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GESPE'GEWA'GI
INSTITUTE OF NATURAL UNDERSTANDING

Cumulative Effects of Industrial Legacy in Inner Mawipoqtapei

Report prepared for the communities of Ugpi'ganjig, Listuguj and Oinpegitjoig

by the Gespe'gewa'gi Institute of Natural Understanding

Website: www.ginu.co

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Executive summary

This "Cumulative Effects of Industrial Legacy" report, prepared by the Gespe'gewa'gi Institute of Natural Understanding (GINU) for the Mi'gmaw communities of Ugpi'ganjig, Listuguj and Oinpegitjoig, is a comprehensive review of the cumulative impacts of industrial legacy within Mawipoqtapei. The report braids both Indigenous and Western Knowledge systems—particularly Mi'gmaw Knowledge—to examine the historical and ongoing impacts of industrial activities on the region's ecosystems, human health, and Mi'gmaw cultural heritage. The report specifically addresses the proposed Pozzolan mine project in Dalhousie, highlighting environmental risks that considers the region's unique history of industrial pollution and its consequences, including high rates of cancer in local communities. The report emphasizes the importance of Indigenous rights, consultation, and the need for decision-making that respects the carrying capacity of the environment and the health and well-being of the region's residents.

Environmental Impacts

1. **What are the potential environmental impacts of the proposed pozzolan mine in Dalhousie?**

   The proposed pozzolan mine raises several environmental concerns, particularly given the Bay of Chaleur's existing environmental challenges:

   - Increased Acidic Runoff: Mining operations can expose sulphide minerals, leading to acid mine drainage. This acidic runoff could pollute waterways, harming aquatic life.
   - Erosion and Sedimentation: Mining can increase erosion, leading to higher sediment loads in water bodies. This can smother habitats, particularly those crucial for fish spawning, and reduce water clarity.
   - Heavy Metal Contamination: Disturbance of the soil and bedrock could release heavy metals, contaminating the water and sediments. This could further pollute the Bay of Chaleur and potentially introduce toxic substances into the food chain.
   - Habitat Destruction: The construction and operation of the mine will inevitably destroy habitats, including wetlands and riparian zones, crucial for filtering pollutants and supporting biodiversity.
   - Dredging Contaminated Sediment: Exporting pozzolan by ship would require dredging Dalhousie Harbour. This process could resuspend contaminated sediment, spreading it throughout the bay and negatively impacting aquatic ecosystems.
   - Air and Noise Pollution: Mining operations will generate dust, emissions, and noise pollution that could impact air quality, human health, and local wildlife.

2. **How will the proposed mine impact the existing legacy of industrial pollution in the Bay of Chaleur?**

   The Bay of Chaleur has a history of industrial pollution, with contaminants like heavy metals and chemicals persisting in the sediment and potentially impacting marine life. The new mine could exacerbate these issues by:

   - Releasing additional pollutants into the environment.
   - Redistributing existing contaminants through dredging and other activities.
   - Adding further stress to already compromised ecosystems, reducing their resilience.

Indigenous Perspectives and Rights

3. **How does the proposed mine relate to the concept of *M'sit No'gmaq* (All Our Relations)?**

   M'sit No'gmaq, a core principle in Mi'gmaw worldview, emphasises the interconnectedness of all beings and the responsibility to maintain harmony within the ecosystem. The proposed mine challenges this principle by:

   - Prioritising economic gains over the well-being of the environment and the species that rely on it.
   - Disrupting the delicate balance of the ecosystem and potentially causing harm to various species, including those culturally significant to the Mi'gmaw people, like salmon.
   - Failing to consider the long-term consequences of mining activities on the interconnected web of life.

4. **What is the significance of Dalhousie Mountain and the surrounding area in Mi'gmaw oral tradition and culture?**

   Dalhousie Mountain and the surrounding area hold deep cultural and spiritual significance for the Mi'gmaw People. They are:

   - Central to many oral traditions and stories that convey knowledge about relationships between species and the importance of ecological balance.
   - Home to important landmarks, including Sugarloaf Mountain, a site connected to salmon migration and spawning, and Heron Island, a traditional burial ground.
   - Considered animate beings deserving of respect and protection within the Mi'gmaw legal consciousness.
   - The proposed mine threatens these culturally significant sites and the traditional knowledge systems they represent.

5. **What are the cumulative effects of past and present industrial activities on the communities of Ugpi'ganjig, Listuguj, and Oinpegitjoig?**

   These communities have experienced a disproportionate burden of industrial impacts, including:

   - Environmental contamination: Leading to concerns about the safety of local food and water sources.
   - Health disparities: Higher rates of cancer and other health issues have been linked to industrial pollution.
   - Economic challenges: Dependence on resource extraction industries has led to boom-and-bust cycles and limited economic diversification.
   - Erosion of traditional ways of life: Pollution and habitat loss have impacted cultural practices and the ability to exercise treaty rights.

6. **How does the concept of "environmental racism" apply to the situation in Dalhousie?**

   Environmental racism refers to the disproportionate exposure of marginalised communities, often Indigenous or people of colour, to environmental hazards. In Dalhousie, this is evident through:

   - The historical siting of polluting industries in close proximity to Indigenous communities.
   - The ongoing legacy of contamination that continues to impact the health and well-being of these communities.
   - The potential for the proposed mine to further exacerbate existing environmental injustices.

7. **What can be done to address the concerns about the potential health impacts of the mine, especially considering limited access to healthcare in the region?**

   Addressing health concerns requires:

   - Proactive health impact assessments to identify and mitigate potential health risks.
   - Community health monitoring programs to track the health of the population and identify any emerging issues.
   - Improved access to healthcare by investing in healthcare infrastructure and services to meet the needs of the community.

- Enforcement of strong environmental regulations to minimise exposure to pollutants and protect public health.

It is essential to advocate for health equity and ensure that the communities most impacted by industrial development have the resources and support they need to protect their well-being.

Indigenous Rights and Consultation in Mining

The extraction and exploitation of natural resources often intersect with Indigenous lands, raising critical concerns about rights, sovereignty, and meaningful participation. Indigenous communities hold inherent rights to their territories, as recognized by international frameworks like the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). These rights include Free, Prior, and Informed Consent (FPIC), a standard frequently undermined or ignored in mining consultations. In Canada, the duty to consult is a legal obligation, yet its implementation often falls short of ensuring genuine engagement, instead favoring checkbox approaches that prioritize project approval over Indigenous voices. This inadequate consultation process marginalizes Indigenous worldviews, cultural values, and ecological knowledge, failing to account for the long-term social, environmental, and cultural impacts of mining projects on communities. Meaningful consultation must respect Indigenous sovereignty, include traditional knowledge systems, and ensure Indigenous peoples are active decision-makers rather than passive stakeholders in resource development on their lands.

Mi'gmaw Worldview and Knowledge

Some of the ecological, economic, spiritual, and cultural significance of Dalhousie Mountain and the surrounding areas is reflected in Mi'gmaw oral traditions. Given the emphasis on relationships in the Mi'gmaw worldview, Mi'gmaw Knowledge is traditionally transferred via storytelling (M'sɨt No'kmaq, 2021). Dalhousie Mountain is culturally and spiritually significant to the Mi'gmaw People of Mawipoqtapei. Traditional medicines, water and rocks have been gathered from this place since time immemorial for ceremonial purposes.

One story is centred on giant *Gopitg* (Beavers) which had built a dam across the Restigouche River (Labillois). The dam was preventing *Plamu'g* (Salmon) from going upriver to spawn. So, the Mi'gmaq held a council near *Sigitomqeg*, what is today called Inch Arran Point. It was decided that the men would go out with their canoes to destroy the dam. But when the men approached, the Beavers slapped their tails on the water, capsizing their canoes. So, the men swam ashore and held another council. It was decided that they would call upon *Gwinu* (Loon) to ask Gloosgap for help. Gloosgap, a cultural hero who transforms and prepares the landscape of Mi'gma'gi to be habitable for humans, receives the request from Loon. He hops on the back of *Pu'tup* (whale) and travels to the Restigouche River. Gloosgap confronts the Beavers. He takes his club and blows out the centre of the dam. The pieces go flying into the bay and turn to stone. These pieces of the dam are today known as *Te'sn'geg* and *Gonteoeteg*–Heron (or Herring) Island (Gespe'gewa'gi Mi'gmawei Mawiomi, 2016) and Battery Point, respectively. Gloosgap then grabs the largest

beaver by the tail. He swings it around and launches it upriver. The beaver crashes into the ground near *Jigu'gw*, on the south side of the Restigouche River where Campbellton and Atholville are today. Here the beaver transforms into *Genisgwagatg* (Sugarloaf Mountain). Gloosgap then shrinks the other beavers down to the size we commonly find today, stabilising the relationship between humans, beavers, and salmon. Finally, Gloosgap promises that the beaver dam issue will not arise again before he departs.

One of the underlying principles which animates Mi'gmaw Knowledge is *M'sit No'gmaq* which translates to "All Our Relations." *M'sit No'gmaq* conveys the idea that everything is related and that our relatives have every right to exist here in harmony with us (Robinson, 2014). We can take some guidance from the story above by considering the relationships involved (M'sit No'kmaq, 2021).

The story highlights ecological relationships between *Gopit* and *Plamu*, Beaver and Salmon. We see that the outsized – one might say giant – influence of any one species in an ecosystem can cause issues for other species that share the same ecological niche (Robinson, 2014). This is as true for beavers as it is for humans. With their ability to fell trees and build dams, beavers can easily create big changes in the lands and waters that impact salmon and other species in a harmful way. The ability for beavers to disrupt local ecosystems may have been even greater in ancient times, such as the Pleistocene epoch, when a now-extinct species of bear-sized beavers (*Castaroides ohioensis*) roamed the continent (Robinson, 2014). We also see the inclusion of *Gwi'mu* and *Pu'tap*, Loon and Whale, who are also partners in shaping the geography and ecology of this region. While whales are perhaps an uncommon sight in *Mawipoqtapei* (*Baie des Chaleurs*) today, the story tells us that they have been coming here for a very long time and have every right to be here. Humans, too, play a central role in maintaining balance between species in this story. It is an ecological imperative that all species can interact in a good way. The tangled web of relationships gives this region its unique ecological biodiversity – of which the Mi'gmaw language and culture more generally is an expression.

Economic concerns are also reflected in the story. It was true then, as it remains today, that Plamu is an important pillar of the Mi'gmaw economy. Mi'gmaq continue to rely on Salmon for sustenance and survival. We have a stake in sustaining *Plamu* populations, including protecting food sources, migratory pathways, spawning grounds, managing interspecies predation, and so on. These interests are reflected in the story. Even the forced transition from a traditional subsistence economy to modern wage labour did not displace or diminish the significance of the salmon for Mi'gmaw economies (Parenteau, 1998).

