Requests to Federal Agencies and Departments for the Regional Assessment in the Ring of Fire Area from the Regional Assessment Working Group – Package 1

Date: September 25, 2025

Guidance

Please submit responses by **October 31, 2025** via email sent to regionalrof-cdfregionale@iaac-aeic.gc.ca. If you need more time to respond, please provide a progress update by the deadline.

Table 1 below lists all general and targeted requests developed by Regional Assessment Working Group ("Working Group"). The Impact Assessment Agency of Canada has identified recipients by relevance to the topic of the requests. In case any were missed, we encourage all federal departments or agencies that are part of the federal review team to read all requests and respond if you have relevant expertise. If you have already provided the requested information in a previous submission, you may simplify your response by including a reference instead of repeating the information.

The Working Group encourages you to respond in **plain language,** and, where appropriate, to presenting information in graphic formats in addition to text.

Context

The federal review team has provided the Working Group with information to support the Regional Assessment process, such as past and ongoing programs, expertise, funding and other references to relevant initiatives. This information was shared via Federal Authority Advice Records (FAARs) received in March and September 2025, presentations provided on June 4 and 5, 2025, and some via response to the Public Call for Information.

In certain instances, the federal review team made references to initiatives (funding, projects, programs) to which they contribute or collaborate in with other parties, such as academia, industry, other jurisdictions (provincial, municipal), and non-governmental organizations. The Working Group would like to obtain more detail to better understand all projects and initiatives currently underway in the Ring of Fire Area and draw upon the available expertise that is relevant to the assessment priorities listed in section 7.5 of the Terms of Reference. The Working Group is developing an inventory of the programs and initiatives relevant its assessment priorities. Understanding these as well as the various roles and responsibilities from all relevant parties will help the Working Group draft the interim and final reports, including to fulfil the requirement of its Terms of Reference to formulate recommendations to appropriate entities.

References

- Presentations to Regional Assessment Working Group *(*CIAR 186)
- Federal Authority Advice Records (FAARs) and other submissions:
    - Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) (CIAR 179)
    - Environment and Climate Change Canada (ECCC) (CIAR 169),
    - Employment and Social Development Canada (ESDC) (CIAR 170),
    - Federal Economic Development Initiative for Northern Ontario (FedNor) (CIAR 173),
    - Fisheries and Oceans Canada (DFO) (CIAR 167),
    - Health Canada (CIAR 180),
    - Indigenous Services Canada (ISC) (CIAR 177),
    - Natural Resources Canada (NRCan) (CIAR 178),
    - Transport Canada (CIAR 176),
    - Women and Gender Equality Canada (WAGE) (CIAR 166),
    - Agriculture and Agri-Food Canada (AAFC) (CIAR 195),
    - Library and Archives Canada (LAC) (CIAR 197),
    - Housing, Infrastructure and Communities Canada (HICC) (CIAR pending),
    - Canada Mortgage and Housing Corporation (CMHC) (CIAR pending),
    - Public Health Agency of Canada (PHAC) (CIAR 196),
    - Innovation, Science and Economic Development Canada (ISED) (CIAR pending),
    - Statistics Canada (CIAR pending)
- Call for Information and Data (CIAR 191)

Table 1. Overview – List of Requests and Targeted Recipients

Federal agencies and departments are invited to provide responses to all requests for which they have relevant expertise. The Table below identifies who the Working Group believes might have relevant expertise to contribute, without limiting who can respond.

#	Request	AAFC	CIRNAC	CMHC	ECCC	ESDC	FEDNOR	DFO	Health Canada	HICC	ISED	ISC	LAC	NRCAN	Parks Canada	PHAC	Statistics Canada	Transport Canada	WAGE
1	Projects and Initiatives relevant for the Ring of Fire Area	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Priority topics identified by the Working Group – Information and Gaps	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Critical Minerals Strategy – Economics				X						X			X					
4	River systems – Scale of studies, existing information and gaps				X			X						X				X	
5	Community wellbeing, Education, Training and Employment					X	X		X			X							X
6	Health Inequity								X							X			
7	Homelands and Reservations, and Housing			X								X							
8	Species at Risk						X					X							
9	Protected Areas				X			X							X				
10	Federal Initiative on Consultation		X																
11	Bird Conservation Strategy				X														
12	Treaty Rights and Wildlife Management		X		X			X				X							
13	Cumulative Effects Assessments				X														
14	Capacity-building											X							
15	Education and literacy											X							
16	Food Security and Nutrition	X										X							

#	Request	AAFC	CIRNAC	CMHC	ECCC	ESDC	FEDNOR	DFO	Health Canada	HICC	ISED	ISC	LAC	NRCAN	Parks Canada	PHAC	Statistics Canada	Transport Canada	WAGE
17	Language Revival and Cultural Heritage											X	X						
18	Development Scenarios																	X	
19	Feasibility of development in this area				X						X			X				X	

Table 2. Requests to Federal Agencies and Departments

#	Targeted recipient(s)	Topic	Request
1	**All**	**Projects and Initiatives relevant for the Ring of Fire Area**	a) Provide a list of the projects and initiatives in which you are involved in that relate to the Ring of Fire Assessment Area. For each item, include: i. Project name, description and timeframe ii. Lead organization iii. Other collaborators iv. Your role v. Geographic location (include maps if available) b) Explain if and how Indigenous Nations and communities in the Ring of Fire Area collaborated in these projects and initiatives. c) Would you be willing to give a public presentation about any of these initiatives to the working group, and if so which ones? **NRCan Response:** In addition to the projects and initiatives detailed in our Federal Authority Advice Record in the Canadian Impact Assessment Registry, NRCan would like to highlight: **a) Snow Dynamics (M. Bonney, Y. Zhang)** i. Canada-wide 30-m resolution snow dynamics, spatial information on the date of snow melt (end date), snow fall (start date), and snow cover duration (length) from satellites for each winter, 2018-2019 to 2023-2024 (and on-going) (See Figure 2 in Ring of Fire report under Indicator 2) ii. Canada Centre for Remote Sensing iii. Parks Canada, Mushkegowuk Council iv. Remote Sensing Physical Scientist v. Canada-wide (See Figure 1 below for extent)

Fig. 1. Spatial coverage of Canada-wide outputs. Includes Canada's landmass and waters up to 10 km from the coast. Over water, the product tracks ice changes.

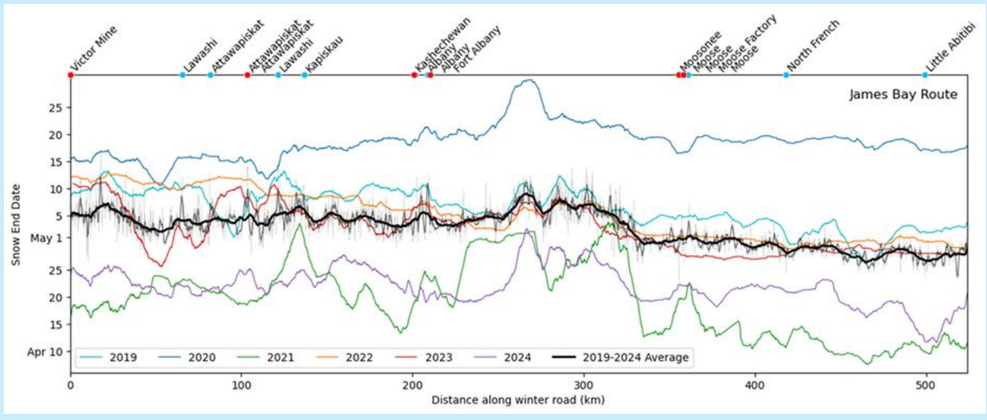

Fig. 2. Variability in snow melt dates along the James Bay winter road (2019-2024), here plotted from Victor Mine to the edge of the Hudson Bay Lowlands. Different line colors represent different years, with points of interest shown above the plot (red: communities, cyan: major rivers). We can use this information to identify the earliest melting sections of the winter road.

b) Mushkegowuk Council has been a collaborating on this project in the Hudson Bay area, especially regarding utility for monitoring winter roads and river ice break up.

