



WEBEQUIE SUPPLY ROAD FINAL ENVIRONMENTAL ASSESSMENT REPORT / IMPACT STATEMENT

January 30, 2026

AtkinsRéalis Ref: 661910

SECTION 8: Assessment of Effects on Groundwater Resources



WEBEQUIE FIRST NATION

AtkinsRéalis



Contents

- 8 Assessment of Effects on Groundwater Resources 8-5**
- 8.1 Scope of the Assessment 8-5
 - 8.1.1 Regulatory and Policy Setting 8-5
 - 8.1.2 Consideration of Input from Engagement and Consultation Activities 8-8
 - 8.1.3 Incorporation of Indigenous Knowledge and Land and Resource Use Information 8-11
 - 8.1.4 Valued Component and Indicators 8-15
 - 8.1.5 Spatial and Temporal Boundaries 8-16
 - 8.1.5.1 Spatial Boundaries 8-16
 - 8.1.5.2 Temporal Boundaries 8-17
 - 8.1.6 Identification of Project Interactions with Groundwater Resources 8-19
- 8.2 Existing Conditions 8-20
 - 8.2.1 Methods 8-21
 - 8.2.1.1 Documents Reviewed During the Desktop Study 8-21
 - 8.2.1.2 Summary of Field Work Programs 8-22
 - 8.2.2 Results 8-23
 - 8.2.2.1 Geological and Hydrogeological Settings 8-23
 - 8.2.2.2 Groundwater Quantity 8-23
 - 8.2.2.3 Groundwater Quality 8-24
- 8.3 Identification of Potential Effects, Pathways, and Indicators 8-25
 - 8.3.1 Vegetation Clearing and Grubbing 8-25
 - 8.3.2 Site Grading / Ground Hardening 8-26
 - 8.3.2.1 Water Balance Analysis – Methodology 8-27
 - 8.3.2.2 Water Balance Analysis – Results 8-28
 - 8.3.3 Blasting of Rocks 8-31
 - 8.3.4 Extraction, Cut, Excavation, Stockpiling and Backfilling 8-32
 - 8.3.5 Dewatering / Pumping 8-34
 - 8.3.5.1 Dewatering for Structure Foundations 8-35
 - 8.3.5.2 Dewatering at Aggregate Sites 8-36
 - 8.3.5.3 Water Supply Wells 8-41
 - 8.3.6 Road Construction 8-42
 - 8.3.7 Disposal of Wastes 8-43
 - 8.3.8 Summary 8-43
- 8.4 Mitigation Measures 8-45
 - 8.4.1 Vegetation Clearing and Grubbing 8-45
 - 8.4.2 Site Grading/Ground Hardening 8-46
 - 8.4.3 Blasting of Rock 8-46
 - 8.4.4 Extraction, Cut, Excavation, Stockpiling and Backfilling 8-47



Contents (Cont'd)

- 8.4.5 Dewatering / Pumping..... 8-47
- 8.4.6 Road Construction 8-48
- 8.4.7 Disposal of Wastes 8-49
- 8.4.8 Summary..... 8-49
- 8.5 Characterization of Net Effects 8-53
 - 8.5.1 Potential Effect Pathways Not Carried Through for Further Assessment..... 8-54
 - 8.5.2 Predicted Net Effects 8-54
 - 8.5.2.1 Change in Groundwater Quantity 8-55
 - 8.5.2.2 Change in Groundwater Quality 8-57
 - 8.5.3 Summary..... 8-58
- 8.6 Determination of Significance 8-61
- 8.7 Cumulative Effects 8-61
- 8.8 Prediction Confidence in the Assessment 8-62
- 8.9 Predicted Future Condition of the Environment if the Project Does Not Proceed 8-62
- 8.10 Follow-Up and Monitoring 8-62
- 8.11 References..... 8-63

In Text Figures

- Figure 8.1: Groundwater Resources Study Areas 8-18
- Figure 8.2: Input Parameters for Thornthwaite Model 8-27
- Figure 8.3: Webequie Supply Road Typical Section..... 8-29
- Figure 8.4: Recommended Aggregate Resources Area – ARA-2 8-39
- Figure 8.5: Recommended Aggregate Resources Area – ARA-4 8-40

In-Text Tables

- Table 8-1: Key Regulation, Legislation, Policy Relevant to Groundwater Resources 8-6
- Table 8-2: Groundwater Resources VC – Summary of Input Received During Engagement and Consultation 8-8
- Table 8-3: Groundwater Resources VC – Summary of Indigenous Knowledge and Land and Resource Use Information 8-12
- Table 8-4: Groundwater Resources VC – Subcomponents, Indicators, and Rationale..... 8-16
- Table 8-5: Project Interactions with Groundwater Resources VC and Potential Effects 8-19
- Table 8-6: Infiltration Factors – Pre-Development 8-29
- Table 8-7: Annual Infiltration Volumes – Pre-Development Road Right-of-Way (Previous Areas)..... 8-30
- Table 8-8: Annual Infiltration Volumes – Post-Development Road Right-of-Way (Pervious Areas) ... 8-31
- Table 8-9: Changes to Annual Infiltration Volumes – Pre- and Post-Development Road Right-of-Way 8-31
- Table 8-10: ABA Results for Rock Samples 8-33
- Table 8-11: ABA Results for Soil Samples 8-34

Contents (Cont'd)

In-Text Tables (Cont'd)

Table 8-12: Input Parameters for Dewatering Assessment – Structure	8-36
Table 8-13: Results of Dewatering Assessment – Each Structure Foundation	8-36
Table 8-14: Input Parameters for Dewatering Assessment – Aggregate Resources Area (ARA-2)	8-38
Table 8-15: Results of Dewatering Assessment – Aggregate Resources Area (ARA-2)	8-38
Table 8-16: Input Parameters for Dewatering Assessment – Water Supply Wells	8-41
Table 8-17: Summary of Potential Effects, Pathways, and Indicators for Groundwater Resources VC ..	8-44
Table 8-18: Summary of Potential Effects, Mitigation Measures and Predicted Net Effects for Groundwater Resources VC	8-50
Table 8-19: Criteria for Characterization of Predicted Net Effects on Groundwater Resources VC.....	8-53
Table 8-20: Summary of Predicted Net Effects on Groundwater Resources VC	8-59



8 Assessment of Effects on Groundwater Resources

Groundwater resources were identified as one of the valued components (VC) during the VC scoping and selection as part of the Environmental Assessment / Impact Assessment (EA/IA) process. This section describes and assesses the potential effects that the Project may have on the Groundwater Resources VC.

Existing conditions for the groundwater resources have been established through the field work programs, desktop studies and engagement and consultation activities completed by the Project Team. This includes, but not limited to, background information review, internet research, groundwater monitoring and sampling, hydraulic conductivity testing, engagement with Indigenous communities and stakeholders, and expert opinion. The existing conditions are being used as baseline conditions to assess and determine the potential effects of the Project. The results of the baseline studies are provided in Appendix F – Natural Environment Existing Conditions (NEEC) Report.

The assessment of potential effects for the Groundwater Resources VC is presented in the following manner:

- Scope of the Assessment;
- Existing Conditions Summary;
- Potential Effects, Pathways and Indicators;
- Mitigation Measures;
- Characterization of Net Effects;
- Determination of Significance;
- Cumulative Effects;
- Prediction Confidence in the Assessment;
- Predicted future Condition of the Environment if the Project Does Not Proceed;
- Follow-up and Monitoring Programs; and
- References.

8.1 Scope of the Assessment

8.1.1 Regulatory and Policy Setting

The Groundwater Resources VC is assessed in accordance with the requirements of the *Impact Assessment Act*, the Ontario *Environmental Assessment Act*, the Tailored Impact Statement Guidelines (TISG) for the Project (Appendix A-1), the provincial approved EA Terms of Reference (ToR) (Appendix A-2), and EA/IA guidance documents.

Table 8-1 outlines the key regulations, legislations, and policies relevant to the effect assessment of the Groundwater Resources VC in relation to the construction and operation of the Project.



Table 8-1: Key Regulation, Legislation, Policy Relevant to Groundwater Resources

Regulatory Agency	Regulation, Legislation, and Policy	Project Relevance
Federal		
Impact Assessment Agency of Canada (IAAC)	<i>Impact Assessment Act</i>	The Project is subject to the federal <i>Impact Assessment Act</i> (refer to Section 2). The Tailored Impact Statement Guidelines (TISG) issued by IAAC (2020) for the Project were used to identify requirements for the assessment of Groundwater Resources VC.
Fisheries and Oceans Canada	<i>Fisheries Act</i>	Work or undertaking that may result in changes to surface water quality, thus affecting fish habitat (e.g., construction groundwater dewatering and discharge at aggregate pits/quarries and watercourse crossings).
Environment and Climate Change Canada	<i>Species at Risk Act</i>	Work or undertaking that may result in changes to groundwater quality or quantity and where applicable its interaction to surface water (including wetlands), thus affecting species at risk (SAR) habitat (e.g., construction dewatering and discharging, operation of septic systems). Road barrier effects may result in changes to groundwater levels of wetlands downgradient of the road, thus affecting the SAR habitat.
Provincial		
Ontario Ministry of the Environment, Conservation and Parks (MECP)	Ontario <i>Environmental Assessment Act</i>	The Project is subject to the Ontario <i>Environmental Assessment Act</i> . The ToR (Webequie First Nation 2020), which was approved by the MECP on October 8, 2021, were used to identify requirements for the assessment of Groundwater Resources VC.
MECP	Ontario <i>Environmental Protection Act</i> (EPA, the Act)	An Environmental Compliance Approvals (ECA) under the Act may be required for the discharge and treatment of wastewater.
MECP	Ontario Soil, Groundwater and Sediment Standards for use under Part XV.1 of the <i>Environmental Protection Act</i>	Ontario's Soil, Ground Water and Sediment Standards (MOE, 2011) set out the prescribed contaminants and the applicable site condition standards for those contaminants for the purposes of Part XV.1 of the <i>EPA</i> .
MECP	Ontario <i>EPA</i> , the Act Ontario <i>Water Resources Act</i> (OWRA)	A permit to take water (PTTW) or Environmental Activity and Sector Registration (EASR) under the Act is required for water takings associated with project activities such as pumping, draining, and dewatering. Dependent upon meeting specific criteria (e.g., water source, purpose, etc.) of the Water Taking EASR Regulation – O. Reg. 63/16, some takings between 50,000 and 400,000 L/day may qualify for registry (EASR), while other takings (e.g., associated with aggregate pit) may require a PTTW. Takings over 400,000 L/day require a PTTW.
MECP	<i>Clean Water Act</i> (CWA)	Work or undertaking that may result in changes to groundwater quality of nearby drinking water sources including water supply wells and springs.
Ontario Ministry of Natural Resources	<i>Aggregate Resources Act</i>	The minimum clearance from the bottom of the aggregate pits to the groundwater table is one of the criteria to determine the category of the aggregate permit. The operation of the aggregate pits (e.g., dewatering and discharge) may affect groundwater and surface water systems near the pits.



Regulatory Agency	Regulation, Legislation, and Policy	Project Relevance
Ontario Ministry of Labour, Immigration, Training and Skills Development	<i>Occupational Health and Safety Act</i> (OHSA)	Groundwater resources related field work programs including groundwater monitoring and sampling, and hydraulic conductivity testing are required to meet the OHSA requirements.
MECP	Ontario Regulation 63/16 – Registrations Under Part II.2 of the Act – Water Taking (under EPA)	An EASR registration is required if the taking of water is more than 50,000 litres of groundwater, storm water, or a combination of groundwater and storm water, but less than 400,000 L/day of groundwater, on at least one day during construction.
MECP	Ontario Regulation 387/04 – Water Taking and Transfer (under OWRA)	Water takings that are outside the EASR application ranges will require PTTW, e.g., water takings of surface water more than 50,000 L/day (with certain conditions), or water takings of groundwater more than 50,000 L/day from aggregate pits, or groundwater more than 400,000 L/day from construction dewatering sources).
MECP	Ontario Regulation 903 – Wells, R.R.O. 1990 (under OWRA)	Well installation and decommissioning should follow the requirements of O.Reg. 903, including monitoring wells for groundwater monitoring and sampling, and water supply wells for construction camps and the Maintenance and Storage Facility (MSF).
MECP	Ontario Regulation 347: General – Waste Management, R.R.O. 1990 (under EPA)	Wastewater disposal will be conducted in accordance with O.Reg. 347, e.g., drilling fluids, extracted water from dewatering, waste water from construction camps and the MSF.
MECP	Ontario Regulation 224/07: Spill Prevention and Contingency Plans (under EPA)	Spills (if any) during road construction and operation and maintenance should be managed according to the Project Spill Prevention and Contingency Plan.
MECP	Water Management: Policies, Guidelines, Provincial Water Quality Objectives (PWQO), 1994 (as amended)	During road construction and aggregate pit operations, dewatering effluent should meet PWQO criteria as the water will be discharged to the natural environment (overland) and may enter surface water bodies.
MECP	Environmental Compliance Approval (ECA)	Wastewater treatment systems/units (e.g., septic systems) will require an ECA from the MECP.
Ontario Ministry of Transportation (MTO)	Ontario Provincial Standard Specifications (OPSS)	Dewatering activities during road construction and aggregate pit operations should follow OPSS 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation; OPSS 518 Construction Specification for Control of Water from Dewatering Operations; and OPSS 805 Construction Specification for Temporary Erosion and Sediment Control Measures, at a minimum. Blasting should be conducted in accordance with OPSS 120 General Specification for the Use of Explosive.



Regulatory Agency	Regulation, Legislation, and Policy	Project Relevance
Other		
Webequie First Nation	Webequie First Nation Community Based Land Use Plan	Webequie First Nation and Ontario have committed to gather baseline environmental data in the Ring of Fire area and track changes in environmental and ecological conditions in the area over time. Ecological systems of focus include water systems and wetlands (Webequie First Nation, 2019).

8.1.2 Consideration of Input from Engagement and Consultation Activities

Table 8-2 summarizes comments and input related to Groundwater Resources VC received during the engagement and consultation for the EA/IA and how the comments and inputs are addressed in the EAR/IS. This input includes concerns raised by Indigenous communities and groups, the public, government agencies, and stakeholders prior to the formal commencement of the federal IA and provincial EA, during the Planning Phase of the IA and ToR phase of the EA. The Project Team considered the comments received on the Draft EAR/IS in finalizing the EAR/IS. Details of responses and how the comments have been addressed are provided in the Record of Engagement and Consultation.

Table 8-2: Groundwater Resources VC – Summary of Input Received During Engagement and Consultation

Comment Theme	How are the Comments Addressed in this EAR/IS	Indigenous Community or Stakeholder
<p>Concerns about potential effects of dewatering resulting in increased methylmercury and other environmental consequences.</p> <p>Attawapiskat First Nation requested that MECP be directly involved in designing and overseeing a water management plan for the Webequie Supply Road (WSR) to protect the Ekwana and Attawapiskat watersheds from contamination and minimizes hydrological changes to downstream environments.</p>	<p>As described in Section 4 (Project Description), the proposed WSR is a linear facility, with no major obstruction to the water flow or to the hydrology of low-lying areas. Planned water crossings (rivers or waterbodies) will be designed not to change the downstream hydrology (i.e., water flow and levels). Where the road passes through low-lying areas and has the potential to change the local hydrology, mitigation measures including, but not limited to, equalization culverts, drainage blankets and/or subdrains will be placed to minimize or eliminate any such changes.</p> <p>Potential effects of temporary dewatering are assessed in Section 7 and Section 8 of this EAR/IS. With the implementation of mitigation measures for dewatering as outlined in Section 7.4, Section 8.4, and Appendix E of this EAR/IS, there are no expected permanent changes to either the regional ground water conditions or the regional surface water conditions/hydrology in the area. No dewatering is anticipated to result in significant permanent changes in the characteristics of the peatland and organics in its vicinity.</p> <p>Methylmercury and other water quality concerns (parameters) have been included in the groundwater baseline investigation program. Groundwater quality was monitored for seasonal and annual changes during the EA/IA process and monitoring will be included in the Groundwater Management Plan during detail design for implementation in the construction and operation phases.</p>	Attawapiskat First Nation



Comment Theme	How are the Comments Addressed in this EAR/IS	Indigenous Community or Stakeholder
<p>Concerns regarding the ecological consequences of the drainage of peatlands that will result from the construction of the WSR.</p>	<p>As described in Section 4 (Project Description), approximately 56 km (52% in length of the WSR) in the eastern half of the WSR is located in wetland/muskeg terrain (or peatlands). A “floating” road design will be used for this section of the WSR, which includes the placement of aggregate material (gravel) and use of a geotextile fabric and/or geogrid, similar to the orange plastic construction fencing often seen). A “floating” road is a road that is constructed directly on top of the peat (no peat is removed) and relies on the strength of existing peat for its support. The road does not actually “float” on the peat but rather a balance builds up between the weight of the road and the strength of the peat. The proposed design will support continuous movement of groundwater/spring water to ensure that the peatlands and wetlands function through the use of a layer of rock or select coarse gravel that permits groundwater/spring water flow to continue. In addition, the installation of equalization culverts is recommended at frequent intervals to support the continued movement of surface and groundwater/spring water in the peatlands.</p> <p>Where dewatering/drainage is required (e.g., at locations where access to bedrock outcrops is necessary to obtain structural foundation or roadbed material, the potential effects on surface and groundwater quantity and quality, and related ecological consequences, including downstream peatland effects are assessed in Section 8.3 and Section 7.4).</p> <p>Groundwater quality will be monitored for seasonal and annual changes during the EA/IA process and monitoring will be included in the Groundwater Management Plan during detail design for implementation in the construction and operation phases.</p>	<p>Attawapiskat First Nation</p>
<p>Concerns about contamination of headwater streams and rivers by heavy metals including chromium.</p>	<p>The Project Team recognizes the sensitivity of the headwater wetlands, streams, and rivers. As part of the groundwater and surface water baseline information collection and geotechnical investigation activities, groundwater monitoring wells (for water level and quality) have been established along the preliminary proposed route for the WSR and in the vicinity of the potential aggregate extraction areas (refer to Section 8.2 – Groundwater and Section 7.2 – Surface Water). To capture seasonal and inter-annual changes, the monitoring and sampling has been conducted in summer and fall of 2020 and continued in spring/summer and fall of 2021 for the purposes of informing the EA/IA.</p> <p>Groundwater sampling and project effects parameters included:</p> <ul style="list-style-type: none"> ▪ General chemistry and inorganics including: <ul style="list-style-type: none"> ▫ alkalinity; ▫ hardness; ▫ pH; ▫ conductivity; ▫ turbidity; ▫ total suspended solids; ▫ total dissolved solids; ▫ cations (i.e., H⁺, Mg²⁺, Na⁺, Ca²⁺, K⁺, NH⁴⁺); 	<p>Attawapiskat First Nation</p>