There is an implied spiritual dimension to the Mi'gmaq relationship with the salmon. The spiritual significance of the story is reflected in the promises that Gloosgap made to the Mi'gmaq about how relations with the beavers and salmon would be going forward. It was Gloosgap who first

received and then shared the original instructions – protocols and ceremonies – with the People to pay respect for harvesting plants and animals (Young, 2016). Such practices encourage Mi'gmaq to be mindful hunters and harvesters and remain a source of ethical guidance that shape hunting and gathering practices to this day (Prosper et al., 2011). Further, Heron or Herring Island, as it is variably known, is not only notable for its cultural connection to the beaver dam story, and ecologically for the abundance of herons and herrings, but it is also known as a traditional burial ground of the Mi'gmaw people (LeClercq, 1691). It is also the case that parts of this island which were formerly above the water are now eroded and submerged by rising sea levels (Gespe'gewa'gi Mi'gmawei Mawiomi, 2016), meaning that the area around the island contains Mi'gmaw remains.

The cultural significance of the story, its places, and characters cannot be overstated. The Salmon, the bay, the river, and the local mountain ranges all factor into the Mi'gmaw sense of identity and to imperil the future of any of these is to imperil the future of the Mi'gmaq as a people. Plamu has been an important part of the local identity of Mi'gmaq in this region from time immemorial, with sources indicating that people from the Restigouche area used to wear medallions with *Plamu ugtutem* (Salmon totems) on them in the late 1600s (LeClercq, 1691). Places and place names are important repositories of Knowledge in the Mi'gmaw language and worldview. The name of a mountain in McLeods, *Nigugtelig*, connects that area to spearfishing. Stories about Sugarloaf Mountain connect it to salmon migration and spawning. Many place names in this area also attest to the state of the river prior to the arrival of European settlers and later harms caused by industries in this area. Place names and stories provide normative or moral guidance on how to relate to places. In the Mi'gmaw language and worldview, mountains and rivers and islands are considered animate (Robinson, 2014). Mi'gmaw legal consciousness considers the rivers, mountains, and islands to be persons deserving of rights and protections. The story above illustrates this principle by personifying Sugarloaf Mountain as Gopit.

The story of how Gloosgap created Sugarloaf Mountain also reflects teachings like *Netugulimg*, a style of provisioning and sharing resources which aims to "avoid not having enough" (Denny and Fanning, 2016). The philosophy encompasses and unites the ecological, economic, spiritual, and cultural dimensions discussed above. The gigantic beaver dam threatened to leave *Plamu* without spawning grounds necessary to reproduce and this would have had downstream negative effects on all other species that rely on Salmon. The beaver dam also threatened to leave Mi'gmaq without enough to survive. Harmony had to be restored so that the needs of *Plamu* and *Gopit* could be balanced. Actively attuning to and maintaining this ecological balance through mindful hunting, harvesting, and management is how Mi'gmaq "avoid not having enough" (Robinson, 2014).

Lastly, the story can be understood using an *Etuaptmumg* or Two-Eyed Seeing perspective. Two-Eyed Seeing is a methodology which takes the best of Indigenous and Eurocentric thought and

combines them for the benefit of all (Bartlett et al., 2012). Taking one eye as representing Mi'gmaw teachings, the story conveys a wealth of Knowledge about relationships between species and how humans managed them in the deep past. Taking the other eye as representing the Western sciences, we can use the methods and instrumentation of the Eurocentric sciences to expand on the big picture perspective offered by the Mi'gmaw eye. This report will weave between these two perspectives to provide a deeper perspective on the potential impacts and cumulative effects of mining on the region.

Dalhousie Mountain: A Sacred Site Impacted by Industrial Legacy

Documented traditional Mi'gmaw Knowledge describes Dalhousie Mountain as a site of cultural and spiritual significance, holding a sacred place in the traditions of local Mi'gmaq communities. Volcanic rock, originating from the ancient Mount Sugarloaf volcano, is also considered sacred and plays a vital role in traditional practices such as sweat lodges. The area surrounding Dalhousie Mountain and the Restigouche River estuary is rich with cultural heritage, evident in the presence of petroglyphs, place names, and archeological sites.

The traditional use study carried out by GINU and Ugpi'ganjig details a deep connection between the community and the land, with generations relying on the area's resources for sustenance, crafting materials, ceremonial uses, and medicinal applications. However, this harmonious relationship has been severely disrupted by the legacy of industrial activity in the region.

Knowledge Holders recount a history of contamination stemming from industries like the Dalhousie thermal plant, the former mercury cell Chlor-Alkali plant, an ore loading facility, and a thermal power station. These industries have released heavy metals, chemicals, and other toxic substances into the environment, contaminating the soil, water, and sediments. The sediment near Dalhousie and Belledune contains high levels of mercury, lead, cadmium, copper, and zinc, exceeding safety guidelines and posing risks to the ecosystem and human health. The contamination has impacted traditional fishing and harvesting practices, leading to a decline in fisheries and traditional ways of life. The once abundant clam harvest, central to the community's economy and cultural practices, has been significantly affected by pollution. Knowledge Holders express concerns about the ongoing impact of contamination on the community's health and well-being, especially given the limited access to healthcare services in the region. Mawipoqtapei has seen some recent signs of recovery following industrial closures: Common lumpfish have returned to spawn, Atlantic sturgeon numbers are increasing as they re-enter the estuaries for feeding, Yellow-fin tuna have also been observed by Mi'gmaw fishers. These observations showcase signs of ecosystem recovery and hope. Resuming industrial activities during this time jeopardises the ecological integrity of Mawipoqtapei.

Legacy Effects and Cumulative Impacts in Mawipoqtapei

The legacy effects of past industries in the aquatic ecosystems of the inner Mawipoqtapei (Bay of Chaleur) are significant and persistent, impacting the environment long after industrial activities have ceased. These legacy effects are mainly due to pollution from past industrial activities, such as power generation, chemical plants, mining and paper mill, and logging, which have left behind contaminants in the soil, water, and sediments.

1. Historical Pollution: The Bay of Chaleur has been subjected to pollution from industries that released heavy metals, chemicals, and other toxic substances into the environment. These pollutants have settled into the bay's sediments, where they continue to pose a risk to aquatic life.
2. Contaminated Sediments: The sediments in the bay act as a reservoir for these pollutants, which can be re-released into the water column due to natural processes like storms or dredging. This re-mobilization can have adverse effects on water quality and aquatic organisms.
3. Bioaccumulation and Biomagnification: Contaminants such as mercury and other heavy metals can accumulate in the tissues of aquatic organisms. As these organisms are consumed by predators, the contaminants become more concentrated, posing significant health risks to higher trophic levels, including fish, birds, and even humans.

The importance of ecosystem-level considerations and the need for risk management to encompass all projects within a given area are of utmost importance.

Sediment Quality and heavy metal contamination

The long history of industrial activity in the area combined with high sedimentation rates in the Restigouche estuary have left a legacy of sediment contaminated with heavy metals and other harmful compounds. Sources of heavy metals to Chaleur Bay include the former mercury cell Chlor-Alkali plant, the ore loading facility and thermal power station in Dalhousie. Sediment cores taken near Dalhousie typically contain high levels of mercury, lead, cadmium, copper and zinc. The figure below shows the high concentrations of contaminated sediment near the industrial areas of Dalhousie and Belledune compared with other parts of the bay (Parsons & Cranston, 2005).

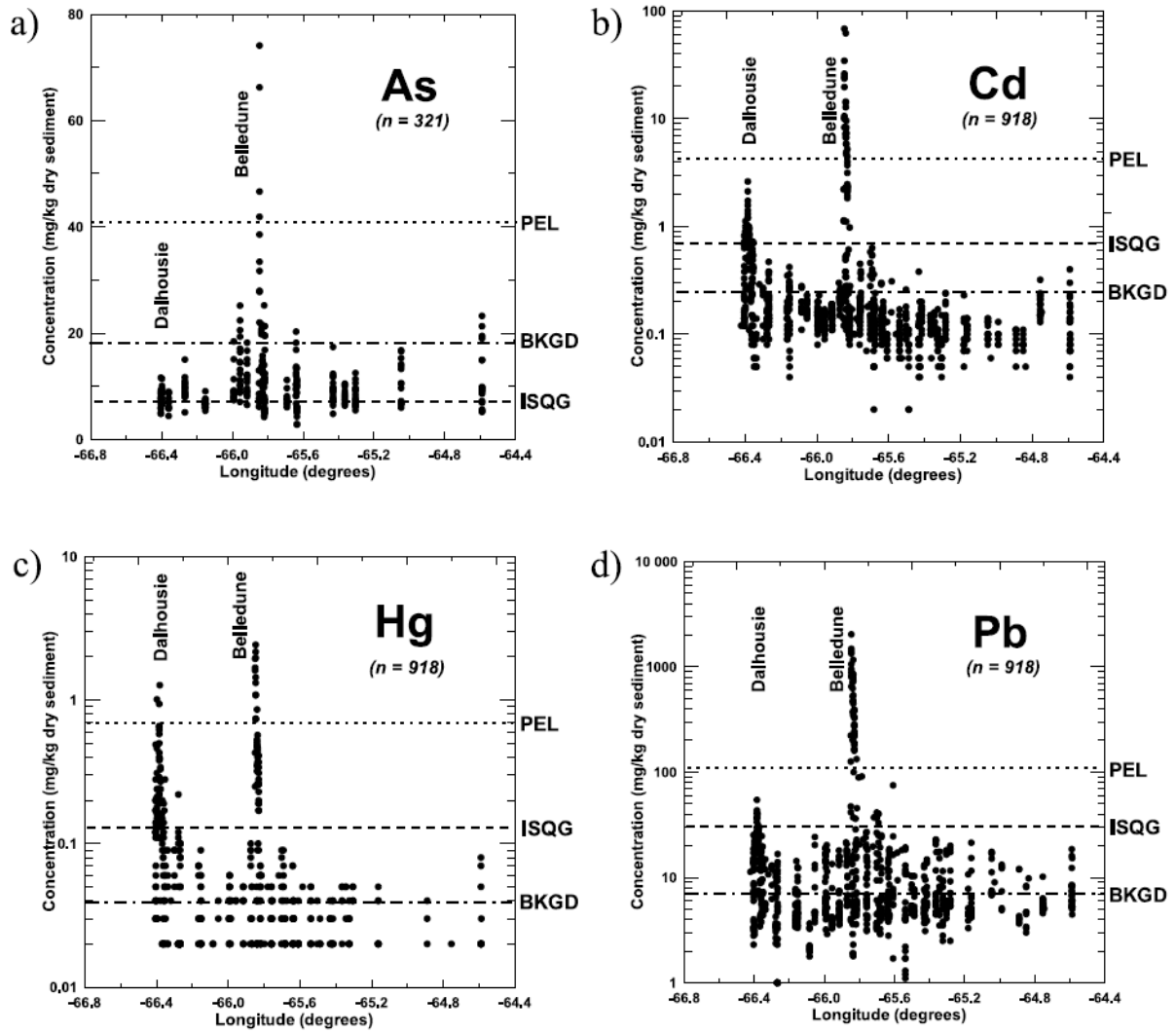


Fig. 4. Concentrations of (a) As, (b) Cd, (c) Hg, and (d) Pb in sediments of Chaleur Bay, plotted versus longitude. The horizontal dashed and dotted lines on each plot show the Canadian Interim Sediment Quality Guideline (ISQG) and the Probable Effect Level (PEL), respectively, for that element in marine sediments (CCME 1999). The black horizontal dot–dash line on each graph represents the upper limit (95th percentile) of background concentrations (BKGD) for that element in the pre-industrial sediments.