			c) NRCan is willing to publicly present or discuss any of the department's initiatives identified in the FAARs or this submission for the Regional Assessment Working Group.
2	**All**	**Priority topics identified by the Working Group – Information and Gaps**	In the Call for Information and Data, the Working Group identified **key priorities** for information gathering and gap identification at this time. Table 3 reflects these key priorities. Referring to the priorities and issues listed in Table 3, based on your expertise, provide advice on: a) the best sources of existing data, including means to access it, b) adequate spatial and temporal boundaries to assess impacts, c) key indicators to describe potential impacts, d) known data gaps or uncertainties, and e) suggestions for studies or other ways to fill those gaps. **NRCan Response:** In addition to the NRCan guidance provided below, NRCan in collaboration with ECCC leads the Government of Canada's Open Science and Data Platform, a public facing tool providing single window access to federal, provincial and territorial data, science and regulatory information to support the understanding of cumulative effects and inform impact assessment processes. In collaboration with IAAC, NRCan developed a curated content collection focused on the Ring of Fire region in Northern Ontario which features content that supports understanding of cumulative effects. **Priority - Water and river systems, including flows - Groundwater** a) the best sources of existing data, including means to access it, a. Most available information comes from individual project studies, such as Eagle's Nest, Cliff's Chromite and Victor mines, as well as academic research. Other reliable data sources should originate from provincial agencies. For example, Ontario's Provincial Groundwater Monitoring Network provides valuable information, although it appears there is no sampling of groundwater data specifically for the Ring of Fire region: https://data.ontario.ca/dataset/provincial-groundwater-monitoring-network. The Groundwater Information Network shows some historic sampling in the region that is sparse and fragmented. b) adequate spatial and temporal boundaries to assess impacts, a. It is strongly recommended to employ models at the watershed scale, although this approach should not be considered limiting. Groundwater flow often transcends watershed boundaries, particularly under altered hydrogeological conditions. For instance, anthropogenic disturbances such as aquifer drawdown resulting from mining excavations can significantly modify natural flow regimes, leading to cross-boundary interactions that must be accounted for in conceptual and numerical models. c) key indicators to describe potential impacts, a. Mining operations in the Ring of Fire region may exert significant pressure on both groundwater and surface water systems. Potential impacts can be identified through several key hydrogeological indicators. These include unnatural fluctuations in groundwater and surface water levels, which may result from direct anthropogenic activities or be compounded by climate change effects. Alterations in recharge rates and baseflow contributions to streams are also critical, as they can disrupt the hydrological balance and affect aquatic ecosystems. Additionally, shifts in water geochemical conditions serve as important indicators of environmental stress. d) known data gaps or uncertainties, and

			a. Mining development in the Ring of Fire region presents significant challenges and uncertainties for groundwater and surface water systems. A thorough understanding of the hydrogeological context is essential for predicting environmental impacts and guiding sustainable resource management. Hydrogeological data in the region is sparse and fragmented. However, there is a lack of regional-scale monitoring and baseline data. The subsurface geology is complex and poorly understood, particularly in terms of aquifer geometry, hydraulic connectivity, and flow regimes. Mining-induced drawdown effects on regional groundwater flow are not well constrained. Hydrological connectivity between wetlands, peatlands, and aquifers is also not well characterized. Additionally, there is insufficient data on natural background water quality and geochemical baselines. The potential for contaminant migration from tailings, waste rock, or disturbed soils into groundwater is not well quantified. Combined impacts of climate variability and mining activities on recharge, evapotranspiration, and water table dynamics are not adequately modeled. e) suggestions for studies or other ways to fill those gaps. a. To address these gaps, comprehensive field investigations are needed, including the installation of monitoring wells across key geological units and wetland interfaces. Aquifer tests should be conducted to determine hydraulic properties. Robust conceptual models informed by field data and geophysical surveys should be developed, followed by numerical models to simulate groundwater flow, contaminant transport, and climate scenarios. Regional water quality benchmarks for both groundwater and surface water should be established, with sampling campaigns that account for seasonal and spatial variability. Surface-groundwater interaction studies are also recommended to quantify exchanges between wetlands and aquifers. All studies and modelling efforts should adhere to the Impact Assessment Agency of Canada's Regional Assessment Terms of Reference and emphasize Indigenous knowledge, cumulative effects, and long-term sustainability. Additionally, NRCan has published: • **Terrestrial Water Status and Trends. (S. Wang)**. o The Canada Centre for Mapping and Earth Observation of NRCan, produces datasets on groundwater storage change and groundwater recharge at national scale, including the Ring of Fire region. These datasets extend beyond the information presented in the report (enclosure 1) "Ring of Fire: Satellite Monitoring of Environmental Indicators" (see Indicator 5: Terrestrial Water Storage), providing long-term historical context on groundwater storage changes and groundwater recharge under natural conditions over the past several decades. The datasets are available at the river-system (watershed) scale for each river identified within the Ring of Fire region. o The information could support efforts on: ▪ Understanding the long-term impacts of climate change on groundwater dynamics; ▪ Informing sustainable resource management; ▪ Guiding planning and adaptation for extreme climate events. **Priority – Water and river systems, including flows – Mining processes and aquatic ecosystems** NRCan has expertise focused on how mining effluent, excavated materials and processed tailings affect aquatic ecosystems. NRCan leads research on chromium behaviour in northern settings, including pilot-scale testing of Ring of Fire chromite to understand how Cr(VI) forms and moves in water. In addition, NRCan provides expert advice on the adequacy of metal leaching and acid rock drainage (ML/ARD) predictions of excavated materials and processed tailings during federal Impact Assessments. This review of the "source term" is paramount as it serves as input in environmental and human health risk assessment models used to design mitigation measures (i.e. effluent treatment requirements, design of structures and barriers within tailing and waste rock management areas) at proposed mine sites. This information is then transmitted to other federal and provincial departments and agencies to support permitting decisions.

			Since all mitigation measures for mining projects are designed with environmental risk assessment models, information not necessarily specific to the Ring of Fire may be relevant in the development of such models. As such, ample historical and potentially relevant studies were carried out through the Mine Environment Neutral Drainage (MEND) Program, which NRCan, through CanmetMINING manages on behalf of the Mining Association of Canada. MEND projects develop and test methods to predict and prevent poor water quality from ML/ARD, and to evaluate effluent treatments that reduce ML/ARD and meet MDMER effluent and provincial limits before water is released.
			
			MEND 1.20.1 – Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (2009) – national guidance on ML/ARD prediction.
			• Where and when the data apply
			  ○ Applies to any mining project.
			• Useful indicators
			  ○ Series of tests required to assess ML/ARD
			• Main information gaps
			  ○ Like other new mining projects, site-specific water quality predictions are needed to support environmental risk models used to design mitigation measures in Impact Assessments. Excavated materials and tailings must first be fully characterized to predict ML/ARD potential and design appropriate treatment and rock and tailings management systems. While local data on treated effluent interactions are limited, these models can be applied along with representative baseline hydrology and water quality data.
			• Suggestions for studies or other ways to fill those gaps.
			  ○ Information provided in the MEND 1.20.1 could be useful in developing expectations regarding the development of source terms to be included in environmental risk assessment models used to design mitigation measures and hence, limit local and regional impacts.
			
			MEND "Drainage Monitoring" library – collection of monitoring case studies linking mine drainage to receiving-water chemistry.
			• Where and when the data apply
			  ○ National coverage across Canada since 1989, focused mainly on hard-rock mines; limited data for northern Ontario and Hudson Bay Lowlands.
			• Useful indicators
			  ○ Some past mining projects operated in similar geological setting to the Ring of Fire, which is situated in the massive Canadian Shield area, could report analog ML/ARD data such as pH, metals in tailings and waste rock seepage, and mining effluent.
			• Main information gaps
			  ○ Being at the conceptual stage, there is little information of potential mining projects to be permitted in the Ring of Fire regional assessment. Therefore, most impacts would be predictive in nature. Analog site data could provide evidence of potential ML/ARD effect to be mitigated.
			• Suggestions for studies or other ways to fill those gaps.
			  ○ The working group could look into similar geological settings to the Ring of Fire area for ML/ARD data that could be used to support environmental risk assessment models predicting water quality after mitigation measures are implemented.
			  ○ If a ferrochrome project is considered in the regional assessment area, the working group may want to consider the Mont-Wright Mine site situated on the Canadian Shield in Northern Quebec as an analog.
			
			Recent CanmetMINING research (Berryman et al. 2020–2022) looked at ferrochrome smelting using Ring of Fire ore.
			Berryman, E.J., Paktunc, D., Kingston, D., & Beukes, J.P. (2022). Composition and Cr- and Fe-speciation of dust generated during ferrochrome production in a DC arc furnace. Cleaner Engineering and Technology, 6, 100386. https://doi.org/10.1016/j.clet.2021.100386

			• Where and when the data apply
			  ○ Results from this work are most relevant where metals may be released from processing or waste materials and interact with peatlands, wetlands, and cold, low-oxygen waters typical of subarctic environments
			• Useful indicators
			  ○ Chromium release rates and associated pH
			• Main information gaps
			  ○ If a ferrochrome project is included in the cumulative assessment, this study may serve as a template for other research aimed at predicting how different metals could behave in northern environments—whether they stay trapped in peat or move into nearby water, how quickly they change form, and what that means for protecting rivers and wetlands in regions like the Ring of Fire.
			• Suggestions for studies or other ways to fill those gaps.
			  ○ This project data could help fill data gaps by serving as a template for assessing how metals of concern behave in northern environments. It could guide future studies, monitoring, and modelling efforts aimed at understanding metal movement, transformation, and potential effects on regional water and peatland systems.
			