Comment Theme	How are the Comments Addressed in this EAR/IS	Indigenous Community or Stakeholder
	<ul style="list-style-type: none"> ▫ anions (i.e., Cl⁻, SO₄²⁻, F⁻, NO₃⁻, NO₂⁻, HCO₃⁻, CO₃²⁻, PO₄³⁻); ▫ dissolved organic carbon; and ▫ ammonia. <ul style="list-style-type: none"> ▪ Metals (total and dissolved): including full metal scan, plus hexavalent chromium and mercury (total mercury and methylmercury); ▪ Radionuclides: radium 226; ▪ Nutrients: including total organic carbon, total kjeldahl nitrogen and total phosphorus; and ▪ Organic compounds: polycyclic aromatic hydrocarbons and petroleum hydrocarbons (PHCs) including benzene, toluene, ethylbenzene, and xylene and PHC F1 to F4. <p>The monitoring and sampling programs are proposed to continue through construction and post-construction periods to test groundwater quality. Best management practices and site-specific mitigation measures as outlined in Appendix E of this EAR/IS will be implemented during construction to minimize the potential impacts to the groundwater.</p>	
<p>Concerns whether the EAR/IS analyzes consequences to fish from alterations in groundwater pathways.</p>	<p>The following sections of the EAR/IS assess changes to groundwater and surface water interactions from the Project, including water quality and quantity and potential linkage to harm fish and/or fish habitat.</p> <ul style="list-style-type: none"> ▪ Section 7 (Assessment of Effects on Surface Water Resources). ▪ Section 8 (Assessment of Effects on Groundwater Resources). ▪ Section 10 (Assessment of Effects on Fish and Fish Habitat). 	<p>Neskantaga First Nation</p>
<p>Concerns whether the proponent possess the financial and technical capacity to protect the fish, wildlife and water resources that will be impacted by the Project.</p>	<p>The assessment of the financial feasibility of the proposed WSR is not part of the scope of the EA/IA. The party(ies) responsible for constructing and operating the WSR will be required to demonstrate the financial and technical experience and capacity to successfully fulfill all environmental commitments made in the EA/IA phase, as well as the conditions of any permits, licences, approvals and authorizations obtained to implement the Project.</p>	<p>Neskantaga First Nation</p>
<p>Concerns about the water table variations causing increased levels of methylmercury in fish. Accordingly, Mushkegowuk recommends adding to the Government of Canada review team: "Health Canada".</p>	<p>Potential effects of the Project resulting in changes to groundwater level are assessed in Section 8.3. With the implementation of mitigation measures for dewatering as outlined in Section 8.4 and Appendix E of this EAR/IS, there are no expected permanent changes to either the regional ground water conditions or the regional surface water conditions/hydrology in the area.</p> <p>Methylmercury and other water quality concerns (parameters) have been included in the groundwater baseline investigation program. Groundwater quality will be monitored for seasonal and annual changes during the EA/IA process and monitoring will be included in the groundwater and surface water management plans during detail design for implementation in the construction and operation phases.</p> <p>Representatives of Health Canada have been part of the Federal Authority team providing guidance and direction to the Webequie Project Team in the development of the study plans that are used</p>	<p>Mushkegowuk Council</p>



Comment Theme	How are the Comments Addressed in this EAR/IS	Indigenous Community or Stakeholder
	to conduct the EA/IA. In particular, Health Canada experts have provided input to the Human Health component and are expected to be principal reviewers of the Human Health Risk Assessment (HHRA), which will include potential effects on country foods such as fish, and the overall Health Impact Assessment, which will incorporate the results of the HHRA.	
Concerns that the list of the primary field methods for collection of data for the physical environment in the ToR does not include groundwater sampling, groundwater elevation or flow monitoring.	The ToR was updated with Section 6.5 that includes the commitment to prepare and submit a groundwater work plan at the outset of the EA/IA for MECP to review and provide guidance on the detailed field methodologies to be used and specific data to be collected for the purpose of the EA/IA and any future monitoring during subsequent phases of the Project.	MECP
Groundwater quality results should be compared with the Ontario Drinking Water Quality Standards and applicable surface water quality standards.	The groundwater quality results have been compared to the following water quality guidelines and standards (refer to Section 6 Groundwater Resources and Appendix 6-F in the Natural Environment Existing Conditions Report (Appendix F of the EAR/IS): <ul style="list-style-type: none"> ▪ Guidelines for Canadian Drinking Water Quality. ▪ Ontario Drinking Water Quality Standards, Objectives and Guidelines. ▪ MECP Table 2 Full Depth Generic Site Condition Standards in a Potable Groundwater Condition (for all types of property use). 	MECP (Groundwater and Surface water Study Plan)
Commented that potential contaminants to the groundwater assessed should include additional parameters, including arsenic, chromium, and mercury.	Appendix 6-F-1 in the Natural Environment Existing Conditions Report (Appendix F of the EAR/IS) outlines the Groundwater Analytical Results in Project area for metals, general chemistry and radioisotopes which includes concentration of Arsenic, chromium, and mercury as well.	Wildlife Conservation Society Canada
Expressed concern about underground water systems.	The potential effects of the Project on Groundwater Resources have been discussed in Section 8.3 .	Fort Albany First Nation

8.1.3 Incorporation of Indigenous Knowledge and Land and Resource Use Information

To date, the following First Nations and groups have provided Indigenous Knowledge and Land and Resource Use (IKLRU) information to the Project Team:

- Webequie First Nation;
- Marten Falls First Nation;
- Weenusk First Nation;
- Kashechewan First Nation; and
- Fort Albany First Nation.



IKLRU reports provided information on groundwater water quality that generally overlapped with information on surface water resources and fish and fish habitat. Surface water quality has been identified as an essential element for community health and foods, as well as wildlife. Constant interactions between groundwater and surface water make groundwater resources one of the essential elements for the health and well-being of the Indigenous communities and groups.

Table 8-3 summarizes IKLRU information relating to Groundwater Resources VC and indicates where the information is incorporated in the EAR/IS.

Table 8-3: Groundwater Resources VC – Summary of Indigenous Knowledge and Land and Resource Use Information

Common Theme	Key Information and Concerns	Response and/or Relevant EAR/IS Section
<p>Water quality and quantity (surface and/or groundwater).</p>	<ul style="list-style-type: none"> ▪ Concerns regarding the risk of spills affecting pristine lakes and land, and the dispersion and migration of contaminants/pollutants. ▪ Many sites have already abandoned materials such as fuel drums, which can cause leaking into the water and onto the lands. ▪ Concerns about potential river system damage and rerouting due to spills during development. ▪ Future contamination of the water in and outside of traditional areas of Indigenous communities. ▪ “No safe distance would exist from contamination related to future development”. ▪ Due to the connectivity between the water and the surrounding wildlife and vegetation, water quality and quantity was identified as important for community health. ▪ Concerns were shared surrounding the short and long-term effects of contamination to water, humans and land, changes to flow patterns, and the impacts of their traditional livelihoods; like trapping and hunting, for future generations. ▪ Heightened levels of concern about the developments in and around the Ring of Fire and emphasized the importance of protecting the watershed for future generations. ▪ It was noted that the introduction of water systems on-reserve has had negative impacts on community members. The community’s water treatment facility, though upgraded in 2019, remains non-operational due to restricted resources. This has led to long-term boil water advisory, requiring community members to rely 	<ul style="list-style-type: none"> ▪ The potential effects of accidental spills are assessed in Section 23 – Accidents and Malfunctions. ▪ Potential project effects on groundwater resources are assessed in this EAR/IS section (Section 8) and Section 21 (Cumulative Effects Assessment). ▪ Potential project effects on other VCs, including Non-Traditional Land and Resource Use VC and Aboriginal and Treaty Rights and Interests VC are assessed in Sections 6, 7, and 9 to 21. ▪ Appendix E of the EAR/IS outlined mitigation measures to eliminate or reduce potential adverse effects of the Project. These mitigation measures reflect environmental protection guidelines to protect “Environmentally Sensitive Areas” as described in the Webequie First Nation On-Reserve Land Use Plan (Webequie First Nation, 2019). Further measures will be provided in the Construction Environmental Management Plan (CEMP) and the Operation Environmental Management Plan (OEMP) that will be developed for the Project. Section 4.6 of the EAR/IS describes the proposed framework for the development of the CEMP and the OEMP. ▪ Proposed water quality monitoring program is outlined in Section 8.9, Section 22, and in Section 5.22 (Water Quality Monitoring) of Appendix E – Mitigation Measures.



Common Theme	Key Information and Concerns	Response and/or Relevant EAR/IS Section
	<p>on bottled water that needs to be flown in and is expensive.</p> <ul style="list-style-type: none"> ▪ Concerns about the rise of pollution as projects develop. From water contamination, noise pollution, industrial dust, contaminants in nearby waterways and groundwater and littering. ▪ Concern about the impact of dust from increased traffic on water, wildlife, and the environment and about the inability to contain the dust and its negative effects of ecosystems and wildlife. ▪ Concerns regarding the illegal dumping of waste which can negatively impact the health and safety of their people, especially if waste leaches into the water table. ▪ Changes in river topography, water levels and flow patterns have been observed during community member lifetimes due to upriver dams. ▪ Declining of water levels has been significant within the last few decades and continuing; and even in the muskeg, the bogs have dried up. ▪ Muskeg is a major contributor to the streamflow and groundwater and there are concerns if it dries up or if contaminants seep through the muskeg. ▪ Water levels remain notably low even during summer due to upriver dams, making upstream navigation difficult and requiring boats to be dragged through rapids. ▪ Kistachowan Sipi (Albany River) system flows through First Nation's traditional territory, providing vital support to terrestrial and aquatic habitats that maintain resources like fish, wildlife, and plant life. ▪ Routes following the Kistachowan Sipi and its tributaries provide First Nation members with access to their traditional territories for resource harvesting and cultural site visits. ▪ According to community members, connection to the Kistachowan Sipi is essential, influencing cultural, social, health, and economic aspects of their lives. 	



Common Theme	Key Information and Concerns	Response and/or Relevant EAR/IS Section
<p>Current state of environment and connectedness of water to cultural and spiritual necessity, livelihood, Indigenous way of life, land, wildlife, fish, plants and herbs.</p>	<ul style="list-style-type: none"> ▪ The land right now is unique, untouched and natural, with no current contaminations or major impacts. It is preserved and safe, allowing for natural activities like drinking directly from the water and living off the land. ▪ The connection between water, wildlife, vegetation, and water quality and quantity are crucial for members' health. While members' traditional territories are generally seen as "pristine" and "safe", some members of the area, including Elders, have noticed changes over their lifetime. The water, once clear and fast, has become murky and shallow, making navigation difficult and unpredictable. ▪ Several waterways in the Winisk River watershed are habitat for medicinal plants and herbs. ▪ Water is the most sacred, spiritual and precious element to Indigenous Peoples and they have protected the water since time immemorial. 	<ul style="list-style-type: none"> ▪ Potential project effects on groundwater resources are assessed in this EAR/IS section (Section 8) and Section 21 (Cumulative Effects Assessment). Potential project effects on other VCs, including Non-Traditional Land and Resource Use VC and Aboriginal and Treaty Rights and Interests VC are assessed in Sections 6, 7, and 9 to 21. ▪ Appendix E of the EAR/IS outlined mitigation measures to eliminate or reduce potential adverse effects of the Project. These mitigation measures reflect environmental protection guidelines to protect "Environmentally Sensitive Areas" as described in the Webequie First Nation On-Reserve Land Use Plan (Webequie First Nation, 2019a). Further measures will be provided in the CEMP and the OEMP that will be developed for the Project. Section 4.6 of the EAR/IS describes the proposed framework for the development of the CEMP and the OEMP. ▪ The recommended monitoring program related to Groundwater Resources VC is outlined in Section 8.9. Additional details on monitoring programs for the Project are described in Section 22 of this EAR/IS, Follow-up and Monitoring Programs.
<p>Involvement with Project related decision-making and Project approvals regarding concerns about spring runoff carrying contaminants downstream and change in flow patterns.</p>	<p>Changes to flow patterns from the WSR and contaminants and pollutants that could be carried downstream from potential future foreseeable developments would impact the environment and natural resources in traditional areas of Indigenous communities and groups, as well as their rights to govern and manage the resources in their traditional areas.</p>	<ul style="list-style-type: none"> ▪ Potential effects on groundwater flow patterns and quality (contamination) are assessed in Section 8.3. Mitigation measures and net effects are provided in Section 8.4 and Section 8.5, respectively.
<p>Ecological function of peatlands.</p>	<ul style="list-style-type: none"> ▪ The importance of ecological function that the peatlands play in filtering contaminants from the air and water. ▪ Suggesting a hydrology study be complete as part of a project-specific mitigation plan in order to understand water movement in the peatlands and how potential contaminants from project related development could circulate, as well as being involved in the suggested hydrology study. 	<ul style="list-style-type: none"> ▪ Groundwater studies completed to date are considered adequate to contribute to the assessment of changes to the ecological functions of peatlands. Further peatland specific hydrological and/or hydrogeological studies, if deemed necessary, will be conducted during the detailed design phase. ▪ Based on the current Project Description, no peat will be excavated or removed, and a "floating" road will be constructed. As a result, the filtering function of the peatlands is not expected to be reduced.



Common Theme	Key Information and Concerns	Response and/or Relevant EAR/IS Section
		Instead, with the anticipated consolidation/settlement, the peatlands may increase the filtering efficiency.
Monitoring.	<ul style="list-style-type: none"> ▪ Concerns regarding keep water clean for next generations. ▪ Community members suggested water monitoring and fish monitoring programs to test contaminant levels in the water and wildlife and requested to be involved in the planning and execution of these monitoring programs. ▪ Rather than a one-time assessment on animals and environment, community members want the next 100 years to be monitored. ▪ Water is deeply spiritual for community members, essential for life, ceremonies, and travel. Protecting rivers and water bodies is a community responsibility. Important waterways include the Winisk River, its channels, and the upper Ekwan and Lower Attawapiskat watersheds flowing to James Bay. Concerns about water quality are significant, impacting both people and wildlife. Over the past 60 years, the community has noticed a decline in water quality. In the past, water from any source was drinkable, highlighting the changes observed over time. 	<ul style="list-style-type: none"> ▪ The recommended monitoring program related to Groundwater Resources VC is outlined in Section 8.9. Additional details on monitoring programs for the Project are described in Section 22 of this EAR/IS, Follow-up and Monitoring Programs.

Notes: Names of First Nations and associated location-specific description in some instances are not presented in this table due to potential sensitivity and confidentiality of IKLRU information.

8.1.4 Valued Component and Indicators

Valued components (VC), including groundwater resources, have been identified in the TISG and by the Project Team and are, in part, based on what Indigenous communities and groups, the public, government agencies, and stakeholders have identified as valuable to them in the EA/IA process to date. Subcomponents (or criteria) of the Groundwater Resources VC are further identified to help inform the report structure and better assess and present the data and assessment results. The assessment of these subcomponents is conducted using the methodology as outlined in Section 5 (Environmental Assessment / Impact Assessment Approach and Methods). The identified subcomponents for Groundwater Resources VC are:

- Groundwater quantity; and
- Groundwater quality.

"Indicators," are used to assess potential effects to a VC. In general, indicators represent a resource, feature or issue related to a VC that if changed from the existing conditions may demonstrate a positive or negative effect.



Table 8-4 shows the subcomponents and indicators identified for the Groundwater Resources VC.

Table 8-4: Groundwater Resources VC – Subcomponents, Indicators, and Rationale

Subcomponent(s)	Indicators	Rationale
Groundwater quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Formation permeability/Hydraulic conductivity ▪ Groundwater infiltration rate ▪ Hydraulic gradient ▪ Groundwater flow direction and pathway 	<ul style="list-style-type: none"> ▪ Project activities and/or components have potential for short-term and long-term effects on groundwater regime (natural flow/recharge interference, quantity, and quality). ▪ Groundwater interacts with surface water and plays an important role in the overall hydrologic cycle and ecological functions.
Groundwater quality	<ul style="list-style-type: none"> ▪ General chemistry (including pH), organic and inorganic parameters, nutrients, metals, and natural radionuclides 	<ul style="list-style-type: none"> ▪ Groundwater is important to human use (potable drinking water supply quantity and quality, or other consumptive uses). ▪ The ability to access and use clean drinking water is fundamental to the health and well of Indigenous communities.