While all four plotted heavy metals are seen to be elevated above the Canadian Interim Sediment Quality Guidelines (ISQG), mercury is of particular concern as its levels also exceed the Probable Effect Level (PEL) which is associated with adverse biological effects (CCME 1999).

Mawipoqtapei (Bay of Chaleur, Baie des Chaleurs) faces contamination from various pollutants, including mercury, arsenic, dioxins and furans, and cadmium. Fraser *et al.* (2011) addressed gaps in understanding heavy metal contamination in Mawipoqtapei by adopting an ecosystem approach to assess the spatiotemporal distribution of contaminants in mussels. Unlike previous research that focused solely on industrial centers, this study revealed, for the first time, cadmium contamination extending across the south coast of Mawipoqtapei, highlighting its broader ecological impact. The findings also corroborate earlier studies showing elevated levels of cadmium (Cd), zinc (Zn), and lead (Pb) in mussels from the Belledune industrial region. The accumulation of pollutants in sediment and marine organisms has led to bioaccumulation and

biomagnification. The legacy of industrial pollution continues to pose risks to aquatic ecosystems. Heavy metals, organochlorine compounds, and other toxic substances remain a concern, particularly in areas with a history of industrial discharge.

Mercury

The marine environment near the former Pioneer Chemicals Canada Inc. (PCI) mercury cell chlor-alkali plant in Dalhousie, New Brunswick, has been significantly impacted by mercury contamination, as highlighted by Garron *et al.* (2005). This study examined mercury concentrations in marine sediments, blue mussels (*Mytilus edulis*), and effluent samples from the Restigouche River and Mawipoqtapei. Results revealed elevated levels of mercury in both sediments and mussel tissue, with contamination levels decreasing with distance from the PCI plant. Sediment mercury concentrations ranged from 1.96 mg/kg near the plant (20 meters from the shoreline) to 0.03 mg/kg at a distance of 4.6 km. Notably, nine sites exceeded the Canadian Council of Ministers of the Environment (CCME, 1999) Interim Sediment Quality Guideline of 0.13 mg/kg, with contamination observed up to 1.1 km from the plant. Biomarker analyses of mussels revealed correlations between mercury levels and both the condition index and zinc concentrations in tissues, indicating physiological stress and potential toxic effects in individuals closer to the plant. Interestingly, some abnormal biomarker results were also observed in locations farther from the plant, suggesting other potential sources of contamination in the region. Effluent samples from the plant showed mercury concentrations ranging from 0.84 to 4.32 µg/L, further implicating the PCI plant as a significant source of mercury pollution. Mercury concentrations exceeding the ISQG were found in sediment over a kilometre from the site of the former chemical plant which utilised mercury in its process (Garron et al., 2005).

A more recent study in 2016 showed an attenuation of mercury concentrations in the surface sediment (0-2 cm) between Dalhousie and Miguasha since the closure of the chlor-alkali plant. Total mercury (THg) concentrations were measured in coastal marine sediments near a former chlor-alkali plant in Mawipoqtapei, Gespe'gewa'gi. The plant was a local point source of THg from 1963 until its closure in 2008. Following the plant's closure, THg concentrations significantly decreased compared to earlier studies. This decrease is likely due to a combination of source control (plant closure) and natural sediment recovery (Walker, 2016). Despite the overall decrease, some localized THg concentrations still exceeded Canadian marine sediment quality guidelines. Additionally, while surface sediment THg concentrations have decreased, burial in deeper anoxic sediments may increase the bioavailability of mercury, potentially posing ecological risks to marine organisms (Walker, 2016).

Mercury contamination poses environmental risks to local ecosystems, particularly through bioaccumulation in species like blue mussels, which are critical components of the marine food web. The findings highlight the legacy of industrial mercury pollution in the Restigouche River and its continued ecological implications, emphasizing the importance of monitoring and remediation efforts to protect the region's biodiversity and ecological health.

Cadmium

The study by Uthe and Chou (1985) highlights significant cadmium and lead contamination in lobsters (*Homarus americanus*) harvested from Belledune Harbour, New Brunswick. Annual monitoring of cadmium levels in lobster tissues since 1980 revealed a peak mean concentration of 223 mg/kg (wet weight) in the digestive glands of lobsters captured deep within the harbour in 1981. Following the establishment of an aqueous effluent and plant run-off treatment facility in late 1980, cadmium levels declined but remained alarmingly high, averaging 73.1 mg/kg in 1983 and 75.4 mg/kg in 1984. For comparison, control lobsters from uncontaminated areas exhibited cadmium concentrations ranging from 3.30 to 4.83 mg/kg during the same period, indicating the substantial contamination of harbour lobsters.

The contamination was not limited to the digestive glands. Cadmium concentrations in the cooked meat of harbour lobsters exceeded acceptable levels, rendering them unfit for human consumption since at least 1979. While lead concentrations in the cooked meat were elevated compared to controls, they fell within the range reported for commercial lobster meat preparations, suggesting less severe contamination by lead compared to cadmium.

These findings underscore the impact of industrial activities in the Belledune Harbour area on local marine ecosystems. The elevated cadmium levels are indicative of persistent contamination, even after the implementation of pollution control measures, highlighting the long-lasting environmental legacy of heavy metal pollution. The study emphasizes the need for continued monitoring and mitigation efforts to address industrial discharges and their effects on marine life, food safety, and human health in the region.

Lead

Milewski (2006) details a four-decade-long environmental and public health crisis in Belledune, New Brunswick, stemming from a lead smelter's operations. The investigation reveals significant heavy metal contamination of soil, water, and seafood, alongside evidence of inadequate government oversight and corporate negligence. Despite numerous studies and warnings, authorities repeatedly downplayed or ignored

the health risks to residents, leading to significant long-term consequences. Parsons and Cranston (2005) carried out an extensive study in inner Mawipoqtapei and found lead concentrations that exceeded background levels in surface sediments throughout the bay.

Overall Legacy on Ecosystem and Human Health

The cumulative impact of industrial activities on aquatic ecosystems is profound, characterised by physical habitat alterations, widespread pollution, and the contamination of food, social, ceremonial, and economic. These changes have resulted in the degradation of aquatic environments, threatening the biodiversity and health of these ecosystems for the long term.

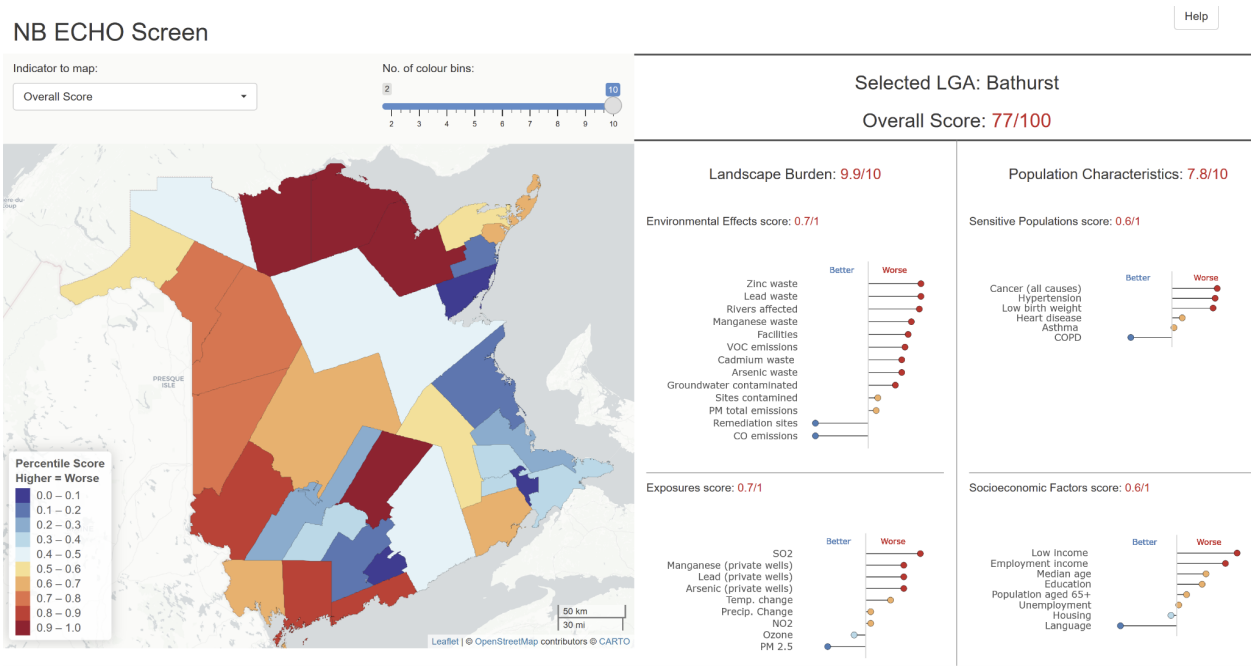
The ECHO EnviroScreen App is an interactive geospatial interface and a screening tool to better understand key indicators of environmental, community and health status as they relate to natural resource development and diverse land-uses across the province of New Brunswick. The screening tool compares indicators on land-use values across geospatial units within the region. A key feature of the tool is that it is comparative by design — it enables direct comparison on the state of those values to other geographic units within the region. Specific indicators and their respective scores and explore the combined influences of value sets on cumulative effects across the province (Table 1).

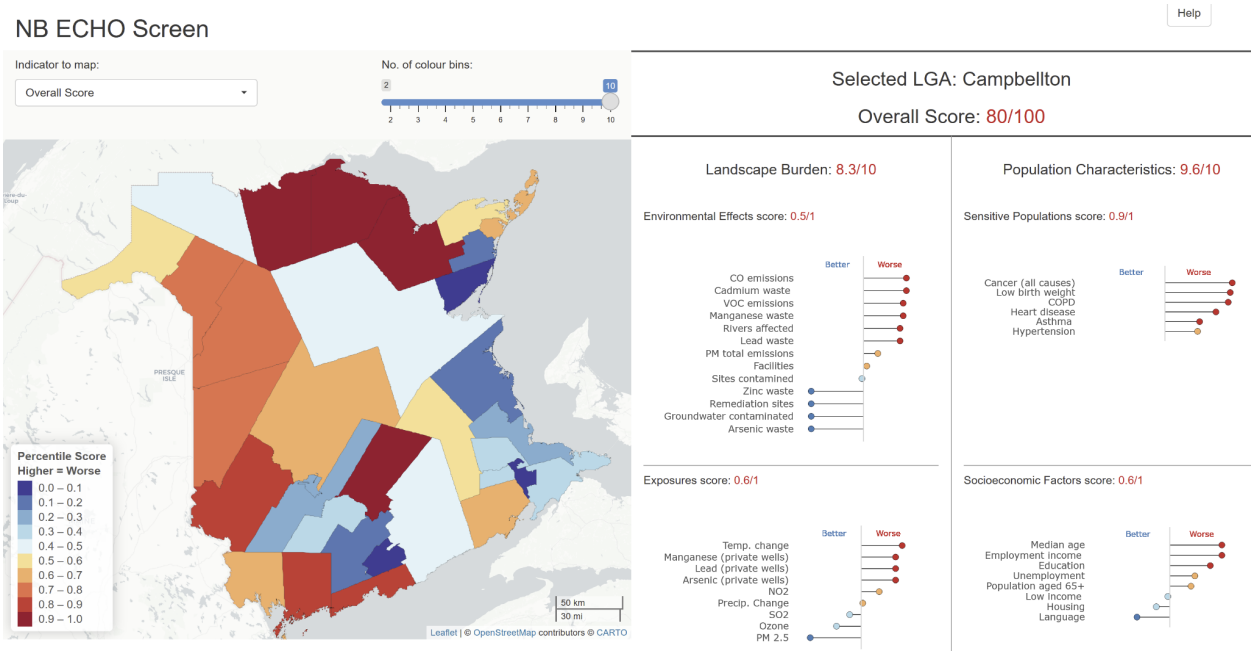
The overall score is a quantitative measure of cumulative effects ranging between 0-100 where higher scores indicate greater environmental, socioeconomic and health pressures relative to other geographic units comprising the overall sample. The Landscape Burden score is a composite measure of environmental exposures and effects that characterises the overall pressure to regional environments and ecosystems. The Environmental Effects score is based on the locations of toxic chemicals or landscape-level changes to environments. Population Characteristics is a composite measure of sensitive populations and socioeconomic factors that may modify human interaction with the environment. Sensitive Populations score refers to the people in communities who may be more severely affected by pollution because of their health.