			CanmetMINING geochemistry, drainage-chemistry and mitigation databases.
			• Where and when the data apply
			  ○ NRCan hosts internal and non-published databases that contain information on geological units and associated metal and sulfur content, static and kinetic leaching data of several metals. Since some of these geological units are found in the Ring of Fire, this information can be used in the Ring of Fire assessment.
			• Useful indicators
			  ○ For each relevant geological unit to the Ring of Fire, metal enrichment in rock, metal solubility data, and metal release rate data.
			• Main information gaps
			  ○ As there is little information about potential mining projects in the Ring of Fire area, the potential release rates associated with potential projects are required for a proper assessment of cumulative impacts.
			• Suggestions for studies or other ways to fill those gaps.
			  ○ The working group could list potential projects, their location and use the information provided in the database to develop conceptual risk assessment models to support their regional assessment.
			
			CanmetMINING Baseline water quality data
			• Where and when the data apply
			  ○ The water quality database provides baseline water quality data for several metals and pH, including the Ring of Fire area.
			• Useful indicators
			  ○ Baseline metal concentrations in water
			• Main information gaps
			  ○ This regional assessment will require baseline metal concentration in water. Baseline metal concentrations are to determine the incrementing metal load from mining projects to the receiving aquatic ecosystems. It is also needed to establish before and after control impact monitoring design to assess the impacts of mining projects when approved.
			• Suggestions for studies or other ways to fill those gaps.

			○ The working group could establish baseline metal concentrations in water from the Ontario provincial data: Provincial (Stream) Water Quality Monitoring Network - Dataset - Ontario Data Catalogue. This could also be done for groundwater: Provincial Groundwater Monitoring Network - Dataset - Ontario Data Catalogue Baseline concentrations are usually set by calculating the 95th percentile of each metal concentration distribution. See Sauve et al. 2021 for guidance on setting baseline concentrations. ▪ Sauvé, D., Clulow, V., & Goulet, R. R. (2021). Quantifying historical releases and pre-operation levels of metals and radionuclides. Journal of Environmental Radioactivity, 237, 106683. https://doi.org/10.1016/j.jenvrad.2021.106683 **CanmetMINING baseline** sediment information • Where and when the data apply ○ The Ring of Fire is situated on the Canadian Sheild. Some sediment core studies in rivers and lakes of the Canadian shield may be relevant to the Ring of Fire assessment. Such studies could serve as analog to reflect baseline metal concentrations (Sauvé et al., 2021) • Useful indicators ○ Baseline metal concentration in river and lake sediments • Main information gaps ○ This regional assessment will require baseline metal concentration in sediment. Baseline metal concentrations are to determine the incrementing metal load from mining projects to the receiving aquatic ecosystems. As a mine release their effluent over time, it is the accumulation of metals in sediment that present an incrementing risk to species living in sediments. It is also needed to establish before and after control impact monitoring design to assess the impacts of mining projects when approved. • Suggestions for studies or other ways to fill those gaps. ○ The working group could establish baseline metal concentrations in sediments. While every opportunity should be taken to collect baseline metal concentration in sediment through the GSC program, baseline sediment concentrations in Canadian shield lakes and rivers may be relevant (Sauvé et al 2021). Baseline concentrations are usually set by calculating the 95th percentile of each metal concentration distribution. See Sauve et al. 2021 for guidance on setting baseline concentrations and assessing the adequacy of the baseline metal concentration in sediment in Sauvé et al. 2021 for the Ring of Fire area. **Priority – Peatlands and other unique environments** NRCan has expertise on how northern peatlands and other organic-rich environments respond to mining-related disturbance and drainage. Pilot-scale research has shown that Cr(VI) can form under high-temperature smelting conditions but can later be reduced and trapped in peat, showing how organic matter and low-oxygen conditions help limit chromium movement. Ongoing work also looks at how mine dust can change peat chemistry and microbial activity, and how these changes might alter greenhouse gas capture. Another concern is that alkaline drainage or dust can raise the pH of peatlands, turning acidic bogs into more neutral fens. This shift changes vegetation, may reduce carbon storage, and weakens the peat's ability to retain certain metals. NRCan is also exploring natural stabilization methods, such as microbial binding and soil hardening, to reduce dust emissions while helping peatlands maintain their structure and resilience near mine sites. **Collaborative research with Ontario Ministry of Natural Resources and Forestry (OMNRF), Canadian Forest Service (CFS), and Lakehead University.** • Where and when the data apply ○ Boreal peatlands near active and historic mine sites in Ontario; data collection ongoing (2024–2026). • Useful indicators

			○ Dust composition (metals, nutrients), peat geochemistry (C, N, Fe, S), microbial community structure and function, and oxidation rates. ○ Mitigation measure: microbial binding and soil hardening potential • Main information gaps ○ Limited information exists on how metal-rich mine dust affects the long-term health of peatlands. It is not well known how dust changes acidity or microbial activity in peat, or how peatland microorganisms naturally help stabilize dust over time. • Suggestions for studies or other ways to fill those gaps. ○ The working group could investigate the usefulness of building pilot cover cells in Hudson Bay Lowlands peatlands to measure carbon and metal attenuation under cold conditions. ○ The working group could integrate such findings when available, either in the regional assessment or as a recommendation for future site-specific assessments. ○ The working group could continue integrating geochemical and microbial studies of mine-impacted peatlands; The working group could recommend evaluating biological dust suppression methods in peatlands to reduce metal dust dispersion and ecosystem impacts. **Ongoing CanmetMINING Climate Change Adaptation Program project (mine dust–peatland interaction) and Literature Review of climate change effects on Chromium Interaction with Peatlands (CanmetMINING, 2024)** • Where and when the data apply ○ As the Ring of Fire has several peatlands, – temperature and hydrological shifts linked to climate change can alter peat redox conditions and chromium and other metals mobility. • Useful indicators ○ Protection of peatlands from mining impacts requires data on peat geochemistry (C, N, Fe, S), microbial community structure and function (i.e. carbon capture measured as methane production). • Main information gaps ○ Limited data on how changing climate may affect the perennity of peatlands structure and functions such as sink for metals and carbon • Suggestions for studies or other ways to fill those gaps. ○ The working group could investigate the usefulness of building pilot cover cells in Hudson Bay Lowlands' peatlands to measure carbon and metal capture under changing climates. ○ The working group could integrate such findings when available, either in the regional assessment or as a recommendation for future site-specific assessments. ○ The Working group could recommend the continued integration of geochemical and microbial studies of mine-impacted peatlands under changing climates; **Priority – Climate change adaptation** Within the Ring of Fire regional assessment, consideration could be towards mitigation measures to be implemented during closure of tailings and waste rock management facilities. When designing closure mitigation measures, it is important to consider changing climates. NRCan, through the Mine Environment Neutral Drainage (MEND) Program, studied how climate change can affect drainage chemistry and the performance of mitigation systems. Changes in temperature, rainfall, permafrost thaw, and freeze–thaw cycles can alter how oxygen and water move through waste rock, tailings, and cover systems, influencing how long these remain effective. In addition, NRCan research funded by the Climate Change adaptation program currently examines how a warming and drying climate may affect cover performance. Changing climate can also increase dust generation and affect water quality and peatland function near northern mine sites, helping to adapt drainage and dust-control designs to future conditions.