8.1.5 Spatial and Temporal Boundaries

The following assessment boundaries have been defined for the Groundwater Resources VC.

8.1.5.1 Spatial Boundaries

The spatial boundaries for the Groundwater Resources VC are shown on **Figure 8.1** and include the following:

- **Project Footprint** – the area of direct disturbance (i.e., the physical area required for project construction and operations). The Project Footprint is defined as the 35 m wide right-of-way (ROW) of the WSR; and temporary and permanent areas needed to support the Project that include access roads, construction camps, laydown and storage yards, aggregate pits/quarries, and a Maintenance and Storage Facility (MSF).
- **Local Study Area (LSA)** – the area where direct and indirect effects of the Project on groundwater resources are likely to occur. The LSA for groundwater resources extends approximately 1 km from the centreline of the preliminary recommended preferred route, and 500 m from the boundaries of temporary and permanent supportive infrastructure.
- **Regional Study Area (RSA)** – the area where potential largely indirect and cumulative effects of the Project may occur in a broader, regional context, which include changes to regional groundwater flows, ground quantity and quality within the sub-watersheds or flow basins. However, the potential Project effects on groundwater resources are not expected to extend beyond the LSA. Therefore, no specific RSA is defined for the Groundwater Resources VC. It is considered the same as the LSA.

In selecting the LSA and RSA boundaries, consideration has been given to the potential effects and effect pathways of the Project. Potential effects to groundwater resources are expected to be localized – limited to the immediate surrounding areas that may interact with Project construction and operation activities. At this stage, the dewatering zone of influence (ZOI) from the construction activities, especially dewatering and pumping operations are not fully known, but it is not anticipated that the ZOI will extend beyond the LSA. Therefore, the LSA boundaries are expected to be sufficient to capture the potential effects of the Project on groundwater resources.



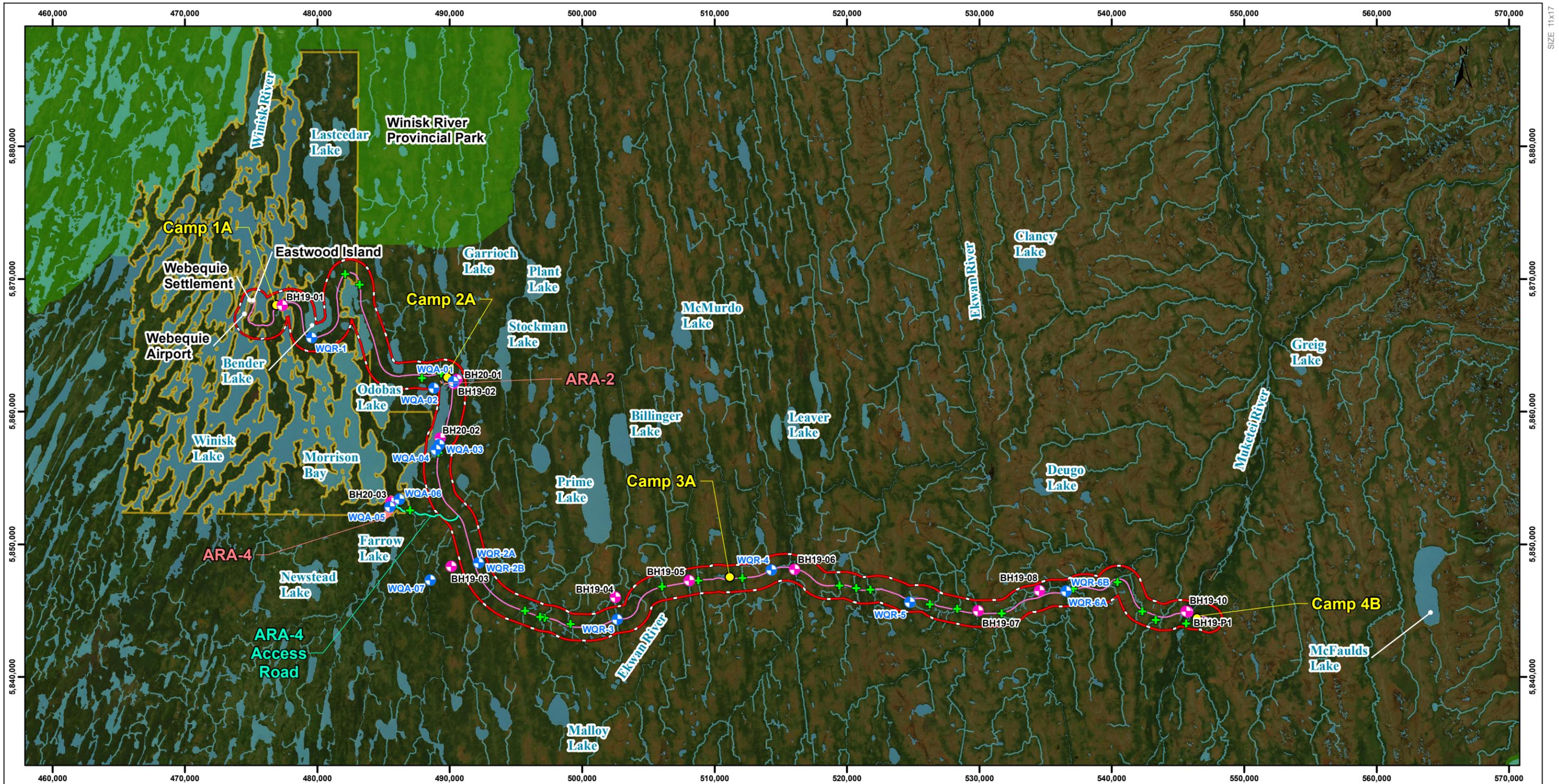
8.1.5.2 Temporal Boundaries

Temporal boundaries for the assessment address the potential effects of the Project over relevant timescales. The temporal boundaries for the Project comprise the following two main phases:

- **Construction Phase:** All activities associated with the initial development and construction of the road and supportive infrastructure from the start of the construction to the start of the operation and maintenance of the Project, and is anticipated to be approximately 5 to 6 years in duration.
- **Operation Phase:** All activities associated with operation and maintenance of the road and permanent supportive infrastructure (e.g., operation and maintenance yard, aggregate extraction and processing areas) that will start after the construction activities are complete, including site restoration and decommissioning of temporary infrastructure (e.g., access roads, construction camps, etc.). The Operations Phase of the Project is anticipated to be 75 years based on the expected timeline when major refurbishment of road components (e.g., bridges) is deemed necessary.

The Project is expected to operate for an indeterminate period; therefore, future suspension, decommissioning and eventual abandonment is not evaluated in the EA/IA (refer to Project Description, Section 4.4).





- Legend**
- Preliminary Recommended Preferred Route
 - Local Study Area (LSA 1km from the Preferred Route)
*Regional Study Area is considered the same as the Local Study Area
 - Webeque First Nation Reserve
 - Waterbody
 - Watercourse
 - Winisk River Provincial Park
 - + Waterbody Crossing
 - Recommended Construction Camps
*Camp 2-A is proposed to include permanent Maintenance and Storage Facility (MSF) for operations of the WSR.
 - ARA-4 Access Road
 - Recommended Aggregate/Rock Source
 - Borehole
 - Monitoring Well

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (<https://github.io.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF). Download Date: 2021-02-04

DISCLAIMER

This drawing was prepared for the exclusive use of Webeque First Nation (the "Client"). Unless otherwise agreed in writing by AtkinsRéalis, AtkinsRéalis does not accept and disclaims any and all liability or responsibility arising from any use of or reliance on this drawing by any third party or any modification or misuse of this drawing by the Client. This drawing is confidential and all intellectual property rights embodied or referenced in this drawing remain the property of such parties, as determined by the applicable services contract or contracts between AtkinsRéalis and the Client.

Webeque Supply Road (WSR)

Groundwater Study Areas

Figure Number: 8.1		REV: PA	
Client: Webeque First Nation	Project Number: 661910	Date: 6/24/2024	
DSC		DRN	CHK
		TE	AD
		APP	WL

8.1.6 Identification of Project Interactions with Groundwater Resources

Table 8-5 identifies project activities that may interact with groundwater resources to result in a potential effect. The identification of project interactions with groundwater resources provides a basis for the subsequent assessment of the potential effects of the Project. The potential effects are described separately for subcomponents of Groundwater Resources VC including groundwater quantity and groundwater quality.

Table 8-5: Project Interactions with Groundwater Resources VC and Potential Effects

Project Activities	Potential Effects	
	Change in Groundwater Quantity	Change in Groundwater Quality
Construction		
Mobilization of Equipment and Supplies: Transport of equipment, materials and supplies to the Project work areas using the winter road network and airport in the Webequie First Nation Reserve.	-	✓
Surveying: Ground surveys are conducted to stake (physically delineate) the road ROW and supportive infrastructure components of the Project (i.e., construction camps, access roads, laydown/storage yards, and aggregate pits).	-	-
Vegetation Clearing and Grubbing: Clearing and grubbing of vegetation (forest & wetland), including removal, chipping and/or disposal.	✓	-
Construction and Use of Supportive Infrastructure: This includes access roads, construction camps, laydown/storage yards, and aggregate pits including blasting.	✓	✓
Construction of Road: removal and stockpiling of organics, subgrade excavation, placement of fill and gravel, grading and drainage work (e.g., road ditches, erosion protection, etc.).	✓	✓
Construction of Structures at Waterbody Crossings: Culverts and bridges – foundations (e.g., spread footings, piles, caissons), wing walls, girders, and decks, etc.	✓	✓
Decommissioning / Closure of Temporary Aggregate Pits: Demobilization of extracting and processing equipment, grading and site reclamation/revegetation. This also includes formalizing / re-purposing select pits and quarries as permanent Project components for operations and maintenance.	✓	✓
Decommissioning of Temporary Construction Camps, Access Roads, and Laydown / Storage Areas: Grading and site reclamation/revegetation. This also includes formalizing / re-purposing select access roads to permanent pits and quarries and a construction camp to an operations and maintenance facility as Project components for use during operations.	✓	✓
Emissions, Discharges and Wastes ¹ : Noise, air emissions / greenhouse gases, water discharge, and hazardous and non-hazardous wastes.	-	-
Completion of Project-Wide Clean-up, Site Restoration / Reclamation and Demobilization: Clean-up of excess materials, site revegetation and demobilization of equipment and materials.	-	✓



Project Activities	Potential Effects	
	Change in Groundwater Quantity	Change in Groundwater Quality
Potential for Accidents and Malfunctions ² : Spills, vehicle collisions, flooding, forest fire and vandalism.	-	✓
Employment and Expenditures ³ .	-	-
Operations		
Road Use: Light and heavy vehicles and maintenance equipment with average annual daily traffic volume of less than 500 vehicles.	-	✓
Operation, Maintenance and Repair of Road: Includes vegetation management and control within the road ROW; repairs/resurfacing of roads; dust control; winter/seasonal maintenance (i.e., snow clearing); road drainage cleanout, repairs of culverts, ditches, and drainage outfalls; rehabilitation and repairs of culverts and bridges; and road inspection.	-	✓
Operation of Pits, Quarries, and maintenance yards/facilities: Includes periodic extraction and blasting and processing operations (i.e., crushing, screening) and stockpiling of rocks and aggregate materials. Also includes operation and repairs of maintenance yards/facilities and components (office buildings, parking lots, storage of equipment and materials).	✓	✓
Emissions, Discharges and Wastes ¹ : Noise, air emissions / greenhouse gases water discharge, and hazardous and non-hazardous wastes.	-	-
Potential for Accidents and Malfunctions ² : Spills, vehicle collisions, flooding, forest fire and vandalism.	-	✓
Employment and Expenditures ³ .	-	-

Notes:

✓ = Potential interaction

- = No interaction

¹ Emissions, Discharges, and Wastes (e.g., air, noise, light, solid wastes, and liquid effluents) can be generated by many project activities. Rather than acknowledging this by placing a checkmark against each of these activities, “Wastes and Emissions” is an additional component under each project phase.

² Accidents and Malfunctions including spills, vehicle collisions, flooding, forest fire and vandalism may occur at any time during construction and operations of the Project. Rather than acknowledging this by placing a checkmark against each of these activities, “Potential for Accidents and Malfunctions” is an additional component under each project phase. The potential effects of accidental spills are assessed in Section 23 – Accidents and Malfunctions.

³ Project employment and expenditures are related to most project activities and components, and are the main drivers of many socio-economic effects. Rather than acknowledging this by placing a checkmark against each of these activities, “Employment and Expenditures” is an additional component under each project phase.

8.2 Existing Conditions

This section summarizes existing conditions of groundwater resources based on desktop review and field investigations conducted for the Project. Detailed descriptions of the methods for desktop review and field investigations and interpretations of the results are provided in Appendix F – NEEC Report.



8.2.1 Methods

This section summarizes methods used to characterize the existing groundwater conditions in the LSA. The methods include desktop review and field investigations with the objective of addressing the requirements in **Sections 8.6** and Section 14.2 of the TISG and meeting the requirements of the MECP and other provincial ministries as identified in the ToR for the Project. The desktop review focused on available published literature and existing geotechnical and hydrogeological reports; while field investigations consisted of drilling and installation of monitoring wells (including piezometers), well development, hydraulic conductivity testing, and seasonal groundwater monitoring and sampling, as detailed in Section 6.2.1 in Appendix F – NEEC Report.



Indigenous community members raised concerns about heavy metals including chromium being introduced to the project area during construction and operations. To address this, strict regulatory guidelines were followed during the groundwater baseline investigation program concerning heavy metals including chromium, mercury and methylmercury. The study also included total metal and dissolved metal concentrations in waterbodies along the proposed ROW of the WSR.

8.2.1.1 Documents Reviewed During the Desktop Study

The documents that have been reviewed and referenced in the desktop study include:

- Topography, surficial geology, quaternary geology and bedrock geology (OGS Maps) where the project study areas are located;
- An Assessment of the Groundwater Resources of Northern Ontario, Hydrogeology of Ontario Series – Report 2, Ministry of the Environment (Singer and Cheng, 2002);
- Eagles Nest Mine Project – Draft Federal/Provincial Environmental Impact Statement/Environmental Assessment Report, Noront Resources Ltd., Knight Piesold Consulting. December 2013;
- Government of Canada Website (Environment and Natural Resource > Water Level and Flow) (https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time&search_type=province&province=ON);
- MECP Water Well Record database and online map (<https://www.ontario.ca/environment-and-energy/map-well-records>);
- MECP PTTW database and online map (<https://www.ontario.ca/environment-and-energy/map-permits-take-water>);
- Ontario Geological Survey Map P.3607. Precambrian Geology, Geology of the Winisk Lake Area, Northwestern Ontario;
- Permafrost in Canada's Subarctic Region of Northern Ontario (Tam, 2009);
- Provincial Groundwater Monitoring Network database and online map (<https://www.ontario.ca/environment-and-energy/map-provincial-groundwater-monitoring-network>);
- Ring of Fire Baseline Environmental Monitoring Program: Preliminary Report. Ministry of Environment, Conservation, and Parks. 2019; and
- Remedial Investigations and Options Analysis – 11 Sites, Webequie First Nation. True Grit Consulting Ltd., July 19, 2013.



8.2.1.2 Summary of Field Work Programs

Key components of the completed groundwater field work programs are summarized below:

- **Wells/Piezometers** – A total of 12 monitoring wells and three piezometers were installed in the summer of 2020.
- **Hydraulic Conductivity (K) Tests** – A total of 11 in-situ K tests were completed, one in each monitoring well in October 2020. One of the wells (WQR-4) could not be completed manually due to fast groundwater recovery.
- **Groundwater Samples** – A total of 36 groundwater samples were collected on three sampling occasions in July and October 2020, and May 2021. A total of 12 samples (one from each of the 12 wells) were collected during each of the three sampling events.
- **Parameters** – The following parameters were analyzed for groundwater samples:
 - General chemistry and inorganics:
 - alkalinity;
 - hardness;
 - pH;
 - conductivity;
 - turbidity;
 - total suspended solids;
 - total dissolved solids;
 - cations (H^+ , Mg^{2+} , Na^+ , Ca^{2+} , K^+ , NH_4^+);
 - anions (Cl^- , SO_4^{2-} , F^- , NO_3^- , NO_2^- , HCO_3^- , CO_3^{2-} , PO_4^{3-});
 - dissolved organic carbon; and
 - ammonia.
 - Nutrients:
 - total organic carbon;
 - total kjeldahl nitrogen; and
 - total phosphorus.
 - Metals and Organics:
 - total and dissolved metals (full metal scan);
 - hexavalent chromium;
 - total mercury;
 - methylmercury;
 - organic compounds: benzene, toluene, ethylbenzene, xylenes;
 - petroleum hydrocarbons (PHCs) fractions F1 to F4; and
 - polycyclic aromatic hydrocarbons.
 - Radionuclides:
 - radium 226.



8.2.2 Results

The existing/baseline conditions of the Groundwater Resources VC established through the desktop study and field investigations are summarized in the following subsections.