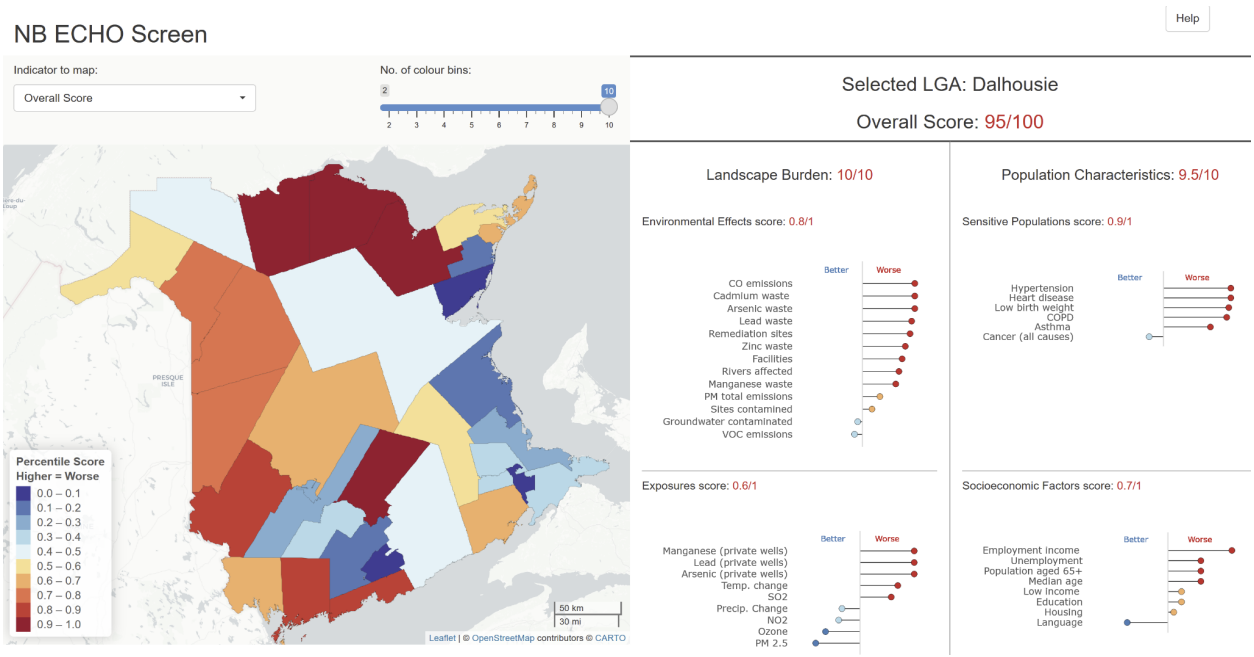
Exposures score measures of different types of pollution that people may encounter. Socioeconomic factors score refers to conditions that may increase people's stress or modify their exposure to the negative impacts of multiple land-uses (Buse et al. 1999).

Table 1. Scores extracted from the ECHO EnviroScreen App for inner Mawipoqtapei indicating cumulative effects and industrial legacy, contamination and how it affects community well-being and health. Note that higher scores indicate greater environmental, socioeconomic and health pressures relative to other geographic units in New Brunswick.

Score Type	Campbellton	Dalhousie	Bathurst
Overall score	80/100	95/100	77/100
Landscape Burden score	8.3 /10	10 /10	9.9 /10
Environmental Effects score	0.5 /1	0.8/1	0.7/1
Population Characteristics	9.6 /10	9.5 /10	7.8 /10
Sensitive Populations score	0.9 /1	0.9 /1	0.6 /1
Exposures score	0.6 /1	0.6 /1	0.7 /1
Socioeconomic factors score	0.6 /1	0.7 /1	0.6 /1


NB ECHO Screen
Help
Indicator to map:
Overall Score
No. of colour bins:
2
10
2 3 4 5 6 7 8 9 10
Selected LGA: Bathurst
Overall Score: 77/100
Landscape Burden: 9.9/10
Population Characteristics: 7.8/10
Environmental Effects score: 0.7/1
Better
Worse
Zinc waste
Lead waste
Rivers affected
Manganese waste
Facilities
VOC emissions
Cadmium waste
Arsenic waste
Groundwater contaminated
Sites contamined
PM total emissions
Remediation sites
CO emissions
Sensitive Populations score: 0.6/1
Cancer (all causes)
Hypertension
Low birth weight
Heart disease
Asthma
COPD
Exposures score: 0.7/1
SO2
Manganese (private wells)
Lead (private wells)
Arsenic (private wells)
Temp. change
Precip. Change
NO2
Ozone
PM 2.5
Socioeconomic Factors score: 0.6/1
Low Income
Employment income
Median age
Education
Population aged 65+
Unemployment
Housing
Language
Percentile Score
Higher = Worse
0.0 – 0.1
0.1 – 0.2
0.2 – 0.3
0.3 – 0.4
0.4 – 0.5
0.5 – 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
0.9 – 1.0
50 km
30 mi
Leaflet | © OpenStreetMap contributors © CARTO


NB ECHO Screen
Help
Indicator to map:
Overall Score
No. of colour bins:
2
10
2 3 4 5 6 7 8 9 10
Selected LGA: Campbellton
Overall Score: 80/100
Landscape Burden: 8.3/10
Population Characteristics: 9.6/10
Environmental Effects score: 0.5/1
Better
Worse
CO emissions
Cadmium waste
VOC emissions
Manganese waste
Rivers affected
Lead waste
PM total emissions
Facilities
Sites contamined
Zinc waste
Remediation sites
Groundwater contaminated
Arsenic waste
Sensitive Populations score: 0.9/1
Cancer (all causes)
Low birth weight
COPD
Heart disease
Asthma
Hypertension
Exposures score: 0.6/1
Temp. change
Manganese (private wells)
Lead (private wells)
Arsenic (private wells)
NO2
Precip. Change
SO2
Ozone
PM 2.5
Socioeconomic Factors score: 0.6/1
Median age
Employment income
Education
Unemployment
Population aged 65+
Low Income
Housing
Language
Percentile Score
Higher = Worse
0.0 – 0.1
0.1 – 0.2
0.2 – 0.3
0.3 – 0.4
0.4 – 0.5
0.5 – 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
0.9 – 1.0
50 km
30 mi
Leaflet | © OpenStreetMap contributors © CARTO



Showcasing these three regions where the communities we serve reside, it is overwhelmingly evident that this region has experienced environmental racism and is the most impacted area in New Brunswick. In the context of cumulative effects, we have exhausted and surpassed the capacity for the ecosystem to recover. The burden of the industrial legacy in the area is evident and community health has and continues to suffer.

It is said that by the 1980's the Northshore of New Brunswick (Dalhousie to Bathurst) was identified as one of the most heavily contaminated areas of Canada's east coast (Milewski, 2012). As highlighted by a case study conducted by Milewski (2012), regions such as Bathurst, Belledune and Dalhousie accounted for as many industries related activities as noted in the region of Saint John (see Table 2 extracted from Milewski, 2012).

Table 2. Major economic activities in 14 urban and rural areas in New-Brunswick between 1989 and 2005 (Milewski, 2012)

Urban/Rural Area	Agriculture	Coal mining	Fossil fuel power generating stations	Chemical manufacturing	Fishing and fish processing	Transportation	Manufacturing	Pulp and/or paper production	Wood products manufacturing (plywood, structural board, lumber etc.)	Metal mining	Oil refining and associated industries	Sawmills/ wood harvesting	Port development	Smelting
Saint John			■	■		■	■	■			■		■	
Moncton						■	■							
Miramichi						■	■	■	■			■		
Caraquet					■	■	■							
Bathurst						■	■	■	■	■		■		
Dalhousie			■	■		■	■	■				■	■	
Edmundston						■	■	■	■			■		
Fredericton						■	■					■		
Minto Area		■	■			■	■		■			■		
Harvey Area						■				■		■		
Base Gagetown Area						■						■		
Upper Miramichi Area						■			■			■		
Belledune Area			■	■		■						■	■	■
Drummond-Denmark Area	■					■						■		

[1] Sources: Statistics Canada Community Profile data for 1991, 1996, 2001 and 2006, Environment Canada's National Pollutant Release Inventory and New Brunswick's Department of Environment Registry of Operating Approvals.

In time, Dalhousie and Belledune communities presented higher rates of cancer when compared to most other communities in New Brunswick. A higher risk for exposure to various known carcinogenic agents directly impacts the health of local populations. Tables 3 and 4 (from Milewski, 2012) provide examples of carcinogens and their links to various cancer types in addition to demonstrating how activities in the general proximity of human populations can be linked to cancer.

