the groundwater in ZGIE North to be characterized. A geochemical data analysis showed a Ca-HCO_3 water composition – hard water – in 75% (275) of the sampled wells. This aspect is associated with low mineral content water from recently infiltrated precipitation and is encountered in free groundwater conditions in 82% of cases (227 wells). Recharge water from groundwater zones infiltrates and flows to capture zones influencing the geochemistry of these aquifers.

Some samples show chloride enrichment that may have unnatural origins, and the absence of bromide in water samples shows an anthropogenic influence in their origin.

In conclusion, the isotopic compositional similarity of precipitation and groundwater indicates a recent recharge, as geological formations have not resulted in significant isotopic modification. Impoverished isotopic composition is observed in precipitation from south to north, which is also reflected in the isotopic composition of groundwater.

Potability standards

The bacteriological contamination of wells is often caused by local conditions. The condition and maintenance of wells as well as the presence of point or non-point contaminations nearby are common causes. According to the *Regulation respecting the quality of drinking water (Q-2, r.40)*, water is considered potable only if it contains no fecal bacteria (*E. coli* or *enterococcus*). According to these standards, 19 wells (20% of the wells studied in the ZGIE) have at least one drinking water standard exceedance.

Furthermore, if water contains more than 10 coliforms in total and/or more than 200 atypical bacteria, it is considered non-compliant. Nine wells in fractured rock aquifers and six wells in granular aquifers were deemed non-compliant in the ZGIE.

The majority of potability standard exceedances and non-compliances were observed in surface wells in free groundwater. These are more vulnerable to surrounding contamination sources and hydrological variation in the spring and autumn.

As for fluoride, of the 96 wells analyzed in the ZGIE, only one was found to exceed standards. It is located in a fractured rock aquifer in Saint-Colomban. For pesticides, pendimethalin was detected in one well and dinotefuran in two wells. However, no potability standard exceedances were observed.

For pharmaceutical products, acetaminophen was detected in 12 private wells and carbamazepine in two private wells and municipal wells. Traces of acetaminophen were also found on the regional scale in residential wells. Traces of ciprofloxacin were also seen in municipal wells. Pharmaceutical products can come from various sources, but the most probable seem to be diffuse residential and municipal wastewater leaks (Gagné et al., 2022).

In general, contaminant exceedances are related to local conditions (leach fields, poor well conditions, connections with surface water, etc.) rather than a regional well issue.

2. Hypothesis of its presence

Ground and surface water

2.1 Agricultural sector

The agricultural zone in the ZGIE spans nearly 470 km² — approximately 20% of the region. Differences in climate and soil type between the north and south explain the varied quantity and diversity of agricultural businesses. In the ZGIE, the soil is more suited to fodder crops and livestock production (Auger et al., 2014).

Table 4. Agricultural area by Regional County Municipality (RCM) in the Integrated Water Management Zone (ZGIE)

Regional County Municipality (RCM)	Agricultural area in the ZGIE (km²)	Agricultural %
Deux-Montagnes	9.42	100.00
Mirabel (Ville)	159.48	91.36
Argenteuil	283.36	38.87
Rivière-du-Nord	16.16	6.49

The Rivière du Nord watershed has a total of 174.2 km² of farmland. The sub-watershed with the largest farmed area belongs to the Rouge River (Saint-André) with a total of 90.31 km². Second is the Rivière de l'Ouest sub-watershed with 18.91 km², followed by the Sainte-Marie sub-watershed with 13.35 km² (Financière agricole du Québec [FADQ], 2022). From 2008-2009, 63 agricultural businesses in the Rivière du Nord watershed reported having carried out phytosanitary interventions, for a total of 41.16 km² (Quesnel, 2010).