8.2.2.1 Geological and Hydrogeological Settings

- **Physiography** – The terrain and topography along the proposed WSR are relatively flat with two distinct sections: namely the north-south trending section and the west-east trending section. In general, the north-south section is typically a high relief plateau while the west-east section is a low relief (Hudson Bay Lowlands).
- **Stratigraphy** – The overburden (surficial geology) consists of sand to silty sand till, silt to silty clay till, peat and muck. The overburden was underlain largely by the intrusive rocks of Archean Age belonging to Superior Province of Canadian Shield, which is believed to be more than 2.5 billion years old. Further to the east beyond the project limits towards James Bay, the bedrock is comprised of Paleozoic sedimentary rocks belong to Ordovician and Silurian Systems.
- **Faults and fractures** – The Superior Province of Canadian Shield has a dominant east-northeast fracture trend and has an extra north-northeast dominant fracture trend. The most prominent right-handed transcurrent (strike-slip) fault zone-the Webequie fault zone-trends south-eastwards extending past the middle section of the WSR ROW. Possible segments of gneissic and intrusive rocks appear to trend north-north-westward from the Webequie fault zone.
- **Hydro-stratigraphic units/aquifers** – The hydro-stratigraphic units/aquifers within the LSA can largely be divided into three large groups: the overburden with fresh water; the shallow bedrock zone less 150 m below grade with freshwater; and the deep bedrock zone with saline water (more than 150 m below grade).
- **Hydraulic conductivity** – The hydraulic conductivity ranges from 1.4×10^{-8} m/s to 1.6×10^{-5} m/s, with a geometric mean of 4×10^{-7} m/s for the overburden (sandy silt till, silt and sand till) and ranges from 3.5×10^{-7} m/s to 1.9×10^{-5} m/s, with a geometric mean of 3.1×10^{-6} m/s for the bedrock (granodiorite, slightly to moderately fractured/weathered). Hydraulic conductivity is a measure of how easily water can pass through soil or rock. Low values of hydraulic conductivity indicate that the material is less permeable, while high values indicate more permeable material through which water can pass easily.
- **Climate** – The relatively flat Canadian Shield provides a few barriers to the weather system sweeping down from the north. As a result, the project study area experiences a variety of weather events. Low temperatures (-26.1 to -48.0°C) occur mainly from November to April, and high temperatures (26.7 to 36.7°C) occur mainly from May to August. Most precipitation falls as rain in the summer (June to September) and as snow in the winter (October to May). Annual precipitation within the Winisk River watershed comprises 471.0 mm of rain and 118.3 mm of snowfall.

8.2.2.2 Groundwater Quantity

- **Groundwater recharge and discharge** – Groundwater recharge occurs in most of the areas where the surficial geology consists of predominantly sand to silty sand till overlying the bedrock. Localized eskers are scattered along the north-south section and towards the east end of the WSR. As these eskers are comprised of predominantly sand and gravel of glaciofluvial ice-contact deposits, the recharge rates are expected to be higher than the remaining sections of the WSR ROW. Groundwater discharges mainly to the surface water bodies including lakes, rivers/streams, and wetlands (e.g., fens where groundwater is one of the main water supply sources for wetland



functioning and sustainability). The primary source for groundwater recharge is precipitation including rain and snowfall (melting).

- **Groundwater Level** – Groundwater levels ranged from 1.0 to 3.1 metres below ground surface (mbgs) in the overburden wells, and from 2.4 to 3.0 mbgs in the bedrock well in the potential aggregate and quarry sites with seasonal groundwater level variations ranging from 0.1 to 0.6 m in the overburden wells and 0.6 m in the bedrock wells. Groundwater levels ranged from 0.1 metre above ground surface (mags) to 0.5 mbgs in the overburden wells, and from 0.1 mags to 0.6 mbgs in the bedrock wells within the LSA for the Project, with seasonal groundwater level variations ranging from 0.1 to 0.5 m in the overburden wells and from 0.2 to 0.4 m in the bedrock wells. Groundwater levels ranged from 0.2 mags to 0.6 mbgs in the peatland areas, with seasonal groundwater level variations ranging from 0 to 0.2 m.
- **Groundwater flow** – Regional groundwater is expected to flow to the north/northeast towards Hudson Bay within the Winisk watershed in the western portion of the WSR; and to the northeast/east towards James Bay within the Ekwano and Attawapiskat watersheds in the eastern portion of the WSR. Within each sub-watershed, groundwater flows in shallow water bearing zones (overburden or shallow bedrock zones) are expected to be towards nearby water bodies and mostly expected to be easterly or westerly.
- **Groundwater and Surface Water Interaction** – Generally, groundwater recharges surface water as a form of discharge at major water crossings, lakes, and wetlands. However, during significant storm events, surface water levels within the water bodies may rise quickly and recharge groundwater for a short period of time. Groundwater contribution rates to the stream flows are estimated to be ranging typically from 20% to 30% at major streams and tributaries, corresponding to annual groundwater contribution (discharge) ranging from 75 mm to 85 mm. The groundwater contribution tends to be smaller at small tributaries compared to major streams and tributaries, and greater during dry seasons compared to wet seasons.
- **Groundwater Users** – One water supply well was identified within the Webequie First Nation Reserve, approximately 200 m southwest of the west end of the WSR. The well screen (open borehole) was installed between 39 and 93 mbgs in the bedrock. Based on the 60-minute pumping test results, the recommended pumping rate was 4 US gallons per minute, or 21,804 litres/day.

8.2.2.3 Groundwater Quality

- **Hydrogeochemical and Groundwater Quality** – Groundwater occurs in the overburden sediments and shallow bedrock formations can be categorized as calcium bicarbonate type, except at one location (BH-6A/B) towards the east end of the WSR (refer to Figure 6.1 in Appendix F – NEEC Report for monitoring well locations), where it can be considered calcium/magnesium bicarbonate type. Naturally elevated dissolved organic carbon, hardness, iron, and manganese are common within the LSA, with occasionally elevated alkalinity, pH, and arsenic (Refer to Appendix F – NEEC Report – Section 6 Groundwater Resources for more details).



Indigenous community members raised concerns about potential contamination of the headwaters and rivers by heavy metals including chromium. Additional water sampling will be conducted to monitor water quality in the project study areas prior to, during and post-construction. This will include sampling and testing for chromium and other heavy metals including mercury and methylmercury. Groundwater monitoring wells to assess water levels and quality have been installed along the proposed ROW for the WSR and around the proposed quarries. The water sampling will be conducted in a variety of flow conditions and seasons to assess seasonal variations of groundwater conditions.



8.3 Identification of Potential Effects, Pathways, and Indicators

As indicated in **Table 8-5**, some project activities may interact with and impose potential effects on groundwater resources during the project construction and operations. This section describes the nature of the potential effects, the pathways that link the project activities and the effects, and the indicators that can be used to assess and measure the effects.

The descriptions of the effects in this section are structured based on project activities instead of project phases to avoid repetition, as some of the activities occur during both construction and operation phases including aggregate extraction pits (borrows and quarries), and use of water supply wells.

The potential effects of accidental spills are assessed in Section 23 – Accidents and Malfunctions.



To address concerns raised by Indigenous communities about potential effects on fish and fish habitat due to potential changes caused by project activities on groundwater pathways, representatives of Health Canada have been part of the Federal Authority team providing guidance and direction to the Webequie Project Team in the development of the study plans that are used to conduct the EA/IA. In particular, Health Canada experts have provided input to the Human Health component and are expected to be principal reviewers of the Human Health Risk Assessment (HHRA), which will include potential effects on country foods such as fish, and the overall Health Impact Assessment (Section 17 and Appendix Q) which incorporated the results of the HHRA (Appendix P).

8.3.1 Vegetation Clearing and Grubbing

Vegetation clearing and grubbing → Alteration of vegetation coverage → Increase of infiltration rate → Increase of groundwater level

Clearing and grubbing of vegetation (including forests and wetlands) involve removal, disposal and/or chipping, which occur in the early stage of the construction phase. These activities allow rainfall to make direct contact with the soils without vegetation interception, and reduce potential evapotranspiration, thus may increase the infiltration rate from a ground cover perspective. With the increased infiltration rate, groundwater levels particularly in the shallow water bearing zones (or aquifers) can rise accordingly at a local scale.

These effects have been reported in many previous studies and published papers. Previous studies discussed in a published paper by Smerdon et al. (2009) noted that:

- In areas (forests) fully cleared for agriculture, the potentiometric surface moved upward at more than 2.6 m per year, averaged over several years. This was equivalent to increased recharge estimated as 6% to 12% of rainfall depending on the specific yield used for the aquifer. The potentiometric surface was observed to rise less rapidly (0.9 m per year) in areas subjected to partial clearing (A.J. Peck and D.R. Williamson 1987, as cited in Smerdon et al. 2009).
- In regions similar to the Coastal Basins & Lowlands, increases in water table elevation have been measured in the order of 50 cm following harvest of peatland forest stands (Dubé et al. 1995, as cited in Smerdon et al. 2009) and shown to remain elevated for three or more years following harvesting (Bliss and Comerford 2002; Pothier et al. 2003, as cited in Smerdon et al. 2009).



Vegetation clearing of the road ROW, temporary/permanent access roads, construction camps with laydown/storage areas and aggregate sources areas (i.e., ARA-2 and ARA-4) will be completed. Grubbing is required at construction camp locations, aggregate source areas, access roads and along the road ROW, except for west to east section (56 km) in the lowlands/peatlands, where no grubbing is proposed and where no vegetation clearing outside the road footprint will be conducted.

The effects are expected to be short-term in nature. Shortly after completion of vegetation clearing and grubbing, the disturbed areas will be under construction for different purposes such as temporary and new roads, laydown areas, storage yards, construction camps, etc. These activities may cause the ground surface to become hardened as construction progresses, and the infiltration rates are expected to be reduced gradually.



Indigenous community members raised concerns about potential effects of the drainage of peatlands that will result from the construction of the WSR. Recognizing the importance of peatlands to First Nations due to their ability to store carbon in their soils and hold a lot of freshwater, a “floating” road design – the proposed road will be constructed on top of the peat (no peat is removed) – will be used for the section of the WSR that crosses peatlands as described in Section 4.3.1.3.1 Road Design in Peatlands. In addition, the installation of equalization culverts is recommended at frequent intervals to support the continued movement of surface and groundwater/spring water in the peatlands. The assessment of effects on peatlands and proposed mitigation measures are presented in Section 11.

8.3.2 Site Grading / Ground Hardening

Site Grading → Hardening of ground surface → Decrease of infiltration/recharge rate → Lowering of groundwater level

Site grading as part of the construction of temporary infrastructure (e.g., laydown/storage yards, construction camps, etc.) and permanent infrastructure (e.g., roads, bridges, MSF) can cause ground hardening, which may result in a decrease of infiltration rates and an increase of direct surface runoff. With the reduced infiltration and recharge rates, groundwater levels are expected to be slightly lower than the pre-construction conditions at and in the vicinity of the infrastructure areas.

Site grading will be carried out shortly after the vegetation clearing and grubbing for the construction of temporary and permanent project components, including laydown areas, storage yards, construction camps, MSF and new roads. Due to machine operation and soil (fill material) compaction, the ground surface in these areas will become hardened, resulting in a reduced infiltration rate and groundwater recharge.

To further assess the changes to the groundwater recharge/water levels due to site grading resulting in ground hardening, a preliminary water balance analysis was conducted for the permanent infrastructure including the new road and MSF. The temporary infrastructure such as construction camps and laydown/storage areas is only needed during construction, and therefore once these areas are decommissioned after construction, the sites are expected to be restored to pre-development conditions.

Section 4.4.2.6 of this EAR/IS provides more details on decommissioning and site restoration/reclamation activities for the proposed project.

The following effects assessment (**Sections 8.3.2.1 and 8.3.2.2**) focuses on the WSR ROW. Construction camps are expected to be fully or partially decommissioned and rehabilitated after construction. The majority of the direct runoff from the permanent MSF and maintenance and rest areas along the road (refer to Section 4.3.1.5 of this EAR/IS) are expected to infiltrate back to the groundwater system in the vicinity of the site.



8.3.2.1 Water Balance Analysis – Methodology

Thorntwaite Model

The water balance method is considered an appropriate tool for predicting the changes to groundwater recharge that may result from the construction of the road, as more sophisticated approaches are not feasible at the preliminary design stage of the Project. The water balance method can calculate the surplus and runoff portions of the total precipitation. The surplus can then be used to estimate the groundwater recharge.

The model used for the water balance analysis is called the Thorntwaite Model, which is based on monthly accounting procedures referenced from the U.S. Department of the Interior, and U.S. Geological Survey (McCabe and Markstrom 2007).

The main input parameters for the model include monthly mean temperature (T, in Celsius), monthly total precipitation (P, in millimeters), and the latitude (in decimal degrees) of the location of interest. The latitude of the location is used for the calculation of daylight hours, which is needed for the calculation of potential evapotranspiration.

This model also has seven other input parameters (runoff factor, direct runoff factor, soil-moisture storage capacity, location latitude, rain temperature threshold, snow temperature threshold, and maximum snow-melt rate of the snow storage) that are modified through the graphical user interface. The range and default values for these parameters are predefined in the model (**Figure 8.2**).

Figure 8.2: Input Parameters for Thorntwaite Model

The screenshot displays the 'Thorntwaite Monthly Water Balance' graphical user interface. At the top, it features the USGS logo (science for a changing world) and the MMS logo (Bringing Modeling to the People). The interface is divided into several sections:

- Input Parameters:** Seven sliders are used to set the following values:
 - Runoff Factor: 50 %
 - Direct Runoff Factor: 5 %
 - Soil-Moisture-Storage Capacity: 325 Millimeters
 - Latitude of Location: 52 Degrees of Latitude
 - Rain Temperature Threshold: 3.3 Degrees Celsius
 - Snow Temperature Threshold: -10.0 Degrees Celsius
 - Maximum Melt Rate: 50 %
- Input File:** A text box containing the file path: I:\E&W\Projects\661910 - Webequie First Nation Supply Rd\40_Execution\47_Wrkg_Vers\47_06 Phys\Groundwater\EAR ISI\Water Balance\Input\20220104_661910_WSR Input.txt
- Output Plots:** A grid of radio buttons for selecting output plots:
 - Actual ET (selected)
 - Potential ET - Actual ET
 - Runoff
 - Soil Moisture Storage
 - Direct Runoff
 - Precipitation
 - Snow Storage
 - Surplus
 - Potential ET
 - Precip - Pot ET
 - Snow Melt
 - Temperature
- Run:** A button labeled 'Run Thorntwaite Model'.



Infiltration

The water balance method developed by Thornthwaite and Mather (1957) determines the potential and actual amounts of evapotranspiration and water surplus (or excess of precipitation over evapotranspiration). Infiltration factors are then used to determine the fraction of water surplus that infiltrates into the ground (to recharge groundwater) and the fraction that runs off to nearby streams.

The Stormwater Planning and Design Manual (MOE 2003) provides a method to estimate the infiltration amount based on the infiltration factor (i). The factor “i” was determined by summing the factors for topography, soils and ground cover and then applied to the water surplus to estimate the amount of infiltration (groundwater recharge) for a given area.

8.3.2.2 Water Balance Analysis – Results

Annual Precipitation and Surplus

The main input parameters used for the water balance model were determined based on the Environment Canada climate data from Lansdowne House meteorological station, which is located approximately 80 km southwest of the WSR (from the middle section of the proposed WSR route). The available complete monthly records from the Lansdowne Station downloaded from the Environment Canada website are from the monitoring periods from 1947 to 1988, from 2002 to 2010, and from 2012 to 2018.

Based on the analysis of 58 years of climate data (mean monthly temperature and monthly total precipitation), the long-term annual precipitation in the project study area is 657 mm, and the annual surplus and total runoff are estimated to be 189 mm and 214 mm, respectively, with an average soil holding/storage capacity of 325 mm (a combined capacity of peat, sandy loam, loam, and clay loam). Detailed annual precipitation and surplus analyses are provided in Section 6 of Appendix F – NEEC Report.

Pre-Development Infiltration Factors

The main factors that affect the pre-development infiltration rates include topography, soils, and ground cover. These factors are determined based on Stormwater Planning and Design Manual (MOE, 2003) – Table 3.1: Hydrologic Cycle Component Values. The infiltration factors are determined as follows:

- Topography Factor (TF): Rolling lands (average slope less than 2.8 m to 3.8 m/km) = 0.2
- Soils Factor (SF): vary according to soil types, ranging from 0.2 to 0.4 (with an average of 0.3)
- Cover Factor (CF): Woodland = 0.2

Based on United States Department of Agriculture Soil Classification System, the surficial soils (less than 3 mbgs) encountered along the proposed road ROW within the LSA can be classified as sand, loamy sand, sandy loam, loam, sandy clay loam and clay loam according to the grain size analysis results. For the purposes of evaluation and according to surficial soils, the WSR is divided into two portions/sections: Western Portion (north-south section of the WSR, upland area, 51 km long) and Eastern Portion (west-east section, lowland area, 56 km long). The values for water holding capacity and soil infiltration factor are chosen from Table 3.1 in the MOE Stormwater Planning and Design Manual based on the soil classification results. The assigned infiltration factors are presented in **Table 8-6**.