Table 3. Selected carcinogenic agents and their occupational links with cancer (Milewski, 2012)

Carcinogenic Agent	Occupation	Cancer site and strength of evidence[2]		Latency Period in years[3]
		Strong	Probable and Suspected	
Arsenic	metal mining and smelting; coal mining and burning; oil refineries; wood preserving operations	bladder; lung; skin; soft tissue sarcoma (angiosarcoma of the liver)	brain/central nervous system; liver; prostate; soft tissue sarcoma	10+
Asbestos	mining; insulation and shipyard workers;	lung; laryngeal; mesothelioma		4-40
Benzene	oil and petrochemical industries; transportation; manufacturing of plastics, resins, some types of rubbers and lubricants	leukemia; non-Hodgkin's Lymphoma	brain/central nervous system; lung; nasal & nasopharynx; multiple myeloma	6-14
Butadiene	oil refineries; petrochemical industries	lung	leukemia	
Cadmium	metal mining and smelting; electrical workers; battery plant and alloy workers; painters		pancreatic; kidney; prostate	
Chromium	steel and alloy producers; chrome plating operations; wood preserving operations	lung; nasal and nasopharynx		5-15
Creosotes; Coal tars	roofing; road paving; aluminum smelting and coking	bladder (coal tars); lung; skin		
Ethylene oxide	laboratory workers; hospital workers; fumigators	leukemia	breast	
Formaldehyde	plywood and oriented strand board manufacturing; appliance, telephone and electrical control manufacturing		nasal and nasopharynx	
Ionizing radiation	high-voltage equipment operators; nuclear reactors; uranium mining	bone; brain & CNS; nervous system; breast; leukemia; liver & biliary; lung; multiple myeloma; soft tissue sarcoma; skin; thyroid	bladder; colon; nasal and nasopharynx; ovarian; stomach	
Lead	metal smelting and mining; battery manufacturing/recyclers		brain/central nervous system; lung; kidney; stomach	
Nickel	nickel smelters, mixers and roasters; electrolysis workers	lung, nasal and sinuses;	laryngeal; pancreatic; stomach	3-30
Pesticides	agriculture and forestry workers; landscapers		brain/ central nervous system, breast; kidney; prostate; lung; leukemia; NHL; colon; Hodgkin's; multiple myeloma; ovarian; pancreatic; soft tissue sarcoma; stomach; testicular	
Silica	mining; foundries, brickmaking and sandblasting; solar panel manufacturing	lung		
Straight oils, soluble oils, synthetic and semi-synthetic fluids	metal machining; print press operations	bladder; laryngeal; lung nasal and nasopharynx; rectal; skin; stomach	esophageal; pancreatic; prostate	
toluene	manufacturing of paint, thinners, adhesives and rubber; oil refineries		brain/central nervous system; lung; rectal	
wood dust	carpentry; furniture and cabinetry making	lung; nasal and nasopharynx	laryngeal	

[1] Source: Adapted from Clapp RW, Jacobs MM and Loechler EL. 2007. Environmental and Occupational Causes of Cancer: New Evidence, 2005-2007. Prepared for: Cancer Working Group of the Collaborative on Health and the Environment. Lowell Center for Sustainable Production. University of Massachusetts. 45 p.

[2] Strong causal evidence of a link is based primarily on a Group 1 (known carcinogen) designation by the International Agency for Research on Cancer. Suspected evidence of a link is based on Clapp et al. 2007 assessment of existing epidemiologic studies.

[3] Source: Adapted from Davis DL. 2007. *Secret History of the War on Cancer.* Basic Books. New York, NY. p. 258-261.

Table 4. Summary of key lifestyle, environmental and occupational risk factors linked to 14 cancer types (Milewski, 2012)

Cancer Type	Risk Factor Type		
	Lifestyle	Environmental	Occupational
Lung	- smoking	- PAHs, silica, asbestos, wood dust, benzene, arsenic, cadmium, chromium, beryllium and nickel in outdoor air pollution - residential radon exposure - arsenic in drinking water	- smelter workers - uranium, coal and base-metal miners - petroleum refinery and petrochemical workers - wood products manufacturers - transportation workers
Colorectal	*	- pesticides	- agricultural workers, landscapers and pesticide applicators - textile workers - metal machinists - firefighters
Breast	- hormone use / treatments	- pesticides, plasticizers, metals, solvents, PAHs, dioxins found in food, air and/or drinking water - exposure to ionizing (e.g. gamma and x-rays, CT scans) and non-ionizing (e.g. microwaves, low-frequency electromagnetic fields) radiation	- pesticide applicators - radiologists and radiologic technicians
Ovarian	- hormone use /treatments	- pesticides, plasticizers, metals, solvents, PAHs and dioxins found in food, air and/or drinking water	- agricultural workers - pesticide applicators
Thyroid	*	- ionizing radiation associated with x-rays, CT scans, sunlight, high-voltage equipment, cancer treatments and gamma rays associated with nuclear reactions	- radiologists and radiologic technicians
Prostate	*	- arsenic in drinking water - cadmium in air and/or drinking water	- agricultural workers, landscapers and pesticide applicators - base-metal miners and smelter workers
Bladder	- smoking	- arsenic in drinking water - trihalomethanes in drinking water - PAHs in air pollution	- coal and base-metal miners - base-metal smelter workers - metal machinists - transportation workers
Kidney	- smoking	- arsenic, lead and cadmium in food, air and/or water	- base-metal mining and smelter workers
Pancreatic	- smoking	- emissions from industries associated with nickel smelting, plating and battery production	- computer manufacturing - food industry workers - electrical workers - nickel smelting, plating and battery production
Non-Hodgkin's Lymphoma	*	- residential pesticide use	- agricultural workers, landscapers and pesticide applicators
Hodgkin's Disease	*	- emissions and leakage from industries associated with solvent use such as dry cleaners; paint, adhesive and varnish manufacturing - residential pesticide use	- pulp and paper mill workers - woodworkers - agricultural workers, landscapers and pesticide applicators
Leukemia	*	- ionizing and non-ionizing radiation - chemotherapy - pesticides - benzene and butadiene in air and/or water	- petroleum industry workers - agricultural workers, landscapers and pesticide applicators - firefighters - laboratory and hospital workers
Brain	*	- ionizing and non-ionizing radiation - benzene and toluene in air - pesticides	- firefighters - oil refinery and petrochemical workers - agricultural workers, landscapers and pesticide applicators
Bone	*	- high doses of ionizing radiation - diagnostic radiation and radiation therapy	*

[1] References to specific studies linking risk factors to cancer types can be found at the end of this report.

* No consistent or conclusive risk factors have been identified.

The data from this work demonstrated that, in the region of Dalhousie, the rate of cancer of various types is elevated as compared to the provincial norms. In males, cancer types such as non-Hodgkin's lymphoma, lung, prostate, colorectal and bladder were ranked in the highest amongst the 14 communities selected for this work. One of the most alarming data brought up by this work is that Ovarian cancer in Dalhousie is more that 200% higher than the provincial rate (Milewski, 2012).

While the industries that once were in Dalhousie have closed, the lasting effect of some of the pollutants will remain in the environment (e.g., bioaccumulation in food). With the record of high cancer rates and other health issues found in the Dalhousie region, it is important to consider the level of access to health care. In 2024, it was reported on several occasions that many New Brunswick residents had difficulty accessing a primary health care provider (Awde, 2024; Brown. L,2024; Brown. S, 2024) and there were as many as 180,000 residents without a family doctor in New Brunswick (Brown, L. 2024). It is also mentioned that the residents that have a primary care physician also have difficulties accessing care in a rapid manner and seek out other ways to access a consultation (e.g., ER or walk-in clinics) (Brown, S. 2024). Other specialised care is also lacking (e.g., neurology and oncology), underserving areas with the highest rates.

Cumulative Effects and Carrying Capacity

Cumulative effects are the combined, incremental impacts on the environment, ecosystems, and communities resulting from multiple activities or developments over time. Unlike single-event impacts, cumulative effects consider how multiple stressors—such as industrial activities, resource extraction, urban development, and pollution—interact and build upon one another, leading to amplified and often unforeseen consequences.

For example, a mining operation may cause localized habitat loss, but when considered alongside the effects of nearby logging, agriculture, road construction, and climate change, the broader cumulative impact may include ecosystem collapse, loss of biodiversity, and significant cultural and social disruptions for local and Indigenous communities.

Cumulative effects are critical to understanding long-term sustainability, as they highlight the interconnectedness of human activities and the environment. Addressing these effects requires holistic, systems-based approaches that account for long-term and large-scale interactions between human actions and natural processes.

Teachings from Elder Albert Marshall on the Carrying Capacity of Mother Earth

Elder Albert Marshall, a Mi'gmaq Knowledge Keeper, emphasizes that humanity has exceeded the carrying capacity of Mother Earth. The concept of carrying capacity refers to the maximum amount of life an ecosystem can support sustainably, given its resources, such as water, soil, and biodiversity. Elder Marshall's teachings reflect Indigenous knowledge systems, which stress the interdependence of all life and the importance of balance within natural systems.

Through his advocacy of Two-Eyed Seeing—a framework that combines Indigenous and Western ways of knowing—Elder Marshall reminds us that the cumulative effects of human actions have pushed Earth beyond her ability to renew herself. This imbalance is evidenced by rising global temperatures, widespread biodiversity loss, degraded water and soil systems, and extreme weather events. His teachings call for an urgent reassessment of humanity's relationship with nature, emphasizing stewardship, reciprocity, and respect for all living beings.

Elder Marshall warns that this overreach stems from a disconnect between modern societies and the natural world, driven by unsustainable resource extraction, overconsumption, and a failure to recognize the finite limits of Earth's systems (M'sit No'kmaq, 2021). By overburdening these systems, we not only harm the environment but also jeopardize the well-being of future generations.

Persistent Issues in Mining Practices

International Laws and Persistent Violations

Despite international agreements such as ILO Convention 169 and the Convention on Biological Diversity, which collectively acknowledge Indigenous peoples' rights to cultural identity, traditional lands, self-determination, and meaningful participation in development planning, violations of these rights persist globally. These agreements also emphasize the importance of Indigenous peoples' right to free, prior, and informed consent before mining development. However, in practice, these rights are frequently disregarded, undermining the protections promised under international law (Whiteman & Mamen, 2002).

Key Themes of Mining Impacts

The literature highlights the extensive negative impacts of mining on the environment, health, human and Indigenous rights, socio-cultural aspects, and gender dynamics. Despite the

severity of these issues, mining companies often fail to implement comprehensive, proactive measures to address them. Environmental damage, health crises, and socio-cultural disruptions are treated as inevitable consequences of progress, exacerbated by weak environmental, health, and safety standards. Corporations and policymakers frequently downplay or overlook these effects, reflecting a systemic failure to prioritize social and environmental well-being over profit (Whiteman & Mamen, 2002).

Inadequate Environmental and Social Impact Assessments

Although some mining companies conduct Environmental and Social Impact Assessments (EIAs/SIAs), these assessments are often incomplete. Critical issues, such as social and gender impacts, are frequently ignored or underexplored. Additionally, cumulative impacts—becoming increasingly significant in contemporary environmental and social planning—are rarely addressed. There is an urgent need for more comprehensive and transparent assessment practices to mitigate these issues effectively and equitably (Whiteman & Mamen, 2002).

Contrasting Perspectives on Consultation

Mining companies and Indigenous communities hold starkly different views on consultation processes. For companies, consultation often functions as a one-way communication tool to present pre-determined corporate plans, restricting Indigenous involvement to limited areas, such as community development. Conversely, Indigenous communities and NGOs advocate for consultation as a two-way, participatory processes, where Indigenous voices shape decisions about mining development. This divergence underscores the need for more meaningful and inclusive consultation practices that respect Indigenous rights and priorities (Whiteman & Mamen, 2002).