In 2004 in the Laurentides, it is estimated that pesticides were applied on nearly 45% of agricultural land (BPR Inc., 2005). At the same time, it is also estimated that around 40% of agricultural businesses in the Laurentides/Laval/Montréal region were considered to be in the process of integrated pest management, meaning that they were monitoring, adjusting their sprayer at least once per year, and keeping a register of phytosanitary interventions (BPR Inc., 2005). These percentages on device adjustments and integrated pest management may nevertheless be underestimated in relation to what really happened in the field (Goyette and MAPAQ, 2012).

Table 5. Use of pesticides by agricultural producers with an environmental farm plan in the Rivière du Nord watershed area from 2008-2009 (Quesnel, 2010)

Practices	Area with phytosanitary interventions	Herbicide-free cultivation	Pesticides applied throughout	Pesticides applied in bands	Reduced-dose herbicide applications	Mechanical weeding
Number of producers in declared area	63	20	50	3	9	17
Declared area (km²)	41.16	6.15	34.70	1.51	6.04	7.27

2.2 Climate change

The climate change expected in the Laurentides region will likely result in an increase in the frequency and intensity of extreme meteorological phenomena, such as heavy precipitation events and periods of drought (Ouranos, 2020). The intensification and multiplication of precipitation events may translate into an aggravation of existing problems attributable to surface runoff and an increase in wastewater overflow. More intense rains and floods may increase shoreline, riverbed, and bank erosion, creating a remobilization of pollutants and metals confined in sediments (MELCC, 2020c).

Periods of drought can also accentuate problems related to erosion by increasing problems related to wind erosion. Indeed, the multiplication and intensification of meteorological phenomena such as droughts, heatwaves, intense rain, violent winds, and drastic temperature swings (freeze-thaw) have an impact on soils and make them more vulnerable to erosion. More severe dry spells and low flow periods may also translate into a weaker dilution of contaminants from urban and industrial waste, causing metal and pollutant concentrations to increase in the vicinity. On the other hand, the slowed current linked to low flow periods may promote the sedimentation of suspended particles at the bottom of watercourses (MELCC, 2020c).

The impacts of climate change may also be felt throughout the water cycle in the entire zone under study. Regional trends for the Laurentides show an increase in annual temperature averages (Ouranos, 2020). This increase can cause an intensification of evaporation and reduce the availability of recharge water (Gagné et al., 2022). These changes may lead to a reduction in available groundwater, deteriorate the water quality of rivers, and modify aquatic ecosystems in the region (Gagné et al., 2022). Increased air temperatures also raise water temperatures, which promotes processes such as leaching, solubilization, or complexing, which may lead to an increase in dissolved substances in water, including certain metals. The extent to which climate change affects parameters such as dissolved organic carbon and pH remains uncertain, but it may modulate the toxicity of metals, which is heavily influenced by such factors (MELCC, 2020c).

Lastly, climate change may cause a worsening of problems related to water salinization. In fact, given that contaminant concentrations (e.g., chloride salts) are correlated with watercourse levels and flow rates, a reduction in these would likely result from an increase in surface water salinity. Furthermore, higher winter temperatures could entail a higher number of thaws. When accompanied by precipitation, these events are likely to require the spreading of de-icers on roads (Communauté métropolitaine de Québec [CMQ] and Ouranos, 2019).

Surface water

Waterfowl—especially ducks—are very present during migratory seasons in the southern part of the Laurentides, particularly close to the Ottawa River. Some bird species are highly dependent on aquatic environments, particularly swimming birds, divers, and waders, which spend part of their life around water to eat or reproduce. In addition, white-tailed deer congregate in the winter in what are known as white-tailed deer ravages. This significant presence of animals and their excrement may constitute a significant influx of contaminants, such as fecal coliforms, nitrate, and phosphorus.

Groundwater

2.3 DRASTIC vulnerability index

The DRASTIC vulnerability index allows the mapping of groundwater vulnerability to a surface-level contaminant circulating vertically towards the aquifer. Nearly 83% of ZGIE North is a water table (unconfined). The ZGIE territory dominated by till and rock outcropping areas therefore has a higher DRASTIC index. In ZGIE North, 74% of the area has an average DRASTIC index and 4% has a high DRASTIC index (Gagné et al., 2022). Groundwater is potentially vulnerable to contamination from the surface.