Table 8-6: Infiltration Factors – Pre-Development

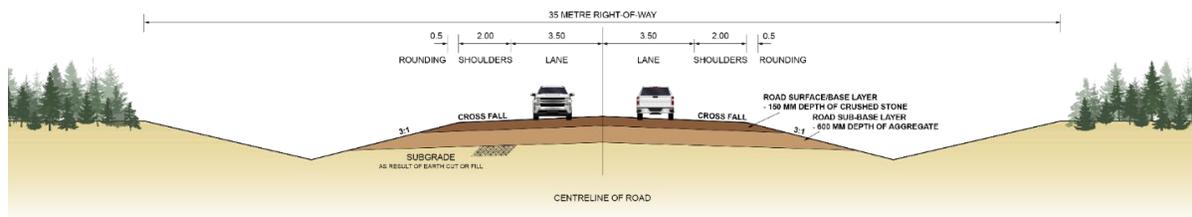
Borehole ID	Sand and Gravel (%)	Silt (%)	Clay (%)	Soil Classification	Water Holding Capacity (mm)	Infiltration Factor (Soil)
Western Portion (North-South Section) – Forests (infiltration factor: TF0.2+SF0.3+CF0.2 = 0.7)						
BH19-01	62.3	37.7		Peat/Sandy Loam	400	0.3
BH19-02	75.3	24.7		Peat/Sandy Loam	400	0.3
WQA-1	85.3	14.7		Peat/Loamy Sand	400	0.3
WQA-3	91.6	8.4		Peat/Sand	400	0.3
Eastern Portion (West-East Section) – Shrubs and Wetlands (infiltration factor: TF0.2+SF0.25+CF0.2 = 0.65)						
BH19-05	56.7	43.3		Peat/Sandy Clay Loam	250	0.2
BH19-06	44.1	55.9		Peat/Loam	250	0.2
BH19-07	37.1	40.9	22.0	Peat/Loam	250	0.2
WQR-3	43.4	56.6		Peat/Loam	250	0.2
WQR-5	37.4	62.6		Peat/Clay Loam	250	0.2
BH19-07	67.9	32.1		Peat/Sandy Loam	400	0.3
BH19-08	67.0	33.0		Peat/Sandy Loam	400	0.3
BH19-10	67.0	33.0		Peat/Sandy Loam	400	0.3

Road Design

According to the preliminary engineering design of the road (Appendix D-1 – Preliminary Engineering Design Report), key criteria/standards are as follows. The typical section of the road is illustrated in **Figure 8.3:**

- Travel portion (pavement) width: 2 × 3.5 m
- Shoulder width: 2 × 2.0 m
- Shoulder rounding: 2 × 0.5 m
- Slope (variable) width: 2 × 7.0 m (average)
- Ditch width: 2 × (1.5+1.5+1.5) m = 2 × 4.5 m

Figure 8.3: Webequie Supply Road Typical Section



WEBEQUIE SUPPLY ROAD



In the western half of the WSR, where soils are in stable conditions, the surface layer of the road will be chip-seal treated, which is similar to asphalt pavement, and consists of a tar slurry and gravel. While in the eastern half of the road in the peatlands where poor soil conditions are present, the driving surface will be initially gravel. During the operations phase, monitoring of the eastern half of the WSR in the peatlands will be conducted to assess settlement, serviceability, and safety issues/concerns related to dust along the WSR. Depending on the outcome of the monitoring, the gravel driving surface may be replaced in approximately 3 to 5 years with chip-seal treatment or asphalt pavement. More details about the road design are provided in Section 4 – Project Description.

Pre-Development Infiltration Rates – Road Right-of-Way

The total width of the ROW for the WSR is 35 m. The entire ROW is considered to be pervious before development, with the total area of the road footprint being measured at approximately 3,745,000 m² (107 km long road ROW times 35 m wide ROW). The corresponding infiltration rates (surplus times infiltration factors) are estimated to be 132 mm for the north-south section and 123 mm for the west-east section. The annual recharge volume for the entire length of the road ROW was estimated to be 476,942 m³/year (Table 8-7).

Table 8-7: Annual Infiltration Volumes – Pre-Development Road Right-of-Way (Previous Areas)

Parameter	Unit	North-South Section	West-East Section	Total
Length	m	51,000	56,000	107,000
Width	m	35	35	35
Pervious Area	Square Metres (m ²)	1,785,000	1,960,000	3,745,000
Pervious Area	Hectares (ha)	178.5	196.0	374.5
Annual Surplus	Millimeters (mm)	189	189	189
Infiltration Factor	-	0.7	0.65	n/a
Recharge Rate	Millimeters (mm) / year	132	123	n/a
Recharge Volume	Cubic Metres (m ³) / year	236,156	240,786	476,942

Post-Development Infiltration Rates – Road Right-of-Way

Under post-development conditions, the infiltration factors are adjusted to reflect the changes in soil types, vegetation, and topography after construction of the road. According to the preliminary design, the road will have an approximate 26 m wide road surface and a 4.5 m wide ditch on each side of the road. Based on industry practices, the road surface is typically considered impervious. Particularly, the compacted backfill materials (e.g., embankment) beneath the crushed stone basecourse and granular subbase under the post-development condition are considered to be imperious (the worst-case scenario). The infiltration factors for the roadside ditches remain the same, which is considered to be pervious, similar to the pre-development conditions.

The roadside ditches are designed only for the western portion of the road in the upland areas. No ditches are designed for the eastern portion of the road, where lowlands exist. Instead, it is proposed that runoff from the road and adjacent peatlands follow the natural existing drainage paths and be conveyed through a series of cross-culverts to ensure that surface water drainage is equalized on both sides of the road.



It is expected that after road construction, the pervious area will be reduced by 2,782,000 m², due to the construction of the paved area. Accordingly, the annual recharge volume directly underneath the road is estimated to be reduced by 354,300 m³ per year (Table 8-8 and Table 8-9).

Table 8-8: Annual Infiltration Volumes – Post-Development Road Right-of-Way (Pervious Areas)

Parameter	Unit	North-South Section	West-East Section	Total
Length	m	51,000	56,000	107,000
Width	m	9	9	9
Pervious Area	Square Metres (m ²)	459,000	504,000	963,000
Pervious Area	Hectares (ha)	45.9	50.4	96.3
Annual Surplus	Millimeters (mm)	189	189	189
Infiltration Factor	-	0.7	0.65	n/a
Recharge Rate	Millimeters (mm) / year	132	123	n/a
Recharge Volume	Cubic Meters (m ³) / year	60,726	61,916	122,642

Table 8-9: Changes to Annual Infiltration Volumes – Pre- and Post-Development Road Right-of-Way

Parameter	Unit	Pre-Development	Post-Development	Change
Pervious Area	Square Meters (m ²)	3,745,000	963,000	-2,782,000
Impervious Area	Square Meters (m ²)	0	2,782,000	2,782,000
Annual Surplus	Millimeters (mm)	189	189	0
Infiltration Factor	-	0.65 to 0.7	0.65 to 0.7	0
Recharge Rate	Millimeters (mm) / year	123 to 132	123 to 132	0
Recharge Volume	Cubic Meters (m ³) / year	476,942	122,642	-354,300

Rainfall, after falling on the road surface, will flow to the roadside ditches through direct runoff or follow natural drainage systems. The ditches themselves are permeable; therefore, the majority of the diverted direct runoff due to road construction is expected to infiltrate and recharge back to the local groundwater system. A portion of the water collected in the ditches may enter nearby surface water bodies (e.g., rivers, creeks, lakes, wetlands, etc.), where collected water surpasses the infiltration capacity during storms.

8.3.3 Blasting of Rocks

Blasting of rocks → Increase of formation permeability → Alteration of flow rate, flow direction and pathway → Change to groundwater level

Blasting of rocks with explosives may be required to create desired road profiles, and extract construction materials at quarry site ARA-2. Blasting of rocks at the ARA-2 quarry site can create more fractures and thus increase the permeability of the formations near the blasting spots, which may result in the increase of infiltration rates. The localized alteration of permeability of the formations may change flow directions and the preferential pathways. Groundwater levels may also change in some areas due to these changes. These changes can occur during both construction and operation phases. Although rock



blasting is an intermittent activity, the alteration of permeability, flow directions and pathways is permanent (irreversible).

Blasting of rocks → Introduction of deleterious substances → Reduction in groundwater quality

By-products of explosive detonation can introduce deleterious substances (e.g., ammonia, nitrate, etc.) to the natural environment. Through precipitation and leaching, these chemicals may move with groundwater flow through existing and newly created fractures. These substances may infiltrate to the groundwater regime through precipitation and leaching or enter nearby surface water bodies through overland flow and can cause reduction in groundwater and surface water quality.

However, the effects are expected to be limited to the vicinity of the blasting spots and generally within the aggregate sites. Although the blasting occurs only periodically, the effects are permanent as once the fractures are created, they are difficult to be reversed (unless a significant geological event occurs). Based on the relatively low volumes of rock needed for the Project (approximately 5,500 m³), the drilling and blasting of rock requiring the use of explosives during construction and operation activities is expected to occur on an infrequent basis.

8.3.4 Extraction, Cut, Excavation, Stockpiling and Backfilling

Extraction, cut and backfilling → Alteration of topography → Alteration of infiltration rate, hydraulic gradient, flow direction and pathway

Activities such as extraction of rocks and granular materials at aggregate pits/quarries, cut, and backfilling (raise grade) along the road ROW will change the local landscape and topography features. These changes may alter groundwater infiltration rates, hydraulic gradients, and flow directions and pathway mainly due to the changes to the topography and landscape. These activities and changes can occur in both construction and operation phases. Although these activities are short-term in nature, the results of the alteration of the topography and changes to groundwater flows and pathways are permanent (irreversible).

Changes to the landscape and topography features due to aggregate extraction, cut, excavation and backfill activities are expected to be limited within the Project Footprint, particularly the road ROW, watercourse crossings and aggregate areas. These changes are permanent in nature. Ground cover and topography are one of the factors that affect the ratio of groundwater infiltration to surface runoff, as well as hydraulic gradients, flow directions and pathways.

In the western half of the WSR, lowering (cut) or raising (fill) of existing grades is anticipated to be approximately 3 m. An average increase to existing grades of approximately 1.5 m in height is expected in the eastern half of the road – lowland areas, with the exception of the watercourse crossing of the Muketei River. An earth cut or lowering of existing grades by approximately 5 m is needed near the Muketei River to allow for the crossing of the floodplain and river.

The quantitative effect (e.g., changes to infiltration and recharge) depends on the scale of these activities, including areas and depths of the extraction, cut, and excavation; hydrogeological settings and groundwater conditions. Models and equations can be used to quantify these effects when more detailed information becomes available during the detail design phase of the Project.



Stockpiling → Leaching of deleterious substances → Infiltration and overland flow → Reduction in groundwater and surface water quality

Stockpiling of extracted and processed (e.g., crushed), and excavated materials will occur during the construction and operation phases. Deleterious substances (e.g., metals, sulphate, etc.) may leach through precipitation and oxidation processes and cause elevated metals and acids in water, particularly when stockpiling metal sulfide enriched minerals. These materials are commonly known as potentially acid rock drainage (ARD) generating materials. The leached substances will move along with water to either infiltrate to the groundwater regime or enter nearby surface water bodies through overland flow.

One of the concerns associated with extraction and utilization/backfill of aggregate materials is the potential of ARD. During the geotechnical field work (drilling) programs, soil and rock samples were collected and submitted to an environmental laboratory for acid-base accounting (ABA) analysis, where the Sobek Method and Synthetic Precipitation Leaching Procedure were used to analyze the samples. The laboratory results are compared to Potentially Acid Rock Drainage Generating (PAG) criteria according to the Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (CANMET, 2009), to determine whether the rocks and soils are PAG or non-PAG. The analysis results and PAG determination are summarized in **Table 8-10** and **Table 8-11**.

Based on the laboratory ABA analysis results and PAG criteria, all the rock and soil samples collected over the length of the road ROW are considered non-PAG material. The potential of causing ARD effect and reduction in groundwater and surface water qualities due to extraction and utilization of aggregate materials is low.

Table 8-10: ABA Results for Rock Samples

Sample ID	Rock	Sample Depth (m bgs)	Paste pH	Sulfide-S (% w/w)	AP/MPA	NP	Ratio (NP/AP)	PAG
WQA-1	Granodiorite	4.3 to 4.6	9.6	0.01	0.3	4	12.8	Non-PAG
WQR-3	Granodiorite	5.5 to 5.7	9.5	0.15	5.0	7	1.4	Non-PAG
WQR-4	Granodiorite	6.3 to 6.6	9.5	0.02	0.6	12	19.2	Non-PAG
WQR-6B	Granodiorite	8.5 to 8.8	9.3	<0.01	<0.3	10	64.0	Non-PAG
Minimum			9.3	<0.01	<0.3	4	1.4	
Maximum			9.6	0.15	5.0	12	64.0	
PAG Criteria			<4.5				<1	



Table 8-11: ABA Results for Soil Samples

Sample ID	Soil (till)	Sample Depth (m bgs)	Paste pH	Sulfide-S (% w/w)	AP/MPA	NP	NPR (NP/AP)	PAG
WQA-3	Sand	3.1 to 3.7	8.3	0.01	0.3	214	684.8	Non-PAG
WQA-5	Gravelly Sand	4.6 to 5.0	8.2	0.02	0.6	358	572.8	Non-PAG
WQR-1	Sandy silt	4.6 to 5.2	8.4	0.02	0.6	441	705.6	Non-PAG
WQR-2A	Sandy silt	1.5 to 2.1	8.1	0.01	0.3	381	1219.0	Non-PAG
WQR-3	Silt and sand	2.3 to 2.9	8.5	0.01	0.3	323	1033.5	Non-PAG
WQR-5	Sandy silt	2.3 to 2.9	8.1	0.01	0.3	404	1293.0	Non-PAG
Minimum			8.1	0.01	0.3	214	572.8	
Maximum			8.5	0.02	0.6	441	1293.0	
PAG Criteria			<4.5				<1	

Notes:

Paste pH – A 10 g sample is saturated with de-ionized water to form a paste. The pH of the paste is measured with a pH electrode and pH meter.

AP/MPA – Acid Generation Potential/Maximum Potential Acidity, expressed as tCaCO₃/kt.

NP – Neutralization Potential, as tCaCO₃/kt.

NPR – Neutralization Potential Ratio (effective neutralization potential divided by acid potential)

PAG – Potentially Acid Rock Drainage Generating

Sulfide-S – Sulfide-sulfur, as % weight/weight (w/w).

8.3.5 Dewatering / Pumping



Indigenous community members raised concerns about how dewatering activities during the project construction may affect levels of methylmercury and other environmental effects. Groundwater quality was monitored for seasonal and annual changes during the EA/IA process and monitoring will be included in the Groundwater Management Plan during detail design for implementation in the construction and operation phases.

Dewatering / Pumping of Groundwater → Lowering of groundwater level → Decrease of water supply capacity → Reduction in baseflow contribution to surface waterbody

Dewatering is likely required during construction to keep the work area dry for the construction of the structure foundations (e.g., bridges and culverts, etc.). Dewatering may also be required when extracting aggregate materials at quarry and borrowing sites if the extraction is advanced below the groundwater table. The water supplies (wells) at the construction camps and maintenance facilities also require pumping of groundwater. These activities can occur during both construction and operation periods. Therefore, the pumping of groundwater can be both short-term and long-term, depending on the project phases. These dewatering activities will lower groundwater levels within the ZOI (also known as the cone of depression).

If there are nearby groundwater supply wells or surface water intakes or springs (for domestic and/or commercial / industrial uses), the reduced groundwater levels may affect these surrounding water supplies by reducing the capacity. When the ZOI extends to surface waterbodies, it can reduce baseflow contribution to the surface waterbodies due to the lowered groundwater level and reduced hydraulic gradient and seepage.



It has been well documented that the extraction of groundwater can result in reduced groundwater levels and flows (to surface waterbodies) and decreases in baseflow in many published literature and papers (Blackport et al. 1995; Power et al. 1999; Fleckenstein et al. 2004; Chu et al. 2008; Perkin et al. 2017, as cited in Brownscombe and Smokorowski 2021).

Dewatering/pumping is likely required at watercourse crossings for the construction of structures (e.g., bridges, culverts, retaining walls, etc.), aggregate pits/quarries, construction camps and the MSF. If the bottoms of the structural foundations and aggregate extraction pits/quarries are below the groundwater tables, dewatering will be required at these locations to achieve and maintain a dry work area. Water supply wells will likely be required to provide drinking water for staff at construction camps and the MSF.

As part of the effects assessment, dewatering volumes, groundwater drawdowns, and associated zones of influence are estimated based on available information including preliminary road design, geotechnical and hydrogeological investigation results with some assumptions. Analytical solutions for unconfined conditions are used for the dewatering assessment.

Water takings that may also be required for other purposes including work area delineation (e.g., in water work), concrete production, dust control, and site restoration – seeding, etc., that involve groundwater and/or surface water takings, are not included in the assessment. These water takings, if required, can be assessed during the detail design phase when more information becomes available.

8.3.5.1 Dewatering for Structure Foundations

Watercourse Crossings

A total of 31 watercourse crossings have been identified along the proposed WSR. All these identified crossings have defined channels/flow paths and will be used for the dewatering assessment as structures (e.g., bridges, culverts) including foundations will be constructed to carry the road over these water crossings.

As detailed in Appendix D-1 –Preliminary Engineering Design Report, corrugated Steel Pipe or open bottom steel box (arch) culverts are proposed at crossings where the width of the waterbody is less than 20 m. Water crossings with width greater than 20 m will require a composite bridge with concrete deck supported by semi-integral or integral abutments. With this design concept, composite bridges will be required at six crossings (WB-1, WC-3, WC-10, WC-13, WC-26, and WC-27), while culverts will be constructed at the remaining crossings. Piles are proposed for the foundations at three crossings (WC-10, WC-13, and WC-19), while spread footings will be used for the remaining crossings.