			MEND 1.61.4 – Covers for Reactive Tailings Located in Permafrost Regions – performance of frozen and saturated covers in permafrost. **MEND 1.61.5a – Mine Waste Covers in Cold Regions** – long-term behaviour of cover materials under freeze–thaw and variable moisture. **MEND 2.18.1 - Review of Water Cover Sites and Research Projects** – case studies of cold-region tailings and climate resilience. **Clemente & Huntsman (2019)** Potential climate change effects on the geochemical stability of waste and mobility of elements in receiving environments for Canadian metal mines south of 60°N **Gagné-Turcotte, R., Reynier, N., Lariviere, D., Zagrtdenov, N.R., Goulet, R.R., Huntsman, P.** Impact of variability in precipitation patterns on the geochemistry of pyritic uranium mine tailings rehabilitated with saturated cover technology. Mining 2022, 2, 385–401. https://doi.org/10.3390/mining2020020 • Where and when the data apply ○ Arctic to sub-arctic mine sites across Canada, including permafrost and peatland settings; some data extend 20–30 years post-closure. Records cover climate ranges from –25 °C to +10 °C, seasonal thaw cycles, and recent observations of warming trends affecting active-layer depth, water balance, and cover stability in northern environments. • Useful indicators ○ Dry covers: Cover temperature and moisture; permafrost thickness; oxygen movement; seepage chemistry (pH, sulfate, metals); rate of freeze–thaw damage. ○ Water covers: water level variations, effects on metal mobility • Main information gaps ○ May be limited applicable data on dry cover performance to the Ring of Fire region available in the grey and open literature. If water covers are identified as mitigation within the Ring of Fire area, the effect of water level variation on the potential release of ML/ARD would be a gap in this area. • Suggestions for studies or other ways to fill those gaps. ○ The working group could review the recommendations of Clemente and Huntsman on how to integrate climate changes in the management of waste. ○ The working group could then identify relevant climate-change scenarios to drainage-chemistry and dry/water cover-performance models. ○ The working group could then review MEND 1.61.5a, as well as chapters 10 to 14 of Hard Rock Mine Reclamation | From Prediction to Management of Acid Mine Reclamation to determine the applicability of these studies to the Ring of Fire. ○ If case studies are of limited use, the working group could consider commissioning or recommending studies that instrument northern cover test cells with temperature, moisture, and oxygen sensors to track long-term trends as well as studies on water cover technology. **Wildlife and wildlife habitat, including species at risk, migratory birds, and fish and fish habitat** NRCan, through the Mine Environment Neutral Drainage (MEND) Program, supports biodiversity, aquatic habitat protection, and human health by providing information on source-term prediction (i.e. predicted drainage chemistry) and mitigation performance. This work helps departments such as Impact Assessment Agency, Environment and Climate Change Canada (ECCC), Fisheries and Oceans Canada (DFO), and Health Canada assess if mitigation measures are adequate and that the predicted residual effects are conservative to support their permitting decisions. **MEND 3.14.1 – Review of Passive Systems for Treatment of Acid Mine Drainage** – shows how wetland and anaerobic systems remove metals • Where and when the data apply ○ Data and case studies from active and closed mines across Canada (1989–present). Most datasets come from temperate and sub-arctic regions;

			• Useful indicators
			  ○ Mine water treatment effluent limits including MDMER parameters listed in Annex 4.
			• Main information gaps
			  ○ Whether peatlands are sink or sources of metals depend on several parameters, such as water residence time, hydrological regime (dry or saturated), temperature, diel cycles, and redox conditions (i.e. reducing conditions favor precipitation of metals as sulfide forms while oxic conditions induce by drying of the peatland may oxidize these minerals and favor remobilisation.
			• suggestions for studies or other ways to fill those gaps.
			  ○ The working group could review MEND 1.62.3 and identify geochemical peatland studies that may be applicable to the Ring of Fire area.
			  ○ The working group may also request monitoring reports of the Island Fen study at the Cluff Lake site from the Province of Saskatchewan or the Canadian Nuclear Safety Commission. This study provides information on how different hydrological regimes affect the stability of metals in a peatland fed for decades with mine water.
			  ○ Based on available data, the working group should develop regional models to better estimate cumulative exposure in northern aquatic environments. Note that this requires an assessment of the number, location and type of mining in the region.
			  ○ Depending on the number of relevant studies, the working group may either commission or recommend further studies on the fate of metal in peatlands under varying temperature and hydrological regimes.
			
			MEND 2.50.1 – Tailings Management Technologies (Encapsulation in Permafrost) – addresses long-term containment of tailings that could affect aquatic habitats.
			• Where and when the data apply
			  ○ Most data come from temperate and sub-arctic regions, but some results can help understand conditions in northern and peatland areas such as the Ring of Fire.
			• Useful indicators
			  ○ Shows how conventional, thickened, paste, filtered, and water-covered tailings perform for water recovery, stability, and seepage control under different Canadian climate conditions.
			• Main information gaps
			  ○ Limited field data exist for thickened, paste, and filtered tailings in cold or wet climates. Few studies assess geochemical changes, oxygen transfer, or climate effects on drainage and consolidation. Long-term cover stability in permafrost and saturated conditions remains poorly understood.
			• Suggestions for studies or other ways to fill those gaps.
			  ○ The working group could review the MEND report and determine if studies may be applicable to the Ring of Fire area. If relevant analogs are found, the working group could collect the monitoring data from northern mines using dewatered or underwater storage, and report how cold, wet climates affect drainage and cover performance.
			  ○ If there are limited data on performance of tailings management technologies under similar climate and geology, the working group should recommend further studies.
			
			While not explicitly tied to a priority in Table 3, NRCan has also conducted earth observation research related to land cover and deformation that could contribute to the understanding of listed priorities, such as critical habitat and wetlands.
			Land cover (F. Mohammadimanesh):

			a) The most suitable sources of data for continuous land cover mapping and monitoring in the ROF area are freely available satellite datasets from the Landsat and Sentinel-2 missions. The Landsat program provides a consistent archive of Earth observations dating back to the 1980s, with a 30-meter spatial resolution. This long-term record makes Landsat data ideal for land cover classification and historical change detection over the past four decades. The Sentinel-2 mission, operational since 2015, offers higher spatial resolution imagery (10 meters) and more frequent revisit times. It serves as a valuable complement to Landsat data, enabling detailed and up-to-date land cover mapping and improved detection of recent landscape changes. Both datasets are publicly accessible through platforms such as: USGS EarthExplorer, Copernicus Open Access Hub, and Google Earth Engine. b) The spatial and temporal resolutions offered by both Landsat and Sentinel-2 are well-suited for assessing land cover dynamics within the ROF area. For long-term analysis, the Landsat time series provides sufficient temporal coverage to detect gradual changes dating back to the 1980s, when most observed variations are expected to be associated with natural processes rather than anthropogenic developments, particularly for changes prior to 2010. For more recent and future monitoring, the Sentinel-2 dataset can also be beneficial as it provides enhanced spatial detail at 10 meters resolution, making it suitable for detecting and assessing impacts related to human activities and infrastructure development across the entire ROF boundary c) Land cover mapping and classification are fundamental for supporting environmental impact assessments (EIAs), providing critical spatial information to evaluate how future developments may affect ecosystems, water resources, and local communities. Accurate and up-to-date land cover data form the foundation for assessing potential disturbances, quantifying habitat loss, monitoring cumulative effects, and guiding evidence-based and sustainable decision-making. The ROF landscape is characterized by extensive boreal forests and peatland wetlands, each playing distinct yet interconnected ecological roles. Using satellite observations, a methodology has been developed to generate land cover classification maps for the region, distinguishing 10 land cover categories, including forest and wetland classes. Future study will focus on long-term analyses of satellite observations to detect historical changes and provide a baseline for evaluating future impacts on these key ecosystems. d) Up-to-date information about the current status of different land cover categories and monitoring of changes (both over the past and future) using remote sensing data and techniques should address data gaps and information regarding biodiversity and habitat changes. e) To address the identified data gaps, several complementary approaches can be employed. Traditional field-based studies conducted through targeted field campaigns can provide valuable on-the-ground information about land cover types and conditions. Although such efforts are labour-intensive, costly, and limited in temporal coverage, they offer essential reference data that can significantly improve the accuracy and validation of satellite-derived land cover maps. In addition, future work could explore the use of higher-resolution imagery (e.g., PlanetScope or commercial data) or drone-based surveys to provide finer-scale validation and bridge remaining gaps in spatial and thematic accuracy if such fine scale studies are deemed necessary. **Pilot National-Scale Mapping of Active Ground Deformation Processes in Canada project, led by S. Samsonov at NRCAN since 2017** • Delivers high-resolution, multiyear map of ground deformation across Canada, capturing subtle ground movement and derived from Sentinel-1 Synthetic Aperture Radar data collected during snow-free seasons. Leveraging advanced interferometric analysis with the Multidimensional Small Baseline Subset (MSBAS) Software Version 10 at the Canada Centre for Mapping and Earth Observation, Natural Resources Canada, this project isolates small-scale deformation signals from broader tectonic and postglacial processes, revealing critical ground shifts linked to phenomena such as landslides and mining activities. This map provides essential data supporting the Regional Assessment in the Ring of Fire area by enhancing the understanding of geohazards and informing sustainable resource development. The project establishes a national framework for continuous monitoring, hazard assessment, and infrastructure planning, with future enhancements anticipated to improve accuracy and reduce processing artifacts. The dataset is publicly accessible at https://app.geo.ca/en-ca/map-browser/record/1da588c1-0dc6-45e4-9e63-9acf2fdc353a.
3	ECCC, ISED, and **NRCan**	**Critical Minerals Strategy – Economics and Valuation**	The Working Group requires information to better understand how industry and governments estimate potential benefits from critical mineral development. a) Describe and explain the choice of methods used in federal reporting to estimate economic benefits related to mining critical minerals in the Ring of Fire Area.