The density of human risk (DHR), representing risks for groundwater associated with human activity, was also calculated for ZGIE North. DHR is calculated by totalling the risks of each human activity per km^2. 19% of the region has a high DHR, meaning that there are many activities with a potentially high impact on groundwater.

Finally, the combination of 74% coverage with an average DRASTIC index and 19% coverage with a high DHR constitutes a significant risk for the deterioration of groundwater quality.

3. General location

Area of the Rivière du Nord watershed : 2,222.70 km² (96.6% of the ZGIE)

- In the St. Lawrence Lowlands, located at the southern end of the watershed, soils are much more prone to erosion and sediment transportation.
- The average building density is between 25-50 buildings per km².
- Population densities by municipality are higher for Saint-Jérôme, Prévost, and Saint-Sauveur (between 200 and 800 inhabitants per km²).
- The reported farmed area in 2022 was 179.82 km². More than half of this farmland is occupied by wide-spaced crops (corn, soybeans). The agricultural zones are mainly in the southern ZGIE, in the Lowlands.
- The watershed soil sealing rate varies between 7.6 and 8.6% and is concentrated in urban areas.
- Individual septic installations are found in the territory of all municipalities in the watershed.
- There are 21 municipal wastewater treatment facilities and 129 overflow structures.
- The area is home to several industries, including mining, forestry, two pulp and paper mills, and an engineered landfill site.
- Over 150 contaminated sites are reported, and 43 sites were not completely rehabilitated in 2023, a third of which are located in Saint-Jérôme (MELCCFP, 2023).
- There are over 450 human-made dams (mainly recreational water retention structures).

3.1 Surface water

Physical-chemical monitoring

For the three parameters monitored by the OBV rivière du Nord sampling program, an upstream-downstream increase is seen in both averages and percentages of quality criteria exceedance. IQBP results further highlight this water quality deterioration. The NOR89 sampling station reports satisfactory water quality, while the NOR6 station has questionable water quality. During the monitoring period, a general improvement in water quality was observed at the NOR89 station. Water quality at the NOR64, NOR51, and NOR6 stations degraded since the beginning of their monitoring. Total nitrogen and nitrite-nitrate concentrations and load trends at the NOR6 station are on the rise. Several stations have total fecal coliform and/or phosphorus averages exceeding quality criteria. NOR16 is the only station with above-average quality criteria for the three monitored parameters.

Metals, emerging contaminants, and pesticides monitoring

Concentrations of dioxins, furans, and planar PCB transformed into toxicity for fish-eating mammals and birds nearly always exceed the criteria for the protection of fish-eating fauna.

Emerging contaminant concentrations tend to be slightly higher downstream of the Saint-Jérôme and Lachute urban zones.

Eastern Canada Diatom Index (IDEC)

In 2019, this index showed a precarious condition for the NOR64 station and a poor condition for the NOR89 station. The biological integrity of the NOR6 station is in very poor condition.

Macroinvertebrates

The biotic integrity index evaluated based on benthic macroinvertebrates in 2016 showed an intermediate integrity for the NOR121 and NOR66 stations, but a degraded integrity for the NOR6 station.

Lake condition

In 2020, two eutrophic lakes, 17 meso-eutrophic lakes, 24 meso-trophic lakes, 56 oligo-mesotrophic lakes, 44 oligotrophic lakes, and three ultra-oligotrophic lakes were surveyed. Of the lakes located in the direct flow of the Rivière du Nord, five are oligotrophic, while Lake Raymond, a widening of the river, is mesotrophic. There seems to be a concentration of lakes in advanced trophic condition in Sainte-Anne-des-Lacs, but this may be associated with the wider monitoring done in this municipality.