Assumptions and Input Parameters

To estimate the dewatering volumes, the following assumptions were made:

- Each foundation (e.g., abutment, pier) for the structures will be approximately 50 m long to accommodate the 35 m road ROW, plus possible wing walls, 5 m wide (average).
- The average groundwater drawdown across the road ROW is assumed to be 4 m, as the shallow groundwater tables were measured near the ground surface and the bottom of the excavations (for shallow footings) are estimated to be 3 m below ground surface and the target dewatering level is assumed to be 1 m below the bottom of the excavation.
- Scenario 1: a geometric mean of hydraulic conductivity of 1×10^{-6} m/s is used for typical overburden, which consist of mainly sandy silt till, and silt and sand till.



- Scenario 2: a higher hydraulic conductivity of 2×10^{-5} m/s is used for sand till.
- The shallow water bearing zone/aquifer is unconfined.
- Distance to the line source (from the dewatering area to the surface water body) is assigned as 10 m for one side of the excavation/trench.

The input parameters are summarized in **Table 8-12**.

Table 8-12: Input Parameters for Dewatering Assessment – Structure

Parameter	Unit	Each Foundation	Note
Length	m	50	To accommodate road and wing/safety barrier walls
Width	m	5	Average
Depth of Excavation	m	3	Average
Initial Groundwater Level	mbgs	0	Assumed to be bear ground surface
Groundwater Drawdown	m	4	1 m below bottom of the excavation
Hydraulic Conductivity (Scenario 1)	m/s	1×10^{-6}	Scenario 1: Geometric mean for the overburden (sandy silt till, silt and sand till)
Hydraulic Conductivity (Scenario 2)	m/s	2×10^{-5}	Scenario 2: Higher value for sand till

Dewatering Assessment

The estimated dewatering volumes and zones of influence are summarized in **Table 8-13**.

Table 8-13: Results of Dewatering Assessment – Each Structure Foundation

Parameter	Unit	Scenario 1	Scenario 2
Zone of influence	m	12	54
Typical dewatering rate	L/day	22,500	277,500
Maximum dewatering rate	L/day	45,000	555,000

Note: maximum dewatering rate – the typical dewatering rate multiplied by a safety factor of 2 to account for hydraulic conductivity heterogeneity and seasonal groundwater level fluctuations.

8.3.5.2 Dewatering at Aggregate Sites

Pits and Quarries

Several potential aggregate sources were assessed during the evaluation of alternative locations for supportive infrastructure. Two aggregate source areas, referred to as ARA-2 and ARA-4, were recommended for development (refer to Section 4).

Aggregate Source Area – ARA-2

ARA-2 is situated near the north-south and west-east sections of the preliminary recommended preferred route. The site consists of an elevated large landform area (refer to cross-sections E to I, **Figure 8.4**). The surface water elevation of the unnamed lake ranged from 191.0 to 191.6 masl according to the light detection and ranging (LiDAR) survey in 2019. A conservative estimate of available materials was made



by assuming that mining/extraction of materials will not extend below the elevation of 193 m to prevent potential flooding into the aggregate pits/quarries. The surface area of ARA-2 (cross-sections E through I) was estimated to be 519,714 m².

Based on potential spoil of material, measured/documentated groundwater levels (194.5 to 195.1 masl at WQA-1) in this area and approach of no mining below elevation of 193 masl, the volume of aggregates and bedrocks that is feasible for extraction at ARA-2 was estimated to be between 893,63 to 1,276,375 m³. Based on this assumption, the total surface area proposed for development at ARA-2 was approximately 45.41 hectares (ha).

Aggregate Source Area – ARA-4

ARA-4 is a large ridge located southeast of Winisk Lake and is approximately 5 km west of the proposed WSR (refer to **Figure 8.5**). ARA-4 is among the largest glaciofluvial landforms mapped in the area and offers one of the largest potential sources of sand and gravel material. Based on the available topographic data, the central part of the ridge stands in the order of 25 m above the surrounding low relief.

ARA-4 is considered a significant reserve of sand and gravel. Groundwater monitoring well WQA-5 installed in this area was observed to be dry during the 2020 and 2021 monitoring events. WQA-5 was installed at 6.1 mbgs, with an elevation of approximately 208 masl at the bottom of the well.

Mining to an elevation of 206 masl at ARA-4 would yield 3,813,600 m³ of material, plus the assumed volume available at ARA-2, the total would be adequate to meet the required total volume of material (4,854,500 m³) for the construction and operations of the Project. However, regional elevation data was used for volume calculations at ARA-4, which included a larger margin of error as compared to the calculations made using LiDAR data at ARA-2. To account for a potential greater margin of error in the volume estimate at ARA-4, it was proposed that mining to elevation of 204 masl be carried forward for the purposes of the effects assessment.

The volume of sand and gravel feasible for mining at ARA-4 based on mining to an elevation of 204 m was estimated to be between 3,782,884 m³ to 5,404,120 m³. The total surface area proposed for development at ARA-4 was approximately 84.24 ha. ARA-4 will provide a source of aggregate/rock material for construction of the road, as well as a source of material for the assumed 75-year operation and maintenance life cycle for the Project.

The aggregate pit/quarry at site ARA-2 will be decommissioned at the end of the construction phase and will progressively be rehabilitated. The pit at site ARA-4 will also be progressively rehabilitated during construction but will be retained as the aggregate source area to support maintenance activities during operations of the Project. Aggregate material at site ARA-4 will be routinely extracted and processed to meet the annual anticipated volume of gravel/sand (26,750 m³) required to maintain and repair the roadway and other areas (access road, maintenance and rest areas).

As monitoring well WQA-5 was measured to be dry, and no other groundwater level information was available at ARA-4, it is assumed the bottom of the extraction pit will be above the groundwater table. If this is not case and dewatering is indeed required at ARA-4, it is assumed the dewatering volume and ZOI will be the same as ARA-2, considering both the resources areas will probably operate in the same way. Further dewatering assessment at ARA-4, if required, can be completed during the detailed design phase.



Assumptions and Input Parameters

To estimate the potential dewatering volumes, the following assumptions were made to determine the input parameters for the dewatering assessment:

- Dewatering is not required at ARA-4, assuming extraction will occur above the groundwater table. Dewatering will be required at ARA-2.
- Approximately one tenth of the total ARA-2 area (proposed for development) will be operating at one-time, which is assumed to be 200 m long and 200 m wide, with an area of 40,000 m² (4 ha).
- The average groundwater drawdown at ARA-2 is estimated to be 3 m, with the target dewatering level at 1 m below the bottom of the pit.
- A typical hydraulic conductivity of 1×10^{-4} m/s is used for fine and medium sand.
- The shallow water bearing zone/aquifer is unconfined.

The input parameters are summarized in **Table 8-14**.

Table 8-14: Input Parameters for Dewatering Assessment – Aggregate Resources Area (ARA-2)

Parameter	Unit	ARA-2	Note
Length	m	200	
Width	m	200	
Bottom of Pit	masl	193	Maximum (lowest) mining / extraction depth
Initial Groundwater Level	masl	195	Measured at monitoring well WQA-1
Groundwater Drawdown	m	3	1 m below bottom of the pit
Hydraulic Conductivity	m/s	1×10^{-4}	Typical for fine and medium sand/clean sand (Freeze and Cherry, 1979)

Dewatering Assessment

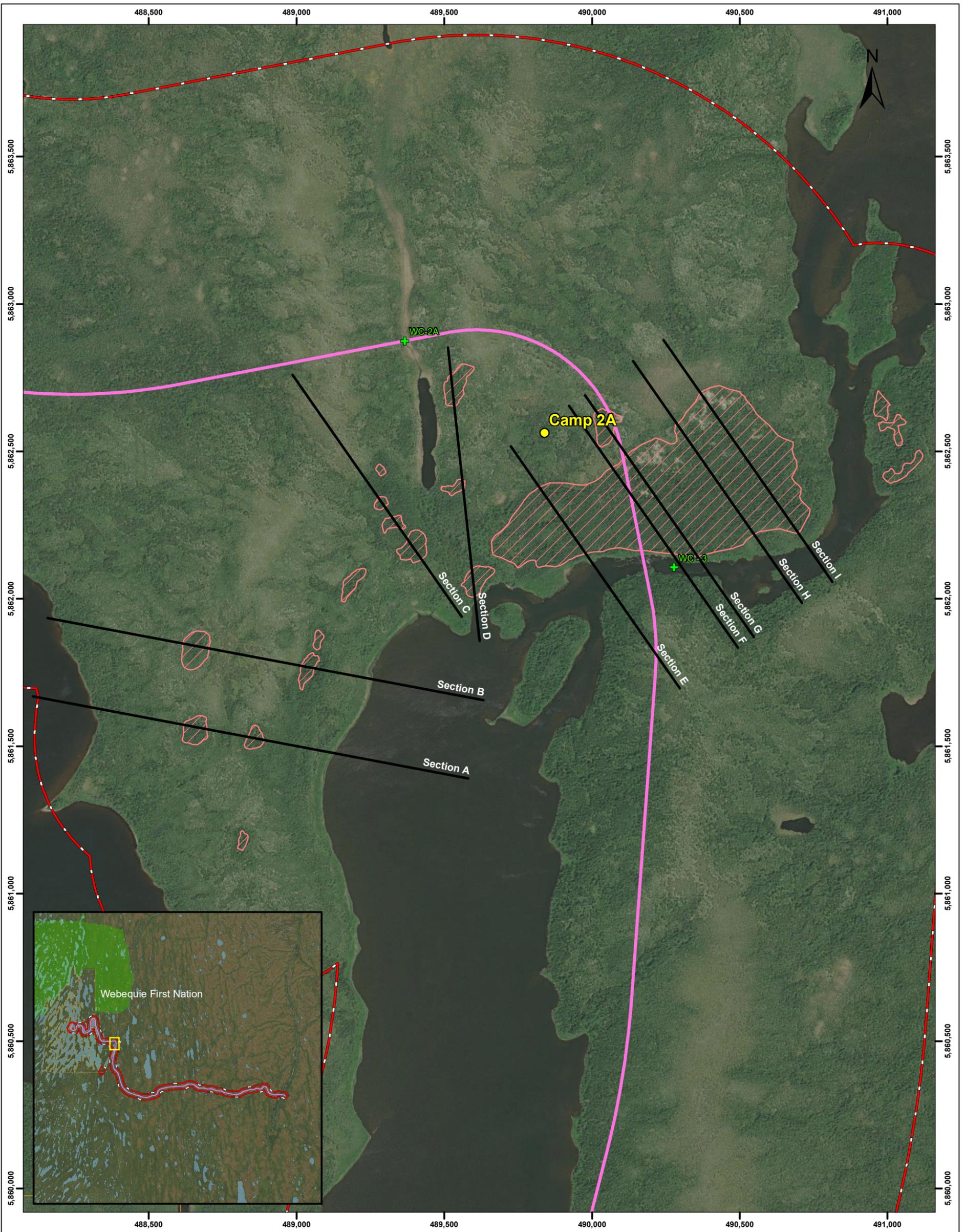
The estimated potential dewatering volumes and ZOI are summarized in **Table 8-15**.

Table 8-15: Results of Dewatering Assessment – Aggregate Resources Area (ARA-2)

Parameter	Unit	ARA-2
Zone of influence	m	90
Typical dewatering rate	L/day	2,183,700
maximum dewatering rate	L/day	4,367,400

Note: maximum dewatering rate – the typical dewatering rate multiplied by a safety factor of 2 to account for hydraulic conductivity heterogeneity and seasonal groundwater level fluctuations.





- Legend**
- Preliminary Recommended Preferred Route
 - Cross Section
 - Recommended Aggregate/Rock Source Area
 - Local Study Area (LSA is 500 m from Aggregate/Rock Source Area and 1 km from Preferred Route)
 - + Waterbody Crossing
 - Recommended Construction Camps
*Camp 2-A is proposed to include permanent Maintenance and Storage Facility (MSF) for operations of the WSR.
 - Webequie First Nation Reserve
 - Provincial Park

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.30.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF). Download Date: 2021-02-04.

DISCLAIMER

This drawing was prepared for the exclusive use of Webequie First Nation (the "Client"). Unless otherwise agreed in writing by AtkinsRéalis, AtkinsRéalis does not accept and disclaims any and all liability or responsibility arising from any use of or reliance on this drawing by any third party or any modification or misuse of this drawing by the Client. This drawing is confidential and all intellectual property rights embodied or referenced in this drawing remain the property of such parties, as determined by the applicable services contract or contracts between AtkinsRéalis and the Client.

Webequie Supply Road (WSR)

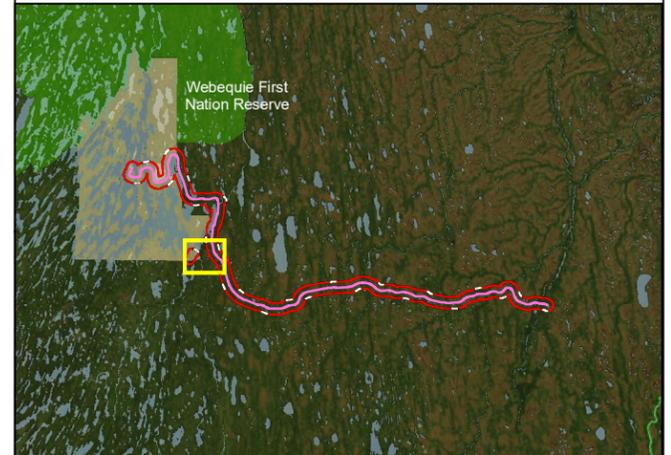
Location of Aggregate Source Area ARA-2

Figure Number: 8.4		REV: PA	
Client: Webequie First Nation	Project Number: 661910	Date: 2/27/2024	
DSC		DRN	CHK
	AD	CW	APP



Legend

- Preliminary Recommended Preferred Route
- Permanent Access Road to Preferred Route (approx. 5.5 km)
- Recommended Aggregate Source Area
- Local Study Area (LSA is 500 m from the Aggregate Source Area and 1 km from Preferred Route)
- + Waterbody Crossing
- Webeque First Nation Reserve



Webeque Supply Road (WSR)

Location of Aggregate Source Area ARA-4

Figure Number:	8.5	REV	PA
Client:	Webeque First Nation	Project Number:	661910
		Date:	2/27/2024
DSC		DRN	CHK
		AD	CW
APP			



NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.io.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF). Download Date: 2021-02-04

DISCLAIMER

This drawing was prepared for the exclusive use of Webeque First Nation (the "Client"). Unless otherwise agreed in writing by AtkinsRéalis, AtkinsRéalis does not accept and disclaims any and all liability or responsibility arising from any use of or reliance on this drawing by any third party or any modification or misuse of this drawing by the Client. This drawing is confidential and all intellectual property rights embodied or referenced in this drawing remain the property of such parties, as determined by the applicable services contract or contracts between AtkinsRéalis and the Client.

5,850,000

5,850,000

8.3.5.3 Water Supply Wells

Construction Camps

Water supply wells may be drilled / installed to provide drinking water supplies for the workforce at the construction camps, assuming delivering potable/drinking water to the camps using trucks is not feasible. The average workforce is estimated to be 50 to 70 people at each construction camp. According to Statistics Canada website, the average daily residential water usage per capita ranges from 172 to 208 litres per person per day from 2011 to 2019, with an average water use of 192 litres per person per day. In this assessment, the water usage / consumption at construction camps is assumed to be 300 litres per person per day for 70 people. The estimated daily pumping volumes of groundwater at each construction camp would be 21,000 L/day based on the above assumptions.

According to MECP well record #7184290 (well Tag #A122606), which is a water supply well installed on the Webequie Reserve (on the Hydro One property). This water supply well was installed in bedrock (granite) at a depth of 305 ft (93 m) below ground surface, with 6-in casings and a 5-in open hole section (equivalent to well screen) from 128 ft to 305 ft (39 to 93 m). The static groundwater level was measured at 48 ft (14.6 m) below ground surface, with a saturated aquifer thickness of 78 m.

For the pumping duration, although the use of the water supply wells is anticipated to last for 5 to 6 years throughout the construction phase, it is likely the pumping operation will mainly occur during the daytime. Minimum use of the wells is expected at night. Therefore, the estimate of the groundwater drawdown is based on the pumping duration of 16 hours a day, and it is assumed the groundwater level will recover overnight (in 8 hours).

To estimate the groundwater drawdown of the water supply well at each of the construction camps, Theis (1935) method (transit solution) is used for the analysis. The assumed input parameters and calculated drawdown are presented in **Table 8-16**. The groundwater drawdown is estimated to be 3.8 m, with a ZOI of approximately 145 m.

Table 8-16: Input Parameters for Dewatering Assessment – Water Supply Wells

Parameter	Unit	Value	Note
Pumping rate	L/day	21,000	300 litres per person per day for 70 people
Aquifer thickness	m	80	Assumed
Well screen radius	m	0.076	6 inches (0.15 m) diameter open hole
Storage coefficient (or storativity)	m	0.0005	Typical for a confined aquifer (Todd, 1980)
Hydraulic Conductivity	m/s	1×10^{-6}	Typical for fractured igneous and metamorphic rocks (Freeze and Cherry, 1979)
Pumping duration	hour	16	16 hours during daytime
Groundwater drawdown	m	3.8	Pumping at a constant rate for 16 hours
Radius of influence	m	145	Also known as ZOI, or cone of depression

Note: ZOI – zone of influence



Maintenance and Storage Facility (MSF)

A permanent MSF will be required to service the newly constructed road. It is proposed that one of the construction camps (Camp 2A) be repurposed to serve as the MSF. The MSF consists of a heated shop equipment shed, for equipment and tool storage, as well as maintenance and repairs of equipment. An office with washroom facilities and lunchroom and potentially accommodations for non-local staff may be required at these yards. A fenced yard for storage of seasonal machinery, materials such as culverts and large machine parts would be attached to these facilities.