Weak Consultations and Corporate Control

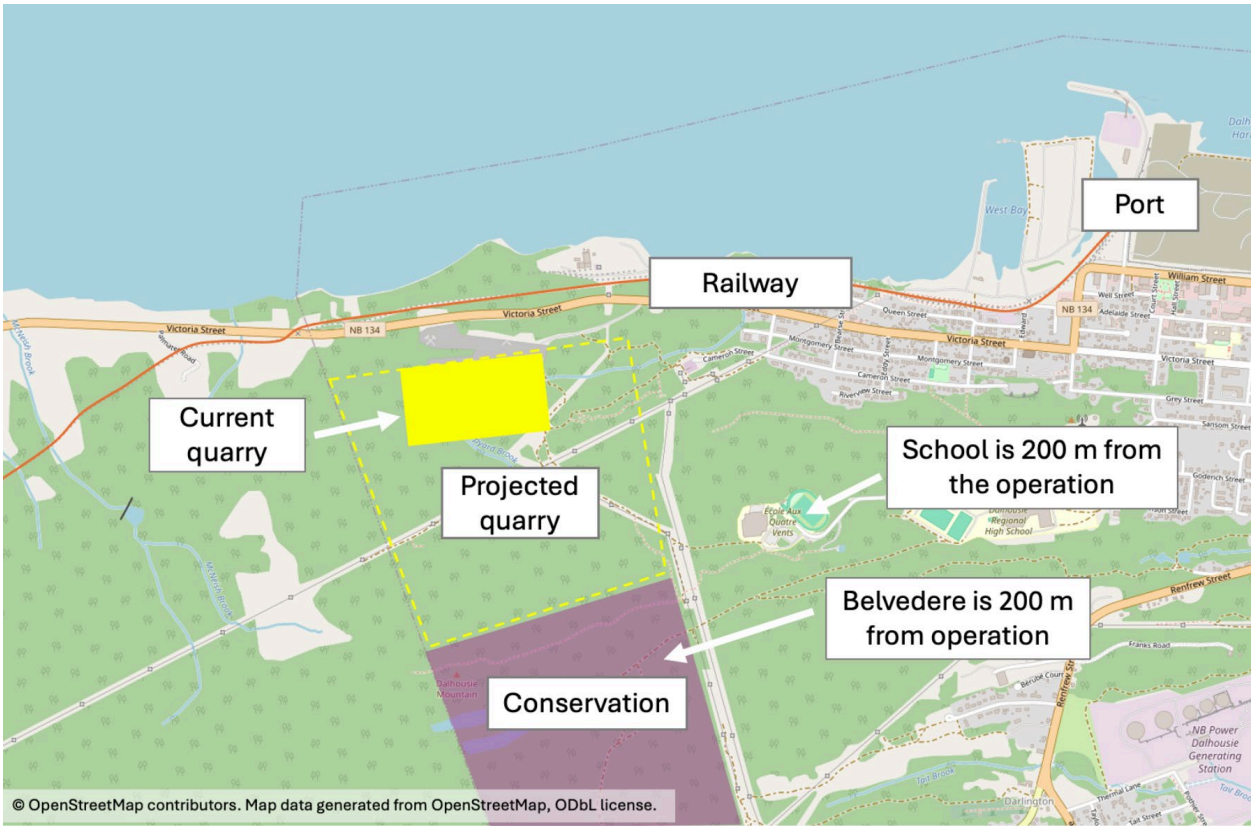
Current consultation practices in the mining sector are characterized by top-down approaches and a lack of genuine engagement. Often, consultations are designed to neutralize opposition and secure local support, rather than to foster collaboration or address community concerns. These processes typically lack dispute resolution mechanisms, follow-up actions, and proper evaluations, and they occur infrequently throughout the mine's life cycle. Corporate control over the consultation agenda marginalizes Indigenous perspectives, framing meaningful participation as a threat to profits. This approach undermines both the spirit of international agreements and the principles of ethical and sustainable development (Whiteman & Mamen, 2002).

Proposed pozzolan mining project in Dalhousie

The proposed mine aims to extract pozzolan. Dalhousie pozzolan is a type of rock composed of volcanic ash that was ejected approximately 400 million years ago by the now-dormant Mount Sugarloaf volcano. This rock is used as a partial substitute for "clinker" (calcined limestone) in cement production. To be utilised, the pozzolan needs to be finely ground. The mine wants to supply the cement industry with a low-carbon cementitious material that can reduce the clinker-to-cement ratio. The rationale for extracting pozzolan is to reduce greenhouse gas (GHG) emissions and the use of fossil fuels from the cement industry by decreasing the quantity of clinker in cement.

Project location

There is an existing stone quarry on the site that has been operational since 1932 (figure 1). Pozzolan extraction is planned to commence in 2026. Other existing infrastructure is planned to be utilised for operations and transport of extracted materials. Pozzolan exploitation has a direct impact on the biophysical environment in which it takes place.



Current quarry location (solid yellow) proposed mine expansion (yellow dash). Source: www.dalhousiepozzolan.com

Concerns about a New Pozzolan Mine

The proposal for a new pozzolan mine in the region raises significant environmental concerns, particularly given the already stressed state of Mawipoqtapei ecosystems.

1. Increased Acidic Runoff: The mining process can expose sulphide minerals, leading to acid mine drainage. This acidic runoff can further degrade water quality, making it more toxic for aquatic life and potentially worsening the existing contamination issues in the bay.
2. Erosion and Sedimentation: Mining activities often lead to increased erosion, resulting in higher sediment loads in nearby water bodies. This can smother habitats, particularly those critical for fish spawning, and reduce water clarity, affecting photosynthesis in aquatic plants.
3. Potential for Heavy Metal Contamination: If the mining operations expose or release heavy metals, there is a risk of further contamination of the water and sediments. Discharge of hydrocarbons used by heavy machinery, the discharge of various types of waste produced (dust deposits, wastewater, used oils, hydrocarbon spills or leaks). This could exacerbate the existing pollution problems in Mawipoqtapei and lead to even higher levels of toxic substances in the food chain.
4. Habitat Destruction: The construction and operation of the mine will destroy local habitats, including wetlands and riparian zones that play crucial roles in filtering pollutants and supporting biodiversity. This disruption could lead to a loss of ecosystem services that are essential for maintaining the health of the bay.
5. Dredging contaminated sediment: Extensive port dredging in Dalhousie Harbour will be required to allow for the docking of large ships to export product to market. This would remobilize buried contaminated sediment which would likely have negative impacts on local aquatic ecosystems.
6. Dust and air pollution: linked to the operation of the quarry (circulation of motorised machines, the expansion and loading) and is materialised by the emission of dust and gases notably CO2, CO and volatile compounds.
7. Noise and vibrations: Dynamite blasting, operation of the several machines on the site, the falling of blocks, the generator, the rotation of trucks and other vehicles will cause noise and vibrations.
8. Decay of the landscape of the project site: During the different phases, the panoramic view of the project site regarding the different installations and developments has a degraded aspect compared to its immediate environment. The vegetation is affected and presents a discontinuous silhouette.

Considering the persistent legacy effects of past industries that continue to influence the aquatic ecosystems of the inner Mawipoqtapei, it is particularly vulnerable to additional stressors. The development of a new pozzolan mine in the area could exacerbate existing environmental problems, highlighting the need to protect this already fragile ecosystem.

Air Quality

Air quality in Dalhousie, New Brunswick, has been historically influenced by industrial activities, with previous monitoring focusing on pollutants such as sulphur dioxide (SO_2) and total suspended particulates (TSP) due to the presence of facilities like the NB Power generating station and the former Mercury Cell Chlor-Alkali Plant (Province of New Brunswick, 2011). These historical operations have left a legacy of air quality concerns, including mercury contamination detected in the lichen *Hypogymnia physodes*, which serves as a bioindicator of air pollution. A study by Sensen and Richardson (2002) demonstrated that mercury deposition from the plant extended up to 3.4 km from the source, highlighting the persistence of industrial pollutants in the region.

Despite past improvements in compliance with air quality standards, the introduction of new industrial activities, such as pozzolan mining, poses significant risks to baseline air quality and public health. Dust, emissions, and other airborne particulates associated with mining operations could exacerbate existing concerns and contribute to measurable declines in air quality. This report examines the potential impacts of these activities on human health, biodiversity, and the surrounding environment, supported by scientific and regulatory frameworks.

Mining Impacts on Air Quality and Human Health

One of the most significant risk factors to human health and environment is poor air quality, at any measurable level (according to the World Health Organisation, Health Canada, 2021). Mining operations are a well-documented source of particulate matter (PM), with adverse effects on human health and the environment. Particulate matter, particularly PM10 (particles less than 10 microns in diameter) and PM2.5 (particles less than 2.5 microns in diameter), poses significant health risks. These fine particles can bypass the nasal epithelial barriers, altering ciliary beat patterns and frequencies, which increases the likelihood of harmful particles reaching the lungs and entering the bloodstream (Jia et al., 2019). The Canadian government recognizes PM2.5 as especially problematic due to its toxicity and role in respiratory and cardiovascular diseases (Government of Canada, 2013; Government of Canada, 2024).

Prolonged exposure to dust generated by mining activities, particularly silica (SiO_2), presents additional risks (Steenland & Ward, 2014). Silica dust is a known cause of silicosis, a progressive and incurable lung disease, and has been classified as a carcinogen (Hoy and Chambers, 2020; Barnes *et al.*, 2019). Samples collected in 2023 by CIMBEC in Dalhousie indicate that the region's pozzolan contains approximately 50–60% SiO_2, raising concerns about occupational and community exposure to silica dust (CIMBEC, 2023).

Dust and airborne particulates from mining operations are not limited to direct health effects. They also degrade air quality for surrounding vegetation, alter ecosystem dynamics, and diminish visibility. Nearby populations, particularly those within 500 meters of the mine, are at increased risk of respiratory ailments and reduced lung function (Nemer et al., 2020).

Projected Decrease in Air Quality on Biodiversity

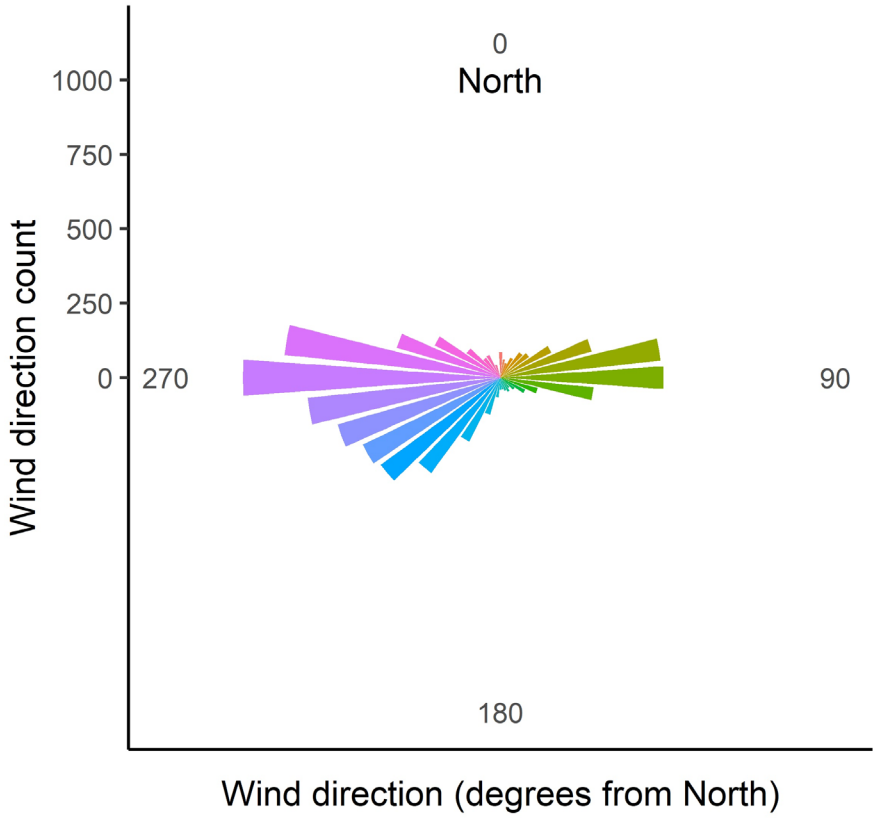
Airborne particulates and emissions from pozzolan mining can have severe consequences for local biodiversity. Dust deposition on plant surfaces interferes with photosynthesis, reduces plant growth, and alters habitat quality for insects and other species. Mercury contamination in lichens, historically documented in Dalhousie, illustrates how bioindicators can reveal cumulative air quality impacts that cascade through ecosystems (Sensen and Richardson, 2002). A decline in lichen populations, for example, could disrupt food webs that support birds, mammals, and other organisms reliant on lichen-rich habitats.