Cyanobacteria

46 different lakes were affected by cyanobacteria at least once between 2004 and 2017.

3.2 Groundwater

Potability standards

In the ZGIE, 19 wells have at least one potability standard exceedance for bacteriological parameters. One single well exceeded drinking water quality standards for the fluorine parameter. Pendimethalin and dinotefuran pesticides were detected in one and two wells, respectively. As for pharmaceutical products, acetaminophen was detected in 12 wells and carbamazepine in two.

DRASTIC vulnerability index

Nearly 70% of the watershed area has an average DRASTIC index and 4% has a high DRASTIC index. DRASTIC indices are higher in the periphery of the Rivière du Nord and some major tributaries.

4. Cause of the issue

4.1 Physical

Erosion, runoff, and leaching

Erosion, runoff, and leaching transport sediments and their contaminants to watercourses.

Flooding

Flood water can transport chemicals, debris, and pollutants present on the surface. Floods can provoke sewer and wastewater overflows.

Geology

The presence of metals in the region is largely the result of parent rock weathering and soil erosion (MELCC, 2020c).

Geochemistry of aquifers

Water that has stayed in the aquifer for longer since recharging may be more mineralized (Gagné et al., 2022). Highly advanced groundwater is found in the Canadian Shield. Certain regulated pollutants are therefore said to be natural because they originate from rock, such as barium, fluorine, magnesium, and uranium.

Forest fires

Soot and ash can contaminate ground and surface water.

4.2 Biological

Wildlife excrement

Particularly during migration periods, congregating wildlife such as aquatic birds and white-tailed deer may increase micro-organism contamination risks due to the increased presence of animal excrement.

4.3 Agricultural

Cultivated area

Soils with very fine clay granulometry are more prone to compaction and absorb runoff water very slowly. When lacking vegetation, these soils are very vulnerable to wind and water erosion. Wide-spaced crops, representing nearly half of ZGIE farmland, are generally considered more susceptible to erosion, since row width and bare surface are much greater (FADQ, 2022).

Storage and use of pesticides and fertilizers

Spread or stored pesticides and fertilizers may be leached during strong rainfall and run off into watercourses or infiltrate groundwater recharge zones. Without an environmental farm plan, agricultural businesses often use more products than necessary, increasing concentrations of nutrients which are unabsorbed by vegetation and readily leached.

Agricultural waste

Wash water and wastewater may contain pollutants that are not processed by wastewater treatment facilities or even discharged directly into the environment. The 2023 Portrait agroenvironnemental des fermes du Québec indicates that dairy water from 55% of dairy animal units was discharged untreated into the Laurentides region (BPR Inc., 2005). In addition, the presence of animals outdoors causes soil to be trampled and animal waste to be washed away during rainfall.

4.4 Municipal

Urbanization

Urbanization creates impervious surfaces, which are a major cause of water contaminant input. Additionally, population growth can lead to the saturation of wastewater treatment facilities and thereby increase overflow events. It can also lead to the reduction of green spaces and the infiltration of water and erosion.

Road network

Several contaminants (hydrocarbons, oils, de-icing salts, abrasives, etc.) may run off into the road network and be found in ground and/or surface water. The density of paved roads is also associated with the presence of several metals in watercourses (extractable copper, nickel, lead, and zinc). For example, 46% of lead emissions can be linked to road network density (MELCC, 2020c).

Individual septic facilities

In the late 2000s, surveys carried out in the Laurentides RCM showed that 10% of inspected septic facilities were a direct source of environmental contamination and nearly 40% were indirectly contaminated (MAMROT, 2011). Independent septic facilities that are outdated or emptied at the wrong frequency may be point or non-point sources of bacteriological and physical-chemical contamination of ground and surface water.

Municipal wastewater treatment and overflow facilities

Discharged wastewater as well as treated water contain high concentrations of contaminants. The Saint-Jérôme wastewater treatment plant is estimated to have discharged 281.5 tons of ammonia and 9.8 tons of phosphorus into the water in 2021. In addition, overflow facilities discharge untreated water directly into watercourses.