The MSF would require a water well based on the remote nature of the site. The direct employment workforce at the MSF is estimated to be 25 per year (full time equivalent). Based on these assumptions, the pumping volume of the water supply well at MSF and the associated effects are expected to be less or smaller than the construction camp.

Maintenance Areas

Maintenance areas are proposed along the WSR to allow for maintenance of equipment/vehicles during the operation phase of the Project. It is recommended that maintenance areas be located along the WSR at alternating directional intervals of every 50 km (total of approximately 3 at start, 50 km mark and at end). Maintenance areas are intended solely for the use by operation and maintenance staff and equipment. It is assumed that water supply wells are not required at the maintenance areas.

Dewatering/Pumping and discharging → Disturbance of subsurface soils → Elevated sediment levels in discharge water → Reduction in surface water quality

Dewatering/pumping activities, particularly for the construction of the foundations (e.g., foundations for the structures including bridges and culverts, etc.) and extraction of aggregate materials (under groundwater tables) will disturb the subsurface soils and increase sediment levels in discharge water. When the extracted water is discharged to the natural environment and reaches nearby surface water bodies, it may impair the surface water quality by introducing the extra sediment (e.g., total suspended solids) to the surface water. In addition, due to the differences in groundwater and surface water temperatures (depending on different seasons), the discharge water may affect/change surface water temperatures as well.

8.3.6 Road Construction

Road construction → Road barrier effect → Blocking groundwater flow → Alteration of flow direction and pathway and lowering of groundwater level

One of the concerns of road construction is the road barrier effect. Upon completion of road construction, especially when the road is constructed perpendicular to the groundwater flow directions and crossing low-lying areas with shallow groundwater conditions (e.g., wetlands), the embankment is expected to be below the groundwater table and may act as a barrier for natural groundwater flows. This road barrier effect can redirect groundwater flow to different directions, resulting in changes to groundwater flow pathways and lowering of groundwater levels downgradient of the road. The lowering of groundwater levels may affect the natural functions of groundwater and dependant wetlands/peatlands including SAR and health of plants near the road. The wetlands or peatlands may be dry under severe situations.



Use of concrete → Increase of pH → Reduction in groundwater quality

The use of poured concrete for the construction of structural foundations has a potential of increasing pH levels in groundwater and surface water. One of the major chemical components of the poured concrete (cement) includes lime (or calcium oxide), which is alkaline in nature. During the curing process, the concrete will react with water (hydration) and produce calcium hydroxide, which may increase the pH level in water in the vicinity of the foundations.

8.3.7 Disposal of Wastes

Disposal of wastes → Leaching and infiltration, overland flow with surface runoff → Reduction in groundwater and surface water quality

Disposal of wastes including solid and liquid wastes from construction camps, and the MSF can cause releases of deleterious substances into the natural environment. These substances may further infiltrate into the ground with precipitation/rain in dissolved phase and then migrate through the vadose (unsaturated) zone and reach groundwater and cause reduction in groundwater quality.

In addition, the released substances may also migrate and reach nearby surface water bodies through surface runoff/overland flow. In this case, it may cause reduction in surface water quality.

Solid and liquid wastes including domestic sewage generated during construction and operations and maintenance are located mainly in the construction camps that will include laydown and storage yards, and the MSF. Domestic sewage could be treated using onsite sewage treatment systems (e.g., septic systems or portable treatment plant). A conventional septic system includes two key components: a septic tank and a leaching field (also known as leaching bed or tile bed). If not managed properly, the wastes may affect the groundwater and surface water quality through infiltration and overland runoff. The effects on water quality include changes to physical, chemical, and bacteriological parameters.

The design, construction and operation of the waste collection, treatment and disposal systems shall be completed by qualified professionals according to applicable regulations and guidelines. A site-specific hydrogeological assessment is required for onsite septic systems, and it shall be completed according to MECP guidelines (e.g., D-5-4 Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment). The construction and installation of large septic systems (with design sewage flows of greater than 10,000 litres / day) is regulated by the MECP and are subject to approval requirements for sewage works under Section 53 of the Ontario *Water Resources Act*.

The mobilization and stabilization of the plumes, particularly potential contaminants of concern (PCOC) associated with the septic systems (if any), depend on natural attenuation processes including hydro-dynamic dispersion (advection and dispersion) and sorption. Considering the PCOCs associated with the septic systems may consist of organic parameters, biodegradation also plays an important role in the natural attenuation. The higher the dissolved oxygen, the faster the plumes will be stabilized, or concentrations reduced to the pre-development conditions.

8.3.8 Summary

Table 8-17 summarize the potential effects and pathways according to project phases and activities, similar to **Table 8-5** in **Section 8.1.5**.



Table 8-17: Summary of Potential Effects, Pathways, and Indicators for Groundwater Resources VC

Potential Effect	Project Phase	Effect Pathway	Effect Indicators	Nature of Interaction and Effect (Direct or Indirect)	Linked Other VCs
Groundwater Quantity					
Change in groundwater quantity	Construction and Operations	<ul style="list-style-type: none"> Clearing of vegetation may increase groundwater recharge rates that result in higher groundwater levels in shallow water bearing zones. Site grading/ground hardening may lower groundwater levels and reduce baseflow contribution to streams and wetlands, and water supply wells. Blasting of rocks may increase permeability of the formations, and result in alteration of groundwater flow rates, directions and pathways, changes to groundwater levels in some cases. Extraction of materials at aggregate pits/quarries, cut, excavation, stockpiling, and backfilling along the road ROW will change the local topography and landscape, which may change groundwater infiltration rates, hydraulic gradients, flow direction and pathways, and groundwater levels. Dewatering/pumping (structural foundations, aggregate pits/quarries, and water supply wells at construction camps and MSF) may lower groundwater levels and reduce baseflow contribution to streams and wetlands, and water supply wells. Upon completion of road construction, the embankment is expected to be below the groundwater table and may act as a barrier for natural groundwater flows resulting in lower groundwater levels downgradient of the road. 	<ul style="list-style-type: none"> Groundwater level; Formation permeability/hydraulic conductivity; Groundwater infiltration rate; Hydraulic gradient; and Groundwater flow direction and pathway. 	Direct	<p>The assessment of this VC is informed by the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Geology, Terrain, and Soils (Section 6). <p>The assessment of this VC informs and is informed by the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Surface Water (Section 7). <p>The assessment of this VC informs the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Fish and Fish Habitat (Section 10); Vegetation and Wetlands (Section 11); Species at Risk (Section 13); Non-Traditional Land and Resource Use (Section 16); and Aboriginal and Treaty Rights and Interests (Section 19).
Groundwater Quality					
Change in groundwater quality	Construction and Operations	<ul style="list-style-type: none"> Blasting may introduce deleterious substances (e.g., ammonia, nitrate, etc. from by-products of explosive detonation) which may infiltrate to the groundwater regime through precipitation and leaching. Extraction of materials at aggregate pits/quarries and stockpiling of excavated soils and crushed stones/rocks may cause infiltration of deleterious substances to the groundwater regime through precipitation and leaching resulting in reduction in groundwater quality. Discharge from dewatering at watercourse crossings and aggregate pits may reduce surface water quality by introducing elevated total suspended solids, nutrients, metals, etc. Use of concrete footings for waterbody crossings has a potential of increasing pH levels in groundwater and surface water resulting in reduction in groundwater and surface water quality. Solid and liquid wastes generated during construction and operations and maintenance may affect the groundwater and surface water quality through infiltration and overland runoff. 	<ul style="list-style-type: none"> General chemistry (including pH) and concentrations of inorganic parameters, nutrients, and metals. 	Direct and indirect (via interaction with surface water)	<p>The assessment of this VC is informed by the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Geology, Terrain, and Soils (Section 6). <p>The assessment of this VC informs and is informed by the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Surface Water (Section 7). <p>The assessment of this VC informs the effects assessment for other VCs:</p> <ul style="list-style-type: none"> Fish and Fish Habitat (Section 10); Vegetation and Wetlands (Section 11); Species at Risk (Section 13); Non-Traditional Land and Resource Use (Section 16); and Aboriginal and Treaty Rights and Interests (Section 19).

8.4 Mitigation Measures

This section describes proposed mitigation measures to eliminate or reduce the potential effects of the Project on groundwater resources. The proposed mitigation measures are organized by project activities that have potential to result in effects on groundwater resources as described in **Section 8.3**. Further measures will be provided in the Construction Environmental Management Plan (CEMP) and the Operation Environmental Management Plan (OEMP) that will be developed for the Project. Refer to Section 4.6 for details of the proposed framework for the development of the CEMP and the OEMP.



Indigenous community members will have an active role in developing and implementing management plans.



An Environment Committee will be established to facilitate communication and engagement during construction and operations of the Project. Committee members will include Webequie First Nation Elders and Knowledge Holders, other First Nations with interest in participating, and appropriate project representatives, to: facilitate communication and engagement during construction and operations of the Project; facilitate use of Indigenous Knowledge in project activities; facilitate evaluation of land use information; and facilitate development of appropriate monitoring programs, protocols and management plans as it relates to Groundwater Resources VC.

In addition to the mitigation measures described below, the recommended preferred route and preliminary road design (including proposed permeable subbase and embankment, and equalization culverts) will help minimize potential impact to groundwater resources, especially at wetlands/peatlands crossings. The full route optimization criteria are presented in Appendix D-1 – Preliminary Engineering Design Report.

Mitigation measures are described for each key project activity that may result in potential adverse effects to groundwater quantity and groundwater quality.

8.4.1 Vegetation Clearing and Grubbing

The increase of infiltration rates and groundwater levels due to vegetation clearing and grubbing can benefit groundwater resources with increases of groundwater recharge and quantity. To further enhance this beneficial effect, the disturbed areas (for temporary supporting infrastructure) can be restored through decompaction of soil and placement of similar native soils (removed or excavated from the same area) or materials that are more permeable than the native soils, where practical. This along with planting of vegetation will restore or increase infiltration rates and groundwater levels and prevent or reduce soil erosion.

For more detailed descriptions of proposed mitigation measures, refer to Section 5.1 (Clearing and Grubbing) and Section 5.21 (Site Decommissioning and Rehabilitation) in Appendix E – Mitigation Measures.

As described above, a temporary rise of groundwater levels is anticipated associated with vegetation clearing and grubbing. The effect is expected to be offset by subsequent construction activities that will make ground hardening and reduce the infiltration rate. The disturbed areas for temporary supporting infrastructure will be restored to their former conditions or conditions that are compatible with the

surrounding areas after construction is complete. This effect will be carried forward to the net effects characterization.

8.4.2 Site Grading/Ground Hardening

The areas designated and used for temporary infrastructure (including access roads, construction camps, laydown areas and storage yards) should be designed and developed as efficient as possible to limit the Project Footprint. The machines and equipment used for site grading will be chosen, where practicable, to minimize the effects of soil disturbance and ground hardening. Appropriate decommissioning and reclamation measures will be adopted to restore the disturbed areas to the pre-development conditions as much as possible to reduce the project effects on groundwater infiltration rate and recharge.

For more detailed descriptions of proposed mitigation measures, refer to Section 5.21 (Site Decommissioning and Rehabilitation) in Appendix E – Mitigation Measures.

For the construction of permanent roads and MSF, consider using coarse materials for the base and subbase, where practical and economically feasible, to enhance infiltration and groundwater recharge.

There will be net effects after implementation of the mitigation measures as described above. Reduction in recharge rates and groundwater levels compared to baseline conditions may occur due to site grading/ground hardening. This effect will be carried forward to the net effects characterization.

8.4.3 Blasting of Rock

The blasting with explosives will be limited to the places where other options are not feasible. Wherever practical, alternatives including bedrock ripping, typical or standard drilling, hammering, and non-explosive agent (e.g., expanding grout) will be considered. A Construction Blasting Management Plan for the Project will be prepared and submitted by applicable contractor(s) after contract award prior to initiation of blasting activities (refer to Section 2.1.3 in Appendix E – Mitigation Measures).

If blasting is required, it should be conducted in accordance with Ontario Provincial Standard Specification (OPSS) 120 General Specification for the Use of Explosive. A pre-blasting survey will be conducted to identify water supply wells and other environmentally sensitive features within 250 m from the blasting location. Mitigation measures will be modified or enhanced, if needed, based on the survey results. Blasting will not be conducted within 50 m of water supply wells (if any) and should be avoided in shallow groundwater table areas, where possible.

For more detailed descriptions of proposed mitigation measures, refer to Sections 5.12 (Blasting near a watercourse) and Section 5.20 (Quarry Site Selection and Development Requirements) in Appendix E – Mitigation Measures.

There will be predicted net effects after implementation of the proposed mitigation measures. Alteration of formation permeability, groundwater flows, pathways and levels, and reduction in groundwater may occur. These effects will be carried forward to the net effects characterization.



8.4.4 Extraction, Cut, Excavation, Stockpiling and Backfilling

The areas proposed for aggregate extraction (including borrows and quarries), cut, and excavation should be designed and developed as efficient as possible to limit the Project Footprint. Appropriate restoration and reclamation measures will be adopted to restore the disturbed areas to their former conditions or conditions that are compatible with the surrounding areas as much as possible to reduce the project effects on groundwater infiltration and recharge rates and water qualities. Avoid or reduce the depth advanced below the water level for construction of project components.

For more detailed descriptions of proposed mitigation measures, refer to Section 5.20 (Quarry Site Selection and Development Requirements) in Appendix E – Mitigation Measures.

There will be predicted net effects after implementation of the proposed mitigation measures. Alteration of infiltration rates, groundwater flow directions, pathways, and levels due to extraction, cut and excavation is expected. This effect will be carried forward to the net effects characterization.

The potential for ARD causing potential adverse effects to groundwater quality due to use of aggregate materials is anticipated to be negligible with the implementation of mitigation measures and a net effect is not predicted. Therefore, this potential effect will not be carried forward to the net effects characterization.

8.4.5 Dewatering / Pumping



Indigenous community members raised concerns about the potential ecological consequences if peatlands were drained during the construction of the WSR. Recognizing the importance of peatlands to First Nations due to their ability to store carbon in their soils and hold a lot of freshwater, a “floating” road design – the proposed road will be constructed on top of the peat (no peat is removed) – will be used for the section of the WSR that crosses peatlands as described in Section 4.3.1.3.1 Road Design in Peatlands.

Regulated by MECP Permits

Based on the dewatering assessment results described in **Section 8.3.5**, the maximum (worst-case) daily water taking volumes are estimated to be more than 400,000 L/day. Therefore, a permit to take water (PTTW) will be required for the Project. At some locations, the dewatering volumes may be more than 50,000 L/day, but less than 400,000 L/day. In this situation, an Environmental Activity and Sector Registry (EASR) registration (for Water Taking) will be used to permit the activity. Several dewatering sources/locations can be combined and included in the same EASR registration or PTTW application.

As part of the supporting documents for the PTTW or EASR applications, hydrogeological studies are required to detail the dewatering and impact assessments, discharge plans, mitigation measures and monitoring plans. Discharge water quality should be tested and meet Ontario Provincial Water Quality Objectives (PWQO) as water will likely be discharged to the natural environment. Detailed discharge monitoring plans including discharge water quality testing, and contingency measures recommended in the hydrogeological studies as supporting documents for the PTTW application or EASR registration should be followed. In general, the applicants and contractors are required to comply with terms and conditions of the approved PTTW or EASR, including monitoring and reporting to verify compliance.



Other Related Mitigation Measures

Dewatering activities should, at a minimum, follow Ontario Provincial Standard Specification (OPSS) 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation and OPSS 518 Construction Specification for Control of Water from Dewatering Operations.

Erosion and Sediment Control measures (e.g., OPSS 805, Construction Specification for Temporary Erosion and Sediment Control Measures) should be incorporated into the detail design and implemented during construction to prevent erosion and migration of soils from the work site during rainfall events. Geotextile filter bag(s) or equivalent sediment trap should also be used at a minimum during dewatering activities to capture and treat dewatering effluent that may have elevated level of sediment (suspended solids). Discharge locations should be at least 30 m away from water bodies.

Use industry best management practices (BMP) to minimize dewatering/pumping volumes:

- Temporary supporting systems can be used, where feasible, to help reduce the amount of groundwater inflow into the excavations.
- Surface water runoff will be directed away from the open excavations to reduce rain and surface water contribution to the total dewatering volumes.

For more detailed descriptions of proposed mitigation measures, refer to Section 5.20 (Quarry Site Selection and Development Requirements) in Appendix E – Mitigation Measures.

There is a predicted net effect after implementation of the proposed mitigation measures. Lowering of groundwater levels due to dewatering / pumping (temporary or long-term) is expected. This effect will be carried forward to the net effects characterization.

8.4.6 Road Construction

To avoid or reduce the road barrier effect in the low-lying areas with shallow water conditions, such as the peatlands, the following measures will be considered during design and construction:

- The materials selected for road construction, especially the portion below the existing ground surface/groundwater table, should have the same or higher permeability compared to the surrounding native soils.
- If needed, crushed stones (rockfill) and/or equalization culverts will be used at wetland and peatland crossings at intervals of 100 m to 250 m to maintain or enhance hydraulic connections between the upgradient and downgradient sides of the road to allow groundwater to flow naturally through the road.
- When crossing wetlands and peatlands, the road design will consider consolidation and compression processes of the peat layers associated with road construction (loading), which may result in reduced permeability of the peat, and thus alter natural groundwater flow directions and pathways. Compression of peat could also have implications on water quality. However, no further assessment is provided here due to uncertainty. Water quality will be monitored during and post road construction.
- In cut areas, groundwater seepage (if any) can typically be controlled and managed through roadside drainage systems (e.g., roadside ditches), where groundwater can infiltrate and recharge back to the local groundwater regime.