NRCan Response:

Use of Input-Output (IO) models is recommended. These models, developed by Statistics Canada, are designed to show how different parts of the economy are linked together.

For the quantitative assessment of economic effects—such as job creation, GDP contributions, and overall economic activity—the proponent is encouraged to use IO models, including Statistics Canada's public IO model. These models not only provide estimates of economic impacts but also illustrate the supply chain linkages that mining activities create.

The IO model breaks down impacts into three main categories:

- Direct impacts: jobs and income generated at the mine site itself.
- Indirect impacts: activity created when suppliers provide goods and services (e.g., equipment, fuel, construction).
- Induced impacts: additional economic activity that happens when workers spend their wages in the broader economy (e.g., housing, groceries, services).

By capturing these layers, IO models allow us to go beyond simple job counts to present a clearer, system-wide picture of how critical mineral development can support communities, supply chains, and Canada's economy as a whole.

The Working Group could consult IAAC guidance developed on economic effects which would provide valuable insights into methodological approaches, data requirements, and best practices aligned with Government of Canada expectations.

b) Share any information you have about how financial revenues from mining in the Ring of Fire might flow to various parties, such as who would benefit at local, regional, national, and international scales. In addition, or if this information is not available, please recommend:

i. existing case studies that could be used as examples, and

NRCan Response:

- **Crawford (Canada Nickel) Impact Statement and technical reviews** — While not within the ROF region, the IS for this project contains project-level economic and socio-economic analysis.
- **Industry / regional analyses on the Ring of Fire** — reports from the Ontario Chamber of Commerce and Northern development organizations that use IO-style assessments (direct, indirect, induced impacts) to estimate jobs and GDP effects.
- **Comparative and policy studies** on mining regions and revenue management (useful for methodology and lessons learned) — OECD case studies on mining regions and Mining2030 / PwC reports that discuss revenue transfers, local benefits, and governance.

ii. sources of expertise within or outside government that could be approached by the Working Group to provide this information.

NRCan Response:

- **Statistics Canada — Input-Output / regional accounts team** (for IO models and provincial multipliers). They publish public IO models and can advise on model use. Input-output multipliers, summary level, Input-output multipliers, summary level - Open Government Portal
- **Natural Resources Canada (NRCan)** — Mining data, statistics and analysis - Natural Resources Canada, Minerals and Metals Facts - Natural Resources Canada
- **The Mining Association of Canada**— Mining Facts - The Mining Association of Canada, Mining Association of Canada Report: Canadian Mining Facts and Figures 2024 | MineConnect
- **Ontario Ministry of Northern Development / Mines** — Ontario's Ring of Fire | ontario.ca, Search | Ministry of Northern Development and Mines,

			c) Explain if and how the federal government has conducted studies to value potentially impacted ecosystem goods and services in comparison to projected revenues from critical minerals mining. **NRCan Response** NRCan has no input to provide
4	DFO, ECCC, Transport Canada, and **NRCan**	**River systems – Scale of studies, existing information and gaps**	The Working Group is interested in baseline studies and analyses of potential impacts at a river-system scale related to geochemistry, hydrogeology, hydrology, water quality and quantify, fish and aquatic wildlife, and navigability. a) Identify existing studies at the spatial scale of the major river systems in the Ring of Fire Assessment Area, i.e.: Abitibi River, Attawapiskat River, Ekwan River, Kenogami River, Mattagami River, Missinabi River, Moose River, the Lower and Upper Albany Rivers, and the Winisk River. **NRCan Response:** SAR Toolbox lake ice breakup method. **(J. van der Sanden)** Earth Observation (both optical and radar) would be a good tool for the mapping of the mentioned river systems as well as for the monitoring of certain changes in these systems. Some information regarding these systems will be available in Canada's National Hydrographic Network database. Snow Dynamics (M. Bonney, Y. Zhang) Over water, our snow dynamics products track the timing of ice break up and freezing. We are using this product to track ice break up and freezing dates along 16 major rivers (Churchill, Nelson, Hayes, Severn, Winisk, Ekwan, Attawapiskat, Kapiskau, Albany, Moose, Harricana, Missiscabi, Nottaway, Rupert, Pontax, Eastmain) across the Hudson Bay Lowlands at the request of the Mushkegowuk Council. We can observe, for example, how hydroelectric dams influence river ice dynamics. In addition to the above studies developed by NRCan there is the Ontario's Provincial Stream Water Quality Monitoring Network tracks water quality at 400+ stream sites since 1964, including four sites in the Ring of Fire region. https://data.ontario.ca/dataset/provincial-stream-water-quality-monitoring-network b) If this information does not exist, advise on how it would be possible to obtain portraits of these river systems, including if there are plans underway to conduct these studies. **NRCan Response:** Mining development in the Ring of Fire region presents significant challenges and uncertainties for groundwater and surface water systems. A thorough understanding of the hydrogeological context is essential for predicting environmental impacts and guiding sustainable resource management. Hydrogeological data in the region is sparse and fragmented and there is a lack of regional-scale monitoring and baseline data. The subsurface geology is complex and poorly understood, particularly in terms of aquifer geometry, hydraulic connectivity, and flow regimes. Mining-induced drawdown effects on regional groundwater flow are not well constrained. Hydrological connectivity between wetlands, peatlands, and aquifers is also not well characterized. Additionally, there is insufficient data on natural background water quality and geochemical baselines. The potential for contaminant migration from tailings, waste rock, or disturbed soils into groundwater is not well quantified. Combined impacts of climate variability and mining activities on recharge, evapotranspiration, and water table dynamics are not adequately modeled.

c) Based on your experience in project-level impact assessments, advise whether there are standard mitigation measures that may be applicable to protect the water systems in the Ring of Fire assessment area from potential impacts for development activities in general.

NRCan Response:

Within NRCan, there is expertise pertaining to how mine waste and tailings can affect water and river systems through changes in water and sediment chemistry. To protect water quality, Canadian mines use a mix of prevention, control, and treatment methods that reduce ML/ARD. There are also other mitigation options not listed here that can be used together with these methods to improve performance.

Common approaches include:

1. **Preventing ML/ARD**
   - Test and separate waste rock based on its potential to create acidic drainage (segregation by acid-generating potential).
   - Mix or blend materials with higher and lower reactivity to balance chemical reactions (blending or co-disposal).
   - Place reactive materials underwater or keep them permanently saturated leading to lower oxidation of sulfide minerals (subaqueous in-pit disposal or water cover, numerous reports and studies at MEND).
2. **Controlling how water moves through mine waste**
   - Build soil, till, or peat covers that limit oxygen and water infiltration (engineered cover systems).
   - Collect seepage and runoff in ditches, trenches, or ponds so it can be treated before release (seepage collection and interception systems).
   - Use liners and underdrains in tailings areas to reduce leakage to groundwater (seepage control and containment systems).
3. **Treating water before it is released**
   - Operate active treatment plants using lime or ferric-based systems to neutralize acidity and remove metals (chemical water treatment - MEND 3.50.1 - Study to Identify BATEA for the Management and Control of Effluent Quality from Mines).
   - For tertiary treatment and post-closure, use of passive systems may be adequate, such as constructed wetlands or saturated rock fills, that rely on natural processes.
   - Reuse or recycle process water to reduce discharge volumes (water recycling and reuse).
4. **Monitoring and adaptive management**
   - Regularly test water quality in rivers, lakes, and groundwater near mine sites (environmental monitoring programs).
   - Adjust operations (i.e. mine plans, rock segregation, tailings management, etc…) or treatment systems if water quality testing results exceed water quality predictions presented to federal and provincial regulatory bodies when obtaining mining permits (adaptive management framework).
5. **Preventing and managing chromium and dust-related impacts if ferrochrome mining projects are considered in the Ring of Fire**
   - Capture fine dust from smelting, crushing, or transport systems using enclosed handling and high-efficiency filters to prevent release of chromium-bearing particles (dust capture and containment).
   - Stabilize or store collected dust and tailings under saturated or low-oxygen conditions to limit oxidation and Cr(VI) formation (wet or subaqueous storage).
   - Use natural peat or engineered organic layers that promote reducing conditions and help convert Cr(VI) to the less mobile Cr(III) form (peat or organic covers).
   - Include total chromium and Cr(VI) in surface-water and effluent monitoring programs near peatlands and wetlands to track mobility and ensure protection of aquatic life (enhanced monitoring and verification).