4.5 Industrial

Engineered landfill leachate

Toxicity issues are sometimes observed at the Lachute wastewater treatment facility due to water originating from a landfill site (Comité de vigilance, 2020a). Indeed, pretreated water discharges from the landfill site are reported to have exceeded ammonia nitrogen, chemical oxygen demand (COD), and Suspended Solids (SS) criteria on several occasions.

Pulp and paper mill waste

Pulp and paper mills are characterized by large volumes of waste (Gouvernement du Québec, 2012). Their wastewater can contain high loads of organic matter, SS, and fatty and resin acids. Petroleum hydrocarbons, metals and salts, phenolic compounds, and nutrients (nitrogen and phosphorus) can also be detected in smaller quantities. When mills use recycled fibres, traces of Polychlorinated biphenyls (PCBs) can also be observed. When chloride is used to bleach pulp, absorbable organic halides (AOX) and organochlorine compounds, such as dioxins and chlorinated furans (D and Fc), can subsist in trace forms (Gouvernement du Québec, 2012). It should be noted that the Saint-Jérôme facility uses a chlorinated pulp bleaching product and the Lachute facility recycles over 1,000 tons of paper and cardboard per month, which forces them to take special measures for PCBs, AOX, D, and Fc.

Forestry industry

Forestry studies show that sedimentation in watercourses close to logging trails is largely attributable to the construction and use of trails and shoreline disturbances caused by machinery (RNC, 2010). Research has shown that water table levels, watercourse flow dynamics and rates, water quality, erosion, and sedimentation represent the most significant changes to occur after harvesting. However, in Quebec, the *Regulation respecting sustainable forest management* requires that a 20-

metre-wide forest buffer be maintained along the edge of open peatlands with pools, marshes, riparian shrub swamps, lakes, and permanent watercourses during timber harvesting. Research has demonstrated the effectiveness of this measure in protecting water quality. (Plamondon, 1982).

Mining industry

In the Laurentides, the mining industry focuses on industrial minerals (graphite and silica) and construction materials (architectural stone, sand, and gravel) (MRNF, 2006). Quarried soils and mining waste are significant sources of sediment and pollutant input in water if mismanaged by the mining operator. Wastewater generated during crushing or screening may also reach surface water, but it must comply with the standards set out in the *Regulation respecting sand pits and quarries* (RLRQ. c. Q-2, r. 7.1).

Contaminated sites

Soils are the receiving environments most affected by the contamination of these sites. The displacement of soils and leaching are therefore potential sources of water contamination.

Other industrial waste

A total of eight institutions in the ZGIE discharge contaminants into the air and/or water (ECCC, 2021). In 2021,

- General Cable Co. in Saint-Jérôme discharged 4 kg of copper (and its compounds) into the air and water;
- Covia Canada Ltd. in Mirabel (Saint-Canut) discharged 0.11 kg of lead (and its compounds) into the water; and
- Waste Management of Canada Corporation discharged 54 kg of ammonia and 1.2 kg of zinc into the water.

4.6 Recreation and tourism

Resorts

The majority of vacation homes are located on the shores of bodies of water. On the shores of some lakes, there are many impervious surfaces (roofs, asphalt), sanitary installations located near bodies of water, etc. Many buildings predate the introduction of by-laws concerning shorelines and septic systems. As a result, many buildings do not comply with these standards but have acquired rights.

Watercraft

Motorized watercraft may have physical, chemical, and biological impacts on aquatic environments. In addition to shoreline erosion that can be caused by excessive speeds, repeated passages, and travel in shallow or narrow areas, motorized watercraft may be considered a source of toxic discharges into the water.