Species at risk, including those protected under the Species at Risk Act (SARA), are particularly vulnerable to declining air quality. Persistent emissions and dust deposition in the Dalhousie region could exacerbate threats to sensitive species by reducing habitat quality and increasing susceptibility to disease. Noise pollution, both land-based and underwater, further compounds these threats by disrupting wildlife behavior, communication, and reproduction.

Wind Direction and Pollutant Dispersion

Wind patterns play a crucial role in determining the dispersion of airborne pollutants. Data collected from Charlo Airport in 2022 indicates that winds predominantly blew in eastern (53%) and western (27%) directions, with occasional movement northward (7%) and southward (12%). While these measurements do not quantify the dispersal range of particles, they suggest that air quality impacts from mining operations would be most pronounced in areas downwind of the proposed site, particularly to the east and west.

The directional frequency of wind patterns highlights the forecasted risk in both human populations and ecosystems. Communities located both easterly and westerly of the proposed mine site could experience significant declines in air quality and increased exposure to harmful particulates.



Hourly wind direction measurements as counts, measured at the Charlo Airport over 2022. Data obtained from the Environment Canada website.

Impacts of Dredging and Industrial Activities on Aquatic Species at Risk in Dalhousie Harbour and Mawipoqtapei

Industrial activities have significantly modified the physical characteristics of aquatic environments. Locally, industrial developments have drastically changed shoreline habitats through backfilling, dredging, and the use of mobile fishing gear, leading to the loss of crucial ecosystems such as salt marshes and shallow subtidal zones.

Pollution from industrial activities has introduced a variety of contaminants into aquatic ecosystems, leading to widespread environmental degradation. Local sources, such as wastewater from municipalities and industrial plants, have released organic pollutants, heavy metals, and persistent chemicals like PCBs and dioxins into rivers, estuaries, and coastal waters. Distant sources, including atmospheric deposition and waterborne inputs from large drainage

basins, have further compounded the contamination, introducing toxic substances into the sediment and biota of aquatic environments.

Dredging can reintroduce pollutants by disturbing contaminated sediments, mobilising them in the water column and exposing the ecosystem to further damage from toxic compounds.

The impacts of dredging on fish includes habitat loss, hydraulic entrainment, release of contaminants, sedimentation, suspended sediment and underwater noise (Wenger et al., 2017). The figure below shows these stressors in schematic form (McCook et al., 2015)

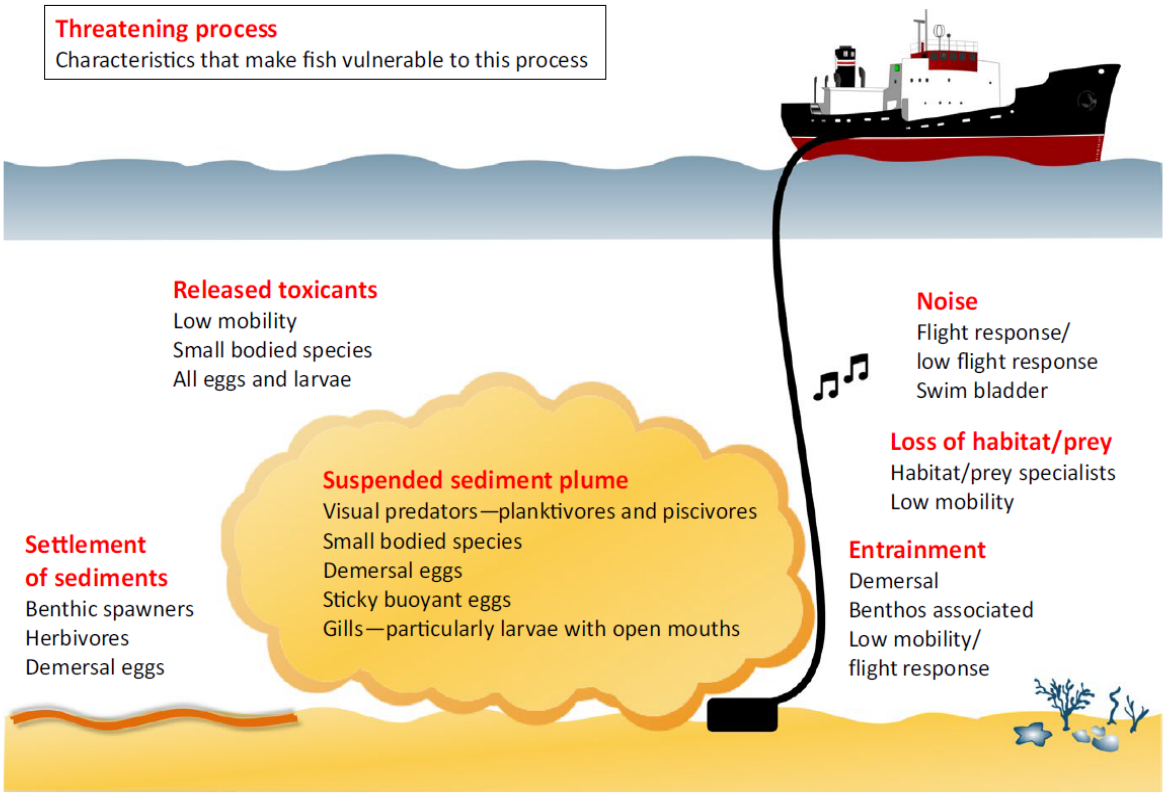


FIGURE 1 A schematic diagram of categories of potential effects of dredging on fish. [Colour figure can be viewed at wileyonlinelibrary.com]

Dredging is a routine activity for port maintenance. In Dalhousie Harbour, dredging has regularly occurred to maintain depth for docking ships. Prior to 1981, dredge spoils were disposed of directly in the harbour or further in the bay. There is evidence suggesting that westward currents pushed the material dumped offshore back towards Dalhousie (Parsons & Cranston, 2005). Sediment that is disturbed by dredging activities and then settles back to the seafloor becomes a lower density bottom deposit which is more susceptible to resuspension and dispersal by the action of the tides, currents and storm surges (Messieh *et al.,* 1991). Prior to dredging activities, the contaminated layers of sediment are more stable and in the case of Dalhousie Harbour, they

are covered by a layer of cleaner surface sediment that has built up since the decommissioning of the industrial facilities (Walker, 2016).

Dredging in Dalhousie Harbour, necessary for accommodating large ships involved in pozzolan export, poses a substantial threat to the local aquatic ecosystem, particularly to aquatic species at risk. The concern stems from the documented contamination of the harbour's sediment with heavy metals, a persistent legacy of past industrial activities. Westward currents have historically carried dredge spoils dumped offshore back towards Dalhousie, exacerbating the issue. Dredging activities disturb these contaminated sediments, mobilising them in the water column and potentially spreading them across Mawipoqtapei. Dredging activities can have major impacts on water quality and on local aquatic biota. The bioavailability of heavy metals in the sediment depends on the proportion of fine particles and organic matter (Zhang *et al.* 2014). When the contaminants are bioavailable, they can be taken up by benthic organisms and bioaccumulate up the food chain with higher concentrations building up in species of higher trophic levels.

There are specific concerns related to various culturally significant species:

- Common Lumpfish, Atlantic herring, Capelin, Winter flounder, Atlantic silverside: Spawning grounds for this species and nursery habitat are found in the Dalhousie area and throughout inner Mawipoqtapei. Dredging-induced sediment disturbance threatens these spawning areas, potentially leading to egg mortality and inhibiting larval feeding. Studies on herring have shown that sediment deposited in spawning areas increased egg mortality and inhibited larval feeding (Messieh et al., 1991).

- Atlantic Salmon: The Dalhousie area is considered a major migratory pathway for Atlantic salmon. This species is facing multiple threats to its survival and stock levels are decreasing. Dredging further jeopardises their migration route as Dalhousie is the only entry and exit used by Restigouche River Atlantic salmon. By re-suspending contaminated sediment, it will impact their migration, survival at sea and prey sources for growth and reconditioning in Mawipoqtapei.

- Atlantic Sturgeon: the overall degradation of the aquatic environment due to industrial activities, including dredging, raises concerns about their well-being as we have seen increased presence over the last decade. Being bottom-feeders, sturgeon are vulnerable to bioaccumulation.

- American Eel: Eel River Bar and Listuguj community members have reported a decline in eel populations, attributed to contamination from industrial activities. Dredging poses a further threat to their nurseries and feeding grounds.

- Clams: Clam harvesting, once a cornerstone of the Eel River Bar subsistence, has been severely impacted by industrial pollution, particularly from the dam constructed for industrial purposes. Dredging could exacerbate this issue by re-introducing contaminants

into clam habitats, further compromising their populations.

- American Lobster and Rock Crabs: Dredging can smother nursery areas for lobster, delaying moulting and impacting the development of commercial-sized lobster. The release of heavy metals due to sediment disturbance can also affect lobster and rock crab populations. Smothering of nursery areas for lobster by dredging activities has been reported by Pottle and Elner (1982). As some juvenile lobster life stages thrive in rocky substrates, deposition of fine particles could delay moulting and have other negative effects on development and recruitment of commercial size lobster.

Beyond the direct impact on these species, dredging has broader consequences for the entire ecosystem. The sediment plume generated can extend for several kilometres, impacting water quality and affecting a wide range of aquatic organisms. The resuspension of contaminated sediment increases the bioavailability of heavy metals, allowing them to be taken up by benthic organisms and bioaccumulate up the food chain, posing significant risks to higher trophic levels, including fish-eating birds and humans.

Overall, the cumulative effects of industrial activities, including dredging, paint a concerning picture for the future of Dalhousie Harbour and Mawipoqtapei aquatic ecosystems. The reintroduction of contaminants through dredging poses a direct threat to the survival of numerous species, including those already at risk due to past industrial activities.

Regional Ecological, Geological and Cultural Context

Restigouche River Area: An Important Bird and Biodiversity Area (IBA)

The Restigouche River Estuary near Dalhousie, New Brunswick, is recognized as an Important Bird and Biodiversity Area (IBA), underscoring its ecological significance for migratory and resident bird species. This designation highlights its regional and national importance as a vital staging, breeding, and feeding ground. Among the key species relying on the estuary is the endangered Barrow's Goldeneye (Eastern population), listed under the *Species at Risk Act (SARA)* and assessed by COSEWIC. The Barrow's Goldeneye is highly dependent on coastal waters for much of the year and is particularly vulnerable to habitat disruptions and contamination. Similarly, the Black Scoter, another species of concern, uses the estuary as a major staging area during spring migration, with over 11,000 individuals observed annually between mid-April and the end of May. This represents between 3% and 14% of the poorly understood eastern North American population. These species, alongside others such as Surf Scoters, Northern Gannets, Snow Geese, Red-breasted Mergansers, and Common Mergansers, rely on the estuary's unique ecological features for survival. Even Ospreys and Common Eiders make use of the area for nesting and feeding, further demonstrating the site's ecological value.