These practices are supported by studies in the Mine Environment Neutral Drainage (MEND) Program, including:

- MEND 1.20.1 – Prediction Manual for Drainage Chemistry
- MEND 1.61.4 / 1.61.5a – Covers for Reactive Tailings and Waste Rock in Cold Regions

			• MEND 1.62.3 – Passive Treatment Technologies for Mine Effluent • MEND 2.50.1 – Tailings Management Technologies d) Include a discussion of the key sources of uncertainty unique to this assessment area related to the effectiveness of these measures, and what your role might be in reducing these uncertainties. **NRCan Response:** Not knowing the number, location and type of ore bodies in the Ring of Fire makes a regional assessment challenging. ML/ARD potential from excavated materials and tailings is required as input to risk assessment models to design mitigation measures and then make residual temporal and spatial predictions of metal contamination in the receiving environment of the Ring of Fire. Not knowing the ore bodies to be exploited also limits our understanding of which metals will need to be managed, or if these metals will include those for which we have little knowledge of environmental dispersion behavior and toxicity. While there is extensive experience with mitigation methods such as mine-water treatment and the management of waste rock and tailings to reduce mining impacts, its applicability to the Ring of Fire area remains to be assessed. For instance, because this is a greenfield region, there are no existing open pits that can be used to dispose of potential ML/ARD tailings and excavated materials. As a result, mine waste will need to be stored on surface, at least for the first project, which will require the construction of engineered berms, above-ground tailings structures, and large waste-rock piles that will be visible to nearby communities. There also remain uncertainties about the long-term performance of dry and water cover systems under changing climate conditions. The ability of dry covers to isolate tailings and waste rock may be compromised in areas of the Ring of Fire that experience seasonal freeze–thaw cycles and/or may still have permafrost beneath mine waste. **Main uncertainties:** • **Quantifying Baseline water and sediment quality.** Baseline water and sediment concentrations of metals are necessary to calculate the incrementing load of mining activities to the environment and to allow for the design of a monitoring program based on the before and after control impact design. • **Identifying ML/ARD potential.** There is no information on potential project included in the regional assessment, it will be challenging to make even conceptual predictions of cumulative impacts. • **Identifying mitigation measures applicable to the ring of fire area**. While there are already mining activities in northern Canada, the choice and design of mitigation measures need to be based on adequate source-term and environmental risk assessment models. • **Unknown long-term fate of metals in peatlands**. It remains unclear how peat will maintain reducing conditions and remove store metals such as chromium, nickel, and copper under freeze–thaw cycles, prolonged flooding or dry conditions. • **Unknown long-term performance of cover systems**. It remains uncertain how these covers will remain intact over time under prolonged dry conditions and heavy sudden precipitation and freeze-thaw cycle. Variation in water level in water cover systems may also affect the ability of covers to limit underwater metal oxidation and generation of ML/ARD. • **Uncertain effects of fugitive dust.** Mining activities can generate fine Cr(VI)-bearing dust that settles on peat surfaces. Its influence on peat chemistry, microbial processes, and long-term carbon storage remains unknown. **NRCan's role:** • **Literature review and synthesis:** Work with partners to compile Canadian data on mine drainage, dust chemistry, and peat–metal interactions in cold regions to identify remaining knowledge gaps.

			• **Field testing and monitoring:** Collaborate with Indigenous communities, provinces, and research institutions to develop small pilot projects in northern peatlands that test subaqueous and saturated-peat cover designs and monitor metal behaviour under cold, reducing conditions. • **Joint research initiatives:** Partner with universities, government agencies, and industry to examine how drainage and dust interact with peat and organic soils, focusing on metal geochemistry induced by microbial and redox processes under climate variability. • **Shared data and knowledge:** Integrate findings from MEND, the critical minerals and climate change adaptation program at CanmetMINING to support design of mitigation strategies suited to cold and peatland environments. • **Model development partnerships:** Work with federal science groups, academia, and consultants to improve baseline data as well as geochemical and hydrological models that include metal–peat interactions and climate-driven changes in water movement across northern aquatic systems.
5	Health Canada, ISC, ISC-FNIHB, ESDC, FedNor, WAGE	**Community wellbeing, Education, Training and Employment**	The Working Group is interested to know federal programs and initiatives related to community wellbeing, education, training, and employment are specifically helpful to meet the needs of communities in the assessment area. The Working Group also identified that groups that have the greatest potential to benefit from potential employment opportunities are often those facing challenges that are barriers to access employment opportunities (e.g. mental health, inter-generational trauma, drugs, and long-term healing programs). a) Identify whether and how your programs and initiatives related to community wellbeing, education, training, and employment are focused on addressing needs of communities in the assessment area. Include lessons learned and best practices from your agency's or department's experience in implementing such programs and initiatives. b) Specifically address how programs can work towards improving level of literacy and bring specialized skills training to remote communities. c) Explain how your programs and initiatives offer support specifically for vulnerable populations to access benefits of potential development. Provide examples relevant to the assessment area. d) If applicable, explain and illustrate the various collaborations and partnership required to carry out these programs and initiatives.
6	Health Canada, PHAC	**Health Inequity**	a) Provide key findings specific to the partnered First Nations of the Working Group of health inequality data and information produced by the Pan-Canadian Health Inequalities Reporting Initiative for First Nations in Canada. b) Describe existing or planned programs or initiatives to address health inequality in these communities, including sources of uncertainty for health reporting and recommendations on how to reduce this uncertainty.
7	ISC, CMHC, HICC	**Homelands and Reservations, and Housing**	a) Share what you know about housing and infrastructure trends in the assessment area, such as rates of overcrowding, waitlists for adequate housing, housing in need of repair, and housing deficits. b) Describe the federal initiatives that support housing for community members in the assessment area, and elaborate on the future of these initiatives. c) Identify all mechanisms available to communities in the assessment area to expand their reserves to address growing populations and infrastructure demands related to potential development (not limited to the Addition to Reserve process). d) Based on your experience, share lessons learned and best practices on how Indigenous communities can enhance use of their homelands to build local capacity while also enhancing local economic activities (including traditional activities).
8	DFO and ECCC	**Species at Risk**	a) Provide summaries of knowledge on species at risk and their habitat in the assessment area, including but not limited to threats, mitigation options, and knowledge gaps. b) Comment on how Indigenous knowledge is braided in this knowledge. c) Identify any plans for conservation and protection measures focused on the species at risk in the assessment area.
9	DFO, ECCC and Parks Canada	**Protected Areas**	a) Provide an overview of the various conservation and protection measures and that could contribute to protection of sensitive areas in the assessment area. Include a description of their purpose, how they complement each other, the lead organisations, and current and future priorities related to the assessment area.

			b) For each measure, identify how federal agencies and departments achieve conservation and protections goals in partnership with other organizations, including First Nations and environmental groups.
10	CIRNAC	**Federal Initiative on Consultation**	a) Describe the Federal Initiative on Consultation, focusing on how it may be relevant for potential studies related to potential development in the assessment area. b) Provide an update on the program's current funding status and plans to renew funding.
11	ECCC	**Bird Conservation Strategy**	a) Please summarize the key findings from the Bird Conservation Strategies that overlap with the assessment area as they related to recommended conservation and protection measures. b) Describe how various parties have a role in the implementations of the conservation strategies, with a focus on the assessment area.
12	ISC, ISC-FNIHB, CIRNA, ECCC, DFO	**Treaty Rights and Wildlife Management**	a) Explain whether and how you obtain information about non-Indigenous land users on traditional territories for hunting, fishing, and harvesting purposes without consent. b) Explain whether and how this information factors into federal responsibilities related to: i. protection of wildlife and their habitat; and ii. documenting and any action relate to protection of Aboriginal and Treaty Rights.
13	ECCC and **NRCan**	**Cumulative Effects Assessments**	a) Identify programs and initiatives related to describing or quantifying cumulative effects within the assessment area. **NRCan Response:** 1. Risk assessment framework for cumulative effects In the Ring of Fire region in Northern Ontario, NRCan conducted the regional assessment of the cumulative effects of mining using the Risk Assessment Framework for Cumulative Effects (RAFCE). The framework enabled the identification of drivers and impacts of cumulative effects and potential preventive and mitigation measures for effective cumulative effects management. 2. Development of a risk assessment software for cumulative effects The Risk Assessment Software for Cumulative Effects (RASCE) is an innovative cumulative effects assessment tool developed using the Ring of Fire region as a case study. RASCE integrates data management, modelling, and risk evaluation to assess multiple stressors across ecological and socioeconomic systems. RASCE reflects community values, supports informed decision-making, strengthens resource management, and promotes sustainable mining development. It empowers communities and industry to identify, prevent, or mitigate impacts before they become worse and cost more for the industry and community. See recent publication: Antwi, E. K., Osei, G., Owusu-Banahene, W., Boakye-Danquah, J., Okafor, P. M., Korankye, K., ... & Yohuno, P. T. (2025). Development of a risk assessment software for cumulative effect. MethodsX, 14, 103155. https://www.sciencedirect.com/science/article/pii/S2215016125000032 3. Socioeconomic framework and indicators for assessing cumulative effects of resource development on Indigenous nations Resource development on Indigenous lands affects not just the biophysical environment but also the economic, cultural, social, and health of communities. Despite this, mainstream cumulative impact assessments of resource development focus disproportionately on biophysical impacts and often exclude Indigenous communities from the assessment process.