Land activities

From spring to autumn, All-Terrain Vehicle (ATV) traffic can damage watercourse beds and wetlands and promote the erosion of nearby soil. In the winter, soil degradation is limited by ice and snow cover. Snowmobiles on frozen lakes can emit pollutants such as polycyclic aromatic hydrocarbons, volatile organic compounds, and metals that remain on the snow until the spring thaw and then end up in the water. Repeated pedestrian traffic on poorly maintained trails can also cause significant erosion that, when located near a body of water, can lead to sediment input. Foot traffic may also compact soil, making it impervious and creating more runoff.

Ski and tubing hills

The artificial snow used on ski hills is three times denser than natural snow and consequently releases three times the volume of water compared to natural snow (Demers, 2006). With steep slopes and little vegetation, ski runs have a higher risk of runoff and erosion.

Golf courses

Golf courses generally use significant quantities of pesticides (herbicides, fungicides, and insecticides). In addition, fertilizers (phosphorus, nitrogen, and potassium) and products such as growth regulators and soil sterilants are sometimes used. A 2008 survey carried out in eight of the 25 golf clubs in the ZGIE showed that each of them was in direct contact with the water system.

4.7 Other

Water impoundments

Although the exact number is unknown, many lakes in the area have been artificially created by human-made dams, which can influence their condition and trophic evolution. These lakes are generally small and shallow, making them more vulnerable to high nutrient concentrations (Bazoge et al., 2005).

Land use

Many land uses may be a source of contamination from point or non-point discharges.

Shoreline development

A riparian buffer composed of a narrow border of herbaceous plants is less efficient in fulfilling ecological functions. Its size and composition are often insufficient to retain the soil particles and nutrients transported by runoff (MELCC, 2020c). In addition, the presence of underground drains and ditches that concentrate water flow before reaching the watercourse limits the performance of riparian buffers as sedimentation or filtration zones.

5. Main consequences

5.1 Environmental

- Toxicity: at certain concentrations, various contaminants can be toxic for fish and other aquatic organisms.

Nutrients (phosphorus/phosphates and nitrates)

- Proliferation of aquatic vegetation (plants and algae) and cyanobacteria
- Proliferation of invasive alien plants to the detriment of indigenous species
- Accelerated eutrophication
- Reduced dissolved oxygen quantity in water
- Reduced water transparency linked to a stronger presence of suspended microscopic algae and cyanobacteria
- Toxicity of nitrates, particularly in more sensitive stages of development, such as embryos or larvae. May also be converted into nitrites, which are even more toxic than nitrates

Suspended solids (SS)

- Reduced transparency (increased turbidity and water colouration)
- Water warming (rising temperatures related to solar energy absorption by SS)
- Fish gill and skin irritation: may eventually lead to asphyxiation
- Sedimentation (silting, sanding, or infilling in bodies of water)
- Accelerated eutrophication and proliferation of aquatic plants due to the formation of muddy beds
- Nutrient and contaminant inputs transported by sediments

Chloride salts

(ionic combination of chloride anions with cations, such as sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}) ions)

- Amplification of lake stratification through water salinization
- Reduction of dissolved oxygen and even anoxia at the bottom of the lake
  → Release of phosphorus

Microbial contamination (fecal coliforms/fecal matter and associated micro-organisms)

- Imbalance of microbial community composition

- Risk to animal health: the presence of fecal coliforms suggests a risk of the simultaneous presence of other pathogens of fecal origin, such as bacteria, viruses, or parasites, which may be harmful to health.
- Increased biochemical oxygen demand/reduced availability of oxygen due to the increase of aerobic microbial colonies

5.2 Economic

- Loss of revenue related to the restriction of recreation and tourism (e.g., closed beaches and fishing areas)
- Loss of shoreline property values
- Increased cost of drinking water treatment
- Reduced or halted production in certain industries

5.3 Social

- Risks for human and animal health
- Water supply risks
- Risk of contaminated agricultural products
- Restriction of uses (recreation) due to direct or indirect contact with compromised water
- Loss of enjoyment due to the restriction of water activities
- Negative perception of the body of water

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