The location of the proposed mine lies directly within the Important Bird and Biodiversity Areas of Canada site NB001.The proposed pozzolan mining operations in this region pose significant risks to the avian species that depend on the Restigouche Estuary. Increased boat traffic associated with mining operations could have devastating consequences, particularly for the Barrow's Goldeneye, which is already concentrated in limited regions like the St. Lawrence Estuary. This species is highly susceptible to oil spills, which compromise the insulating properties of their feathers, rendering them unable to regulate body temperature or fly effectively. Such incidents are especially catastrophic during their moulting period when they gather in large numbers. Oil spills also threaten the broader ecosystem, affecting food webs and habitats crucial to the survival of other species, including the Black Scoter and Surf Scoter.

The increased boat traffic and associated noise from mining operations can also disrupt critical bird behaviors, including feeding, nesting, and staging. Migratory species like the Black Scoter rely on the precise timing of seasonal movements, and disturbances during these sensitive periods can have cascading effects on their populations. Habitat degradation from mining operations, such as sedimentation and pollution, further threatens the ecological balance of the estuary, reducing its capacity to support the rich avian biodiversity it currently sustains.

The Restigouche Estuary IBA designation reflects its significance for avian biodiversity. Conservation measures are supported by existing legislative frameworks such as the *Species at Risk Act (SARA)* and the *Migratory Birds Convention Act,* which protect at-risk and migratory bird species. These acts emphasize the importance of mitigating activities that harm bird populations or their habitats. Additionally, ecotoxicological considerations highlight the long-term impacts of contamination on reproductive success and survival rates, underscoring the need for proactive environmental management.

The Restigouche River Estuary plays a critical role in supporting bird populations, including species at risk, and is a key part of the global network of IBAs. However, the proposed mining operations threaten to undermine its ecological integrity and jeopardize the survival of species like the Barrow's Goldeneye and Black Scoter. To safeguard this globally significant habitat, rigorous environmental impact assessments must incorporate cumulative effects, and stronger conservation measures are essential to preserve the estuary's role as a haven for avian biodiversity and ecological health.

Geological Significance of the Dalhousie-Campbellton Area and Miguasha UNESCO Fossil Site

The Dalhousie-Campbellton area in New Brunswick, Canada, holds exceptional geological and paleontological importance due to its Devonian-age formations, volcanic history,

and cultural heritage. This region provides a unique window into Earth's history, highlighting the evolutionary transition of life from aquatic to terrestrial environments and the interplay between geology and Indigenous cultural significance.

The Campbellton Formation and Devonian Fossils

The Dalhousie-Campbellton area is renowned for its fossils, primarily preserved in the Lower Devonian Campbellton Formation. Dating back approximately 400 million years, this formation represents a subtropical basin from the Early Devonian period, a transformative era in Earth's history. The Campbellton Formation's rich fossil assemblages and paleoenvironmental features make it a key site for understanding evolutionary and ecological processes.

The Campbellton Formation contains a diverse array of fossils, including early plants, fish, invertebrates, and tetrapods, all of which provide critical insights into the Devonian period's evolutionary developments:

a. Rich Fossil Assemblage: Since the mid-19th century, the formation has yielded well-preserved fossils, including early vascular plants, jawed fish, and some of the earliest tetrapods. These discoveries illuminate the origins of modern ecosystems and the transition of life from water to land.

b. Paleoenvironmental Insights: The formation comprises coastal, riverine, and lacustrine environments within an intermontane basin, offering clues about subtropical ecological dynamics. These fossils document a landscape where plants colonized land, stabilizing soils and creating new habitats, which in turn supported the diversification of terrestrial life.

c. Evolutionary Milestones: Fossils from this region capture pivotal stages in the evolution of vascular plants and vertebrates. Early jawed fish found here shed light on the origins of modern vertebrate structures, while plant fossils trace the spread of vascular systems critical for life on land.

Dalhousie Mountain and Volcanic History

Dalhousie Mountain and its surrounding formations are part of a geologically dynamic history, with evidence of ancient volcanic activity that shaped the region's landscape. This volcanic past contributed to the unique mineralogy and stratigraphy of the area, influencing the sedimentary environments in which Devonian fossils were

preserved. The volcanic features also hold cultural significance for the Mi'gmaw People, serving as sites of spiritual importance and as sources for sacred rocks such as those used for sweat lodge ceremonies.

Miguasha UNESCO Fossil Site

Located near the Campbellton Formation, the Miguasha National Park (Megwa'saq) in Quebec is recognized as a UNESCO World Heritage Site. Known as one of the world's most significant Devonian fossil sites, Miguasha preserves an extraordinary record of vertebrate evolution. Fossils found here include early sarcopterygian (lobe-finned) fish, which are ancestors of all terrestrial vertebrates. These fossils provide unparalleled insight into the "Age of Fishes" and the evolutionary transition to tetrapods.

The proximity of Miguasha to the Dalhousie-Campbellton area enhances the regional significance as a paleontological hotspot. Together, these sites offer complementary views of the Devonian ecosystems and evolutionary milestones.

Cultural and Archaeological Importance

The geological and paleontological significance of the Dalhousie region is mirrored by its cultural importance to the Mi'gmaw People. Dalhousie Mountain and other local sites contain petroglyphs, sacred rocks, and evidence of long-standing occupancy and relationships with lands and waters. The Mi'gmaq recognize the area as deeply intertwined with their heritage, with place names, oral histories, and archeological sites reflecting its enduring significance. The Dalhousie-Campbellton area is a site of unparalleled importance, offering insights into the Devonian era's evolutionary breakthroughs, a record of volcanic and sedimentary processes, and a connection to Indigenous cultural heritage. Coupled with the UNESCO-designated Miguasha fossil site, this region represents a critical resource for scientific research and cultural understanding. Efforts to preserve and study these sites are essential to safeguarding their value for future generations, ensuring that their contributions to both science and culture remain enduring.

The Path Forward

Learning from Cumulative Effects and Teachings

To address cumulative effects and respect the carrying capacity of Mother Earth, Elder Marshall advocates for:

1. A Shift in Perspective: Recognizing that humanity is part of nature, not separate from it, and fostering a relationship of respect and reciprocity.
2. Holistic Approaches: Incorporating cumulative effects into decision-making processes, ensuring that long-term and interconnected impacts are assessed and mitigated.
3. Indigenous Knowledge and Two-Eyed Seeing: Drawing on Indigenous wisdom, such as that shared by Elder Marshall, to balance modern scientific approaches with traditional ecological knowledge.
4. Stewardship Over Exploitation: Transitioning from exploitative resource use to practices that support regeneration, sustainability, and harmony with natural cycles.

By heeding these lessons and addressing cumulative effects, we can work toward restoring balance and ensuring that Mother Earth's carrying capacity is respected for generations to come.

Cumulative thinking can preserve individual and community well-being for Reconciliation. In Reed et al. (2024), "All Our Relations," visually depicts this concept. It illustrates the interconnectedness of various elements, including Traditional ways and knowledge, Honouring Mother Earth. Resource extraction and industry, Colonisation, Youth and future generations, Specific health impacts, Land degradation.

"Over history, we have not had it easy. With colonial pressures from the government and mining companies, the harm done through the [Indian] Residential School System, our forced removal from our traditional communities and Lands, along with many other influences that exist in our lives today, we have an uphill battle. But our Elders fought and died for our Land, and we have a duty to continue to protect it. There is strength and resilience in our people and in our community when we come together. We have the wisdom. We are the original land stewards."

– Excerpt from Ross River Dena Council and The Arctic Institute of Community-Based Research, 2019, p. 8.

Figure 4: All Our Relations.
Source: Galway et al., 2022

Recognizing systemic issues to disrupt the status quo

"Pollution in colonialism" refers to the environmental degradation resulting from colonial and post-colonial activities, particularly in Indigenous and marginalised communities, where large-scale development projects have been imposed without consent or regard for local ecosystems. This legacy of colonialism often leads to the over-exploitation of resources, ignoring the carrying capacity of Mother Earth, an essential concept in Indigenous perspectives on environmental stewardship.

1. **Disregard for Carrying Capacity**: Colonial development practices, including resource extraction, infrastructure projects, and industrial expansion, typically focus on profit over sustainability, often ignoring the carrying capacity of local ecosystems. Carrying capacity, the threshold at which an environment can support a population or industry without degrading, is frequently overlooked, leading to deforestation, overfishing, mining, and other resource-intensive activities. Indigenous communities, who view the land as a sacred being that requires careful management, witness firsthand the devastating effects of projects that push ecosystems beyond their limits. This disregards the interdependence within ecosystems, which Indigenous knowledge systems have

long upheld, recognizing the need to respect natural limits to maintain ecological balance.

2. **Environmental Racism**: Environmental racism refers to the disproportionate impact of environmental hazards on people of colour and Indigenous communities. Under colonialism, Indigenous lands were often chosen for high-pollution projects like mining, waste disposal, and heavy industries because they were geographically and politically marginalised. These communities continue to bear the brunt of environmental degradation, experiencing higher rates of health issues, contamination of natural resources, and loss of traditional lands. Moreover, decision-makers often fail to consult with local Indigenous populations or disregard their objections, perpetuating a system where these communities are left to deal with severe environmental and health consequences with limited legal or financial recourse.
3. **Cumulative Effects of Past Industry**: The cumulative effects of past industries compound environmental degradation, especially in areas with a long history of industrial activity. Mining, pulp and paper mills, oil and gas extraction, and similar industries have left a legacy of contamination, often with no remediation efforts, leading to a cascade of ecological impacts over time. For example, contaminated waterways disrupt local food sources, degrade water quality, and harm wildlife, all of which are crucial for the livelihoods and cultural practices of local Indigenous communities. When new development projects are introduced, they add further strain on these already compromised ecosystems, exacerbating the damage and diminishing resilience.
4. **Lack of Remediation Efforts**: In areas heavily impacted by industry and contamination, a failure to conduct remediation or restoration efforts compounds the damage caused by colonial pollution. Without proper cleanup or recovery measures, toxic materials remain in the soil, water, and air, creating persistent health risks for local communities and disrupting natural cycles essential for ecosystem balance. Remediation is often neglected due to the high costs or political complexities involved, leaving impacted communities with enduring contamination and weakened ecosystems that make them vulnerable to future industrial projects.

In sum, pollution in colonialism represents more than environmental degradation; it is a form of ongoing violence against Indigenous communities, perpetuated through disregard for ecological limits, environmental racism, cumulative industrial impacts, and systemic failure to remediate contaminated sites. Addressing these issues requires not only legal and regulatory changes but also a deep respect for Indigenous Knowledge Systems and the carrying capacity of Mother Earth, ensuring that future development practices honour ecological integrity and community well-being.

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