			The Socioeconomic framework and indicators for assessing cumulative effects of resource development on Indigenous Nations project is conducted in collaboration with community members from the Apitipi Anicinapek from the Algonquin Anicinapek Nation, Indigenous scholars, and Elders. It aims to develop a holistic framework for regional-level socioeconomic cumulative effects assessment of resource development on Indigenous Nations. See recent publication: Antwi, E. K et al. (2025). Socioeconomic framework and indicators for assessing cumulative effects of resource development on indigenous nations. The Extractive Industries and Society, 24, 101735. https://www.sciencedirect.com/science/article/pii/S2214790X25001248 4. Risk assessment of potential impact of mining development (linear infrastructure) on peatland ecosystems in the Ring of Fire region, Northern Ontario Peatlands in the Ring of Fire are globally significant, storing approximately 74 gigatons of carbon and regulating climate as well as supporting unique biodiversity of fauna and flora. Disturbance could transform them from carbon sinks to sources, accelerating climate change, exacerbating wildfire risk, and contributing to habitat loss for vulnerable species like woodland caribou. This project entitled Risk assessment of potential impact of mining development (linear infrastructure) on peatland ecosystems in the Ring of Fire region, Northern Ontario aims to inform sustainable planning amid ongoing political, environmental, and Indigenous rights challenges. See recent publication: Dabros, A., Antwi, E. K., Waldron, C., Darko, A. N., & Higgins, K. L. (2025). Risk assessment of potential impact of mining development (linear infrastructure) on peatland ecosystems in the Ring of Fire region, Northern Ontario. Frontiers in Environmental Science, 13, 1676633. https://doi.org/10.3389/fenvs.2025.1676633 https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2025.1676633/full 5. Offsite effect of mines on northern biodiversity The Offsite effect of mines on northern biodiversity project, conducted as part of a collaboration with the Université du Québec en Abitibi-Témiscamingue Research Chair on Northern Biodiversity in a Mining Context (Chair BCM), aims to assess the offsite effects of mines on northern biodiversity to develop strategies to reduce the impacts of mine development in the context of cumulative effects including climate change. The project is taking place in the Abitibi-Témiscamingue and Nord-du-Québec regions, in Quebec, which are good analogs of the Ring of Fire as they share similar environmental features. See publications: Yin X., Martineau C., Samad A., Fenton N.J. 2023. Out of site, out of mind: Changes in feather moss phyllosphere microbiota in mine offsite boreal landscapes. Frontiers in Microbiology, vol. 14. doi:10.3389/fmicb.2023.1148157. https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1148157/full Yin X., Martineau C., Fenton N.J. 2023. How big is the footprint? Quantifying offsite effects of mines on boreal plant communities. Global Ecology and Conservation. Vol. 41, e02372. doi:10.1016/j.gecco.2023.e02372. https://www.sciencedirect.com/science/article/pii/S2351989423000070 Yin X., Martineau C., Fenton N.J. 2022. Synergistic effects in mine offsite landscapes: Predicted ecosystem shifts could exacerbate mining effects on bryophyte community structure. Ecological Indicators, Volume 144. doi:10.1016/j.ecolind.2022.109555. https://www.sciencedirect.com/science/article/pii/S1470160X22010287

			6. Earth Observation for Cumulative Effects project at the Canada Centre for Mapping and Earth Observation (CCMEO). See CCMEO Ring of Fire report - "Ring of Fire: Satellite Monitoring of Environmental Indicators" for more information". 7. National Scale Vegetation Status and Trends Monitoring System. (R Fernandes): CCMEO has worked with CFS, Ontario and Forests Canada NGO to develop key satellite indicators of afforestation, deforestation and forest cover change. Tools for generating these indicators for the Ring of Fire are available for impact assessment studies. 8. SAR Toolbox lake ice breakup method. (J. van der Sanden): No collaboration with Indigenous Nations or communities in the Ring of Fire area. This study delivers a tool that can be accessed by e.g. federal users but does not deliver multi-year lake ice extent information map products or derived statistics. The applied information collection method is limited by the availability of suitable radar EO images. b) For each, summarize the focus of the assessment, the approach used to assess cumulative effects, key assumptions and limitations, and any key findings to date as well as future plans to continue or conduct new studies.
14	FedNor	**Capacity-building**	a) Describe the Prosperity and Growth Strategy for Northern Ontario, the Regional Economic Growth through Innovation program, the Northern Ontario Development Program, the Community Futures Program, and the Economic Development Initiative and how your can facilitate participation by communities in the assessment areas. b) Identify known barriers for participation in these initiatives by Indigenous communities in the assessment area, and potential solutions to address them.
15	ISC	**Education and literacy**	a) Describe federal roles and responsibilities related to education and literacy in the assessment area. b) Advise on how education and literacy programs can be used or designed to ensure that Indigenous communities have access to education required to benefit from potential development in a manner that is equitable with populations that are non-Indigenous and less remote.
16	AAFC, Health Canada, ISC and ISC-FNIHB	**Food Security and Nutrition**	a) Share what you know about food security conditions in the assessment area. b) Describe federal programs related to food security and nutrition that are available in the assessment area. Explain whether and how these programs are targeted to address food insecurity and barriers to traditional food access in First Nation communities, which can be associated with negative effects to social, mental, and physical well-being. c) Explain how development has been observed to positively or adversely impact health in Indigenous communities, such as through changes in access to land, changes in cost of living, etc.
17	ISC and LAC	**Language Revival and Cultural Heritage**	a) Describe programs or initiatives for learning and preservation of traditional language use, including details on how success is measured for languages in the assessment area. b) Provide information and data about traditional language retention in First Nations communities in the assessment area, and describe any plans or suggestions to enhance learning and preservation of traditional languages. c) Offer suggestions and ideas on how existing federal programs could be focused to the assessment area for language revival and learning about cultural identity. Include example of how other Indigenous communities in Canada have used archives and other historical records to reclaim and revive their cultural heritage.

18	Transport Canada	**Development Scenarios**	a) Provide a description of the existing or planned development activities under Transport Canada's jurisdiction in the assessment area. b) Advise on the development activities you anticipate may occur in the assessment area for different development sectors and intensities, this should include scenarios related to railways, roads, seaports and marine terminals, airports, etc.
19	ECCC, ISED, **NRCan**, and Transport Canada	**Feasibility of development in this area**	Based on the sensitivity of peatlands in the assessment area and their role in global carbon sequestration, as well as the challenges related to building infrastructure on peatlands, the Working Group requests that you: a) Provide a summary of the state of knowledge regarding the sustainability of building on peatlands. b) Advise on the worst-case scenarios that have been explored for impacts of future development on the ecosystems of the Hudson Bay Lowlands, including but not limited to impacts on carbon storage. **<u>NRCan Response</u>** The type of future development is critical to know as impact will be dependent on type of development. Development (e.g., removal of peat to access subsurface minerals) could lead to in worst-case scenarios: • Water draw-down, water re-routing, flooding • Local permafrost thaw • Extraction and/or piling of peat • Peat subsidence and/or compaction • Creation of upland features using fill/rock These impacts affect carbon storage and could lead to the release of higher levels of CO2 and CH4 to the atmosphere, change of water routing and localized drought or flooding, increased risk of wildfire, changes in landcover that could negatively affect ecosystem and habitat integrity (including negative impacts to species at risk such as caribou). Additional impacts on ecosystems of the Hudson Bay Lowlands could be impacted by • Release of fine Cr(VI)-bearing dust from chromite processing or transport if capture systems fail, leading to potential deposition on peatlands and wetlands. • Drying or oxidation of peat through drainage or disturbance, reducing its capacity to attenuate metals and potentially mobilizing Cr and other contaminants. • Combined effects of metal-bearing dust, altered hydrology, and loss of reducing conditions leading to secondary contamination of surface waters. c) Explain how sensitive the ecosystems in the assessment area are to climate change and explain whether there has been research done on the interactions between climate change and potential development for this area. **<u>NRCan Response:</u>** <u>Climate change and Carbon storage</u>

			This area is experiencing higher rates of temperature increase than regions further south. This has impacts on water storage and water table depth, susceptibility to wildfire, permafrost thaw, and increases in soil/peat temperatures. These changing climate conditions could exacerbate some development impacts.
			
			Some carbon, greenhouse gas and hydrology/water quality monitoring has been done in the RoF by Ministry of the Environment, Conservation and Parks (MOECF) and the Ontario Ministry of Natural Resources (MNR) over the last ~15 years. In the area previously occupied by the Victor Diamond Mine, there was extensive work by universities in the early 2000's that examined interactions between interannual climate variability and water draw-down in the vicinity of the diamond mine. There has been an increase in work done by ECCC, Parks Canada, universities and local First Nation Communities over the last 3 years both on the ground (biodiversity monitoring of flora and fauna, peat coring, environmental and hydrology monitoring) at sporadic locations throughout the region and by remote sensing.
			
			We are in the process of doing a regional run of the Canadian Model for Peatlands (CaMP model) for the Hudson Bay Lowlands, starting first with a baseline (1990 to present) run. Future runs could examine climate change scenarios. Currently CaMP has disturbance matrices that examine fire disturbance. Other disturbance matrices for development scenarios in the Oil Sands Region have been developed by ECCC scientist (Kelly Bona). Additional work would be required to modify the disturbance matrices to deal with RoF specific developments.
			
			We are presently developing new modules for CaMP that will: 1. include soil temperature and permafrost, and; 2. account for dissolved organic carbon (DOC) transfers. These updates to the model will be implemented and tested over the next 1-2 years.
			
			<u>Cr behaviour</u>
			
			The smelting and dust-speciation papers do not include climate-sensitivity modelling, but the peatland literature review indicates that Cr and other metals behaviour strongly depends on redox and moisture. Warming or drying trends that raise oxygen availability could increase Cr(VI) and other metals mobility. Peatlands in the Hudson Bay Lowlands are therefore highly sensitive to both climate change and development disturbance, because small hydrologic shifts can alter their ability to retain metals and support natural neutralization processes.
			
			<u>Additional studies</u>
			
			• **National Scale Vegetation Status and Trends Monitoring System. (R Fernandes):**
			  ○ NRCan has produced climatology of vegetation cover, density and productivity during the baseline 2013-2023 period and will be providing them ongoing. These data are being used to quantify the impact of climate change on vegetation status and trends.
			• **Investigating the use of satellite radar interferometry in the Hudson Bay Lowlands. N. Short (exploratory research):**
			  ○ Investigating the use of satellite radar interferometry in the Hudson Bay Lowlands, to determine if large area maps of terrain stability can be efficiently made to effectively guide planning and development in the area; to avoid sensitive and unstable terrain when routing transportation and communication links, when siting or expanding facilities, or when disturbing the surface to extract resources or manage byproducts and waste. Such maps could both speed up planning decisions and improve environmental outcomes.
			• **Snow Dynamics (M. Bonney, Y. Zhang):**
			  ○ Work already described with winter roads viability connects with (c): interactions between climate change and development. Y. Zhang's work on permafrost mapping/modelling (Indicator 10 of the Ring of Fire report), which makes use of the snow dynamics data, connects with (b): impacts on carbon storage in Hudson Bay Lowlands.
			
			d) Describe all innovative approaches being explored and invested in by Canada to enable development in the assessment area, across all possible sectors, beyond mining.

			NRCan Response: NRCan led innovative research projects applicable to development in the Ring of Fire: • Pilot-scale furnace testing to reduce Cr(VI) formation during chromite smelting through control of oxygen ingress and feed composition. • Advanced dust-capture and filtration systems (cyclone and baghouse designs) targeting sub-micron Cr(VI)-bearing particles (and other metals). • Use of saturated or organic covers to maintain reducing conditions that limit oxidation of metals in waste materials. • Inclusion of chromium speciation (Cr(VI)/Cr(III)) (and other metals) and redox parameters in water-quality monitoring to verify effectiveness of mitigation in peatland and wetland environments. Additionally, as highlighted in NRCan's presentation to Regional Assessment Working Group on June 5, 2025, the Critical Minerals Infrastructure Fund (CMIF) is providing up to $1.5 billion in federal funding until 2030 for clean energy and transportation infrastructure projects necessary to enable the sustainable development and expansion of critical minerals in Canada. The CMIF currently offers two types of funding support: • CMIF Contribution funding supports preconstruction activities to advance infrastructure projects to a "shovel ready" state; and shovel ready infrastructure projects that support construction and deployment activities. CMIF Indigenous Grants funding supports Indigenous engagement, participation and capacity building related to infrastructure projects that would enable critical minerals development.

Table 3. Key priorities – Existing information and gaps (see request #2)

Theme	Priority	Issues
To be well together (Community wellbeing)	Community safety (especially for Indigenous women, men and youth)	**Policing of roads;** Drug trafficking; Safety supports/ programs; Safety issues around mining/ work camps (ex: substance use, violence, MMIWG2S); Human trafficking; Environmental hazards & areas of concern; Evacuation plans
	Family, youth and children	**Poverty and Homelessness;** Elder care; Impacts on the family unit; Services and supports for children and families
	Housing and Infrastructure	**Overall housing picture;** Infrastructure development and maintenance; Community infrastructure deficit; Land base expansion; Transportation infrastructure; Waste management and recycling
	Education	Special needs within communities; Distance education opportunities; Education levels within communities
	Food Security	Food shipping and storage; Potential for growing food locally; Food insecurity, costs and subsidies
	Economic development and livelihoods	Cost of living; Power supply ownership opportunities; Renewable energies; Employment and jobs availability; Building community economic development; Potential for members to fill project jobs
	Community health, including exceptional needs, mental, emotional and physical wellbeing	Mental wellness; Health issues (incl. rare and chronic conditions)
Cultural and spiritual wellbeing	Physical and cultural heritage, including burial sites	Sites of archaeological significance; Historical trade routes and ecological corridors; Identification of routes, corridors, and cultural sites linked to routes and corridors
	Cultural vitality and traditional practices, including traditional food and medicine	Loss of cultural practices, ceremonies, etc
	Continued way of life and exercising Aboriginal and Treaty rights	**Enacting and protecting rights, way of life;** Treaty rights education
	Community-based teachings, including oral history	Oral history vs. Crown info
	Language maintenance and revival	**Use of traditional languages**
	Traditional community processes for deliberation and decisions	**Potential for new governance structures**
	Exercise of natural law	
Social and Economic Equity	Intra and intergenerational values	**Income distribution within communities.**
	Social and economic conditions, including immediate and long-term social and economic benefits	**Potential partnerships with developers;** Industry investment in communities; Regional collective approaches to Ec. Dev.; Capturing economic benefits of projects; Economic leakage
	Diverse economies and livelihoods	Land-based economy; Workforce participation
	Indigenous Women, girls and two-spirit individuals	Economic barriers and benefits for women; Childcare; Violence and harassment
	Current use of lands and resources for traditional purposes, including access to land and resources	**On-the- land activities;** Harvesting

	Access to skill development and economic opportunities	Successes and challenges re: education/ employment; Indigenous employment at projects
Healthy Environment Relationships	Water and river systems, including flows	**Groundwater effects; Water usage (processing); Changes to flow (dams)**
	Wildlife and wildlife habitat, including species at risk, migratory birds, and fish and fish habitat	Effects on harvest species; Impacts on ecological corridors; Effects to spiritual beings; New species making use of road corridors; Higher risk of roadkills; Impacts to breeding and migratory areas
	Peatlands and other unique environments	**Effects of disrupting peatlands;** Permafrost;
	Forest ecosystems, including plants	ITK, 2- eyed seeing in Forest Management Plans; Impacts due to clear cutting
	Climate change adaptation	Use of fossil fuels for electricity; Change in species
	Biodiversity	Change in biodiversity