There will be a net effect after implementation of the proposed mitigation measures. This effect will be carried forward to the net effects characterization.



8.4.7 Disposal of Wastes

A construction waste management plan will be developed to minimize the amount of the waste to be generated, and the portion going to landfills, by applying industry BMP including collection, recycling and disposal. All the solid and sewage wastes collected will be disposed and treated at designated facilities.

Domestic wastewater and sewage in the form of liquid effluent generated at construction camps and the MSF may be treated on site using a portable treatment facility/plant, conventional septic system as described in **Section 8.3.7** or transported off-site by tanker truck for treatment at the approved sewage treatment and disposal facility in Webequie. Note that the specific sewage and wastewater treatment systems for camps and the MSF is to be determined during the detail design phase and is based on further assessment of site conditions and the selected construction contractor.

For more detailed descriptions of waste disposals and proposed mitigation measures, refer to Section 5.5 (Materials Handling and Storage) and Section 5.22 (Water Quality Monitoring) in Appendix E – Mitigation Measures.

Net effects are not predicted after implementation of the proposed mitigation measures. This effect will not be carried forward to the net effects characterization.

8.4.8 Summary

A summary of the potential effects, mitigation measures and predicted net effects for Groundwater Resources VC is provided in **Table 8-18**.



Table 8-18: Summary of Potential Effects, Mitigation Measures and Predicted Net Effects for Groundwater Resources VC

VC Subcomponent	Indicators	Project Phase	Project Component or Activity	Potential Effect	Key Mitigation Measures	Predicted Net Effect
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Groundwater infiltration rate 	Construction	Vegetation clearing and grubbing	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ The disturbed areas will be restored with native soils (removed or excavated in the same area) or materials that are more permeable than the native soils, where practical, and covered by native vegetation. This can help restore or increase infiltration rates and groundwater levels and prevent or reduce soil erosion. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.1 – Clearing and Grubbing; and ▫ Section 5.21 – Site Decommissioning and Rehabilitation. 	Yes
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Groundwater infiltration rate 	Construction and Operations	Site grading/ground hardening (roads, laydown and storage yards, construction camps, maintenance facilities)	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ The areas for temporary infrastructure (including access roads, construction camps, laydown and storage yards) will be designed and developed as efficient as possible to limit the Project Footprint as much as possible. The machines and equipment used for site grading will be selected, where practicable, to minimize impacts on soil disturbing and ground hardening. Appropriate decommissioning and reclamation measures will be adopted to restore the disturbed areas to pre-development conditions as much as possible to reduce the project effects on groundwater infiltration and recharge. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.21 – Site Decommissioning and Rehabilitation. 	Yes
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Formation permeability ▪ Groundwater infiltration rate ▪ Groundwater flow direction and pathway 	Construction and Operations	Blasting of rocks (at quarry sites)	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ The blasting will be used at places where other options are not practical. Wherever practical, alternatives including bedrock ripping, typical drilling, hammering, and non-explosive agent (e.g., expanding grout) will be considered. A Construction Blasting Management Plan for the Project will be prepared and submitted by applicable contractor(s) after contract award prior to initiation of blasting activities (refer to Section 2.1.3 in Appendix E – Mitigation Measures). ▪ If blasting is required, it will be conducted in accordance with OPSS 120 General Specification for the Use of Explosive. A pre-blasting survey will be conducted to identify water supply wells and other environmentally sensitive features within 250 m from the blasting locations. Mitigation measures will be modified or enhanced, if needed, based on the survey results. Blasting will not be conducted within 50 m of water supply wells (if any) and should be avoided in shallow groundwater table areas, where possible. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.12 – Blasting Near a Watercourse; and ▫ Section 5.20 – Quarry Site Selection and Development Requirements. 	Yes
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Hydraulic gradient ▪ Groundwater infiltration rate ▪ Groundwater flow direction and pathway 	Construction	Extraction (borrows and quarries), cut, excavation, stockpiling, and backfilling	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ The areas proposed for cut, excavation, and extraction (including borrows and quarries) will be designed and developed as efficient as possible to limit the Project Footprint as much as possible. Appropriate restoration and reclamation measures will be adopted to restore the disturbed areas to the pre-development conditions as much as possible to reduce the project effects on groundwater infiltration and recharge. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.20 – Quarry Site Selection and Development Requirements. 	Yes
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level 	Construction and Operations	Dewatering/pumping (structure foundations, borrows and quarries, and water supply wells at construction camps and the MSF)	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ The dewatering and pumping activities will be regulated through permitting processes (e.g., EASR and/or PTTW) to reduce the potential effects on groundwater resources. In addition, industry BMP will be used to minimize dewatering / pumping volumes including: <ul style="list-style-type: none"> ▫ Use temporary supporting systems, where feasible, to help reduce the amount of groundwater inflow into the excavations; ▫ Surface water runoff will be directed away from the open excavations to reduce rain and surface water contribution to the total dewatering volumes; and ▫ Water Conservation techniques and methods. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.20 – Quarry Site Selection and Development Requirements. 	Yes

VC Subcomponent	Indicators	Project Phase	Project Component or Activity	Potential Effect	Key Mitigation Measures	Predicted Net Effect
Groundwater Quantity	<ul style="list-style-type: none"> ▪ Groundwater level ▪ Groundwater flow direction and pathway 	Construction	Road construction	Change in groundwater quantity	<ul style="list-style-type: none"> ▪ To avoid or reduce the road barrier effects in low-lying areas, such as the peatlands, with shallow water tables, the following measures will be considered during design and construction: <ul style="list-style-type: none"> ▫ The materials selected for road construction, especially the portion below the existing ground surface / groundwater table, will have the same or higher permeability compared to the surrounding native soils. ▫ If needed, crushed stones (rockfill) and/or equalization culverts will be used at wetland and peatland crossings to maintain natural hydraulic connections between the upgradient and downgradient sides of the road to allow groundwater to flow naturally through the road. ▫ When crossing wetlands and peatlands, the road design will consider consolidation and compression processes of the peat layers associated with road construction (loading), which may result in reduced permeability of the peat, and thus alter natural groundwater flow directions and pathways. Compression of peat could also have implications on water quality. Water quality will be monitored during and post road construction. ▫ In cut areas, groundwater seepage (if any) can typically be controlled and managed through roadside drainage systems (e.g., roadside ditches). 	Yes
Groundwater Quality	General chemistry and inorganic parameters, including nutrients	Construction and Operations	Blasting of rocks (at quarry sites)	Change in groundwater quality	<ul style="list-style-type: none"> ▪ Blasting will be used at places where other options are not practical. Wherever practical, alternatives including bedrock ripping, typical or standard drilling, hammering, and non-explosive agent (e.g., expanding grout) will be considered. A Construction Blasting Management Plan for the Project will be prepared and submitted by applicable contractor(s) after contract award prior to initiation of blasting activities (refer to Section 2.1.3 in Appendix E – Mitigation Measures). ▪ If blasting is required, it will be conducted in accordance with OPSS 120 General Specification for the Use of Explosive. A pre-blasting survey will be conducted to identify water supply wells and other environmentally sensitive features within 250 m from the blasting location. Mitigation measures will be modified or enhanced, if needed, based on the survey results. Blasting will not be conducted within 50 m of water supply wells (if any) and should be avoided in shallow groundwater table areas, where possible. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.20.2 – Quarry Development; and ▫ Section 5.22 – Water Quality Monitoring. 	Yes
Groundwater Quality	General chemistry and inorganic parameters including nutrients, and metals	Construction and Operations	Extraction and stockpiling	Change in groundwater quality	<ul style="list-style-type: none"> ▪ The areas proposed for extraction (including pits and quarries) and earth cut will be designed and developed as efficient as possible to limit the Project Footprint. Appropriate restoration and reclamation measures will be adopted to restore the disturbed areas to pre-development conditions as much as possible to reduce the project effects on groundwater quality. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.20.2 – Quarry Development; and ▫ Section 5.22 – Water Quality Monitoring. 	No
Groundwater Quality	General chemistry and inorganic parameters including nutrients, and metals	Construction and Operations	Dewatering	Change in groundwater quality	<ul style="list-style-type: none"> ▪ Dewatering activities will, at a minimum, follow OPSS 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation and OPSS 518 Construction Specification for Control of Water from Dewatering Operations. ▪ Erosion and Sediment Control measures (e.g., OPSS 805, Construction Specification for Temporary Erosion and Sediment Control Measures) will be incorporated into the detail design and implemented during construction to prevent erosion and migration of soils from the work site during rainfall events. ▪ Filter bag(s), and/or sediment trap, will be used at a minimum during dewatering for treatment of dewatering effluent. ▪ Discharge locations from dewatering activities will be at least 30 m away from water bodies. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.20.2 – Quarry Development; and ▫ Section 5.22 – Water Quality Monitoring. 	No
Groundwater Quality	General chemistry and inorganic parameters (including pH)	Construction and Operations	Use of concrete (for structure foundations at watercourse crossings)	Change in groundwater quality	<ul style="list-style-type: none"> ▪ Apply industry BMPs for the use of concrete. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.22 – Water Quality Monitoring. 	No

VC Subcomponent	Indicators	Project Phase	Project Component or Activity	Potential Effect	Key Mitigation Measures	Predicted Net Effect
Groundwater Quality	General chemistry and inorganic parameters including nutrients, and metals	Construction and Operations	Disposal of wastes (from construction camps and the MSF)	Change in groundwater quality	<ul style="list-style-type: none"> ▪ A Construction Waste Management Plan will be developed for the management of waste products and how they are collected, stored, transported and disposed of in accordance with provincial and federal legislation and guidelines (refer to Section 2.1.5 in Appendix E – Mitigation Measures). ▪ No septic systems (with potential leaching chambers/beds) will be used for sewage treatment. Either portable treatment facilities or trucks will be used to dispose the sewage. ▪ Refer to Appendix E – Mitigation Measures: <ul style="list-style-type: none"> ▫ Section 5.5 – Materials Handling and Storage; and ▫ Section 5.22 – Water Quality Monitoring. 	No

8.5 Characterization of Net Effects

Net effects are defined as the effects of the Project that remain after application of proposed mitigation measures. The effects assessment follows the general process described in Section 5 – Environmental Assessment / Impact Assessment Approach. The focus of the effects assessment is on predicted net effects, which are the effects that remain after application of proposed mitigation measures. Potential effects with no predicted net effect after implementation of mitigation measures are not carried forward to the net effects characterization or the cumulative effects assessment. **Table 8-19** presents definitions for net effects criteria, developed with specific reference to Groundwater Resources VC. These criteria are considered together in the assessment, along with context derived from existing conditions and proposed mitigation measures, to characterize predicted net effects from the Project on groundwater resources.

Table 8-19: Criteria for Characterization of Predicted Net Effects on Groundwater Resources VC

Characterization Criteria	Definition or Description	Categories and Measures
Direction	Direction relates to the value of the effect in relation to the existing conditions.	<p>Positive – Net gain or benefit; effect is desirable.</p> <p>Neutral – No change compared with baseline conditions and trends.</p> <p>Negative – Net loss or adverse effect; effect is undesirable.</p>
Magnitude	Magnitude is the amount of change in measurable parameters or the VC relative to existing conditions.	<p>Negligible – No measurable change.</p> <p>Low – Less than seasonal variations.</p> <p>Moderate – Within seasonal variations.</p> <p>High – Higher than seasonal variations.</p>
Geographic Extent	Geographic extent refers to the spatial area over which a net effect is expected to occur or can be detected within the Project Footprint, Local Study Area (LSA), or Regional Study Area (RSA).	<p>Project Footprint – The effect is confined to the Project Footprint.</p> <p>Local Study Area – The effect is limited to LSA.</p> <p>Regional Study Area – As noted in Section 8.1.5.1, the RSA is considered the same as the LSA.</p>
Timing	Timing criteria indicate the important or sensitive timing of the net effect (e.g., dry seasons featuring low groundwater levels).	<p>Non-sensitive – Non-dry seasons (non-summer seasons featuring moderate to high groundwater levels).</p> <p>Sensitive – Dry seasons (summers featuring low groundwater levels).</p>
Duration	Duration is the period of time required for the measurable indicators to returns to their baseline conditions, or the net effect can no longer be measured or otherwise perceived.	<p>Short-term – The net effect is restricted to the construction phase (approximately 5 years).</p> <p>Medium-term – The net effect extends through both construction and operation phases (75-year life cycle).</p> <p>Long-term – The net effect extends beyond the operation phase (greater than 75 years).</p> <p>Permanent – The net effect is unlikely to recover to its baseline condition.</p>
Frequency	Frequency refers to how often an effect occurs during the Project phases.	<p>Infrequent – The effect is expected to rarely occur.</p> <p>Frequent – The effect is expected to occur intermittently.</p> <p>Continuous – The effect is expected to persist continually.</p>

Characterization Criteria	Definition or Description	Categories and Measures
Context	Context considers sensitivity and resilience of the VC to the project related changes.	Sensitive – With measurable changes in the short-term. Resilient – No measurable changes in the short-term.
Input from Indigenous People	Views of the Indigenous communities and groups in assigning the criteria to be used and in characterizing the effects.	Not applicable – No inputs on net effects criteria were received during the engagement and consultation.
Reversibility	Reversibility refers to whether a measurable indicator can return to its existing condition after the project activity ceases.	Reversible – The net effect is likely to be reversed after activity completion and rehabilitation. Irreversible – The net effect is unlikely to be reversed.
Likelihood of Occurrence	Likelihood of occurrence refers to how likely a project activity will result in an effect.	Unlikely – The effect is not likely to occur. Possible – The effect may occur, but is not likely. Probable – The effect is likely to occur. Certain – The effect will occur.

8.5.1 Potential Effect Pathways Not Carried Through for Further Assessment

With the implementation of mitigation measures, the following potential effect pathways are expected to be eliminated:

- Reduction in groundwater quality due to extraction and processing of aggregate materials, stockpiling, dewatering and use of concrete footings. No materials (soils or rocks) with potential acid drainage generating will be used for road construction and maintenance.
- Reduction in groundwater quality due to waste disposal. Domestic wastewater and sewage in the form of liquid effluent generated from construction camps and the MSF may be treated on site using portable facilities or transported offsite by tanker truck for treatment at approved disposal facilities, depending on available facilities.

Potential residual effects that remain following the implementation of mitigation measures are carried forward for further assessment (**Section 8.5.2**).

8.5.2 Predicted Net Effects

Some effects on the Groundwater Resources VC may still occur or remain after the implementation of mitigation measures (also known as the net effects or residual effects). The following sections provide detailed description and characterization of the predicted net effects. The determination of whether a net effect is considered significant is described in **Section 8.6**.

Predicted net effects include:

- Change to groundwater quantity due to:
 - Vegetation clearing and grubbing;
 - Site grading/ground hardening;



- Blasting of rocks;
- Extraction, cut, excavation, stockpiling, and backfilling;
- Dewatering/pumping; and
- Road construction.
- Change to groundwater quality due to:
 - Blasting of rocks.

8.5.2.1 Change in Groundwater Quantity

8.5.2.1.1 Increase of Groundwater Levels due to Vegetation Clearing and Grubbing

The effect of vegetation clearing and grubbing on groundwater resources (increase of groundwater levels) is considered to be positive as infiltration rates may increase after vegetation clearing and grubbing resulting in higher groundwater levels, which would be beneficial to groundwater resources, as well as to groundwater dependent ecosystems. The magnitude of the effect is low to moderate as the change in groundwater levels is expected to be less than or within the range of seasonal variations.

The effect's geographic extent will be limited to the disturbed areas within the Project Footprint. The effect will occur at the early stage (beginning) of the construction phase. This could happen either in dry or non-dry seasons. The effect is short-term in duration and expected to be offset by subsequent construction activities including site grading and soil compaction activities, which may reduce groundwater recharge and lower groundwater levels due to ground hardening. The effect is anticipated to occur intermittently in frequency. The rise of groundwater levels corresponds to seasonal rainfall or snow melting events.

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels in shallow aquifers are expected following the rainfall or snow melting events, although may slightly lag behind the events. The effect is reversible as groundwater levels are expected to recover to pre-development conditions after site restoration, especially in those temporary supporting infrastructure areas (e.g., temporary access roads, laydown yards, construction camps, etc.). The effect is likely to occur (probable) after the rainfall or snow melting events.

8.5.2.1.2 Reduction in Recharge and Lowering of Groundwater Levels due to Site Grading/ Ground Hardening

The effect of site grading/ground hardening on groundwater resources (reduction in recharge and lowering of groundwater levels) is considered to be a negative or adverse effect as the reduced recharge and lowering of groundwater levels may affect the functions of groundwater dependent ecosystems (e.g., wetlands), water supply capacity and baseflow contribution. The magnitude of the effect is low to moderate as the change in groundwater levels is expected to be less than or within the range of seasonal variations. Majority of the extra direct runoff caused by site grading/ground hardening is expected to recharge back to the groundwater system through nearby roadside ditches.

The effect's geographic extent will be limited to the disturbed areas within the Project Footprint. The effect will start at the early stage of the construction phase. This could happen either in dry or non-dry seasons. The effect is short-term in duration and predicted to be intermittent in the temporary infrastructure areas, but continuous in the permanent development areas (i.e., road, MSF) for the Project.



For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels in shallow aquifers are expected. The effect is reversible as groundwater levels are expected to recover to pre-development conditions after site restoration, especially in those temporary supporting infrastructure areas (e.g., temporary access roads, laydown yards, construction camps, etc.). The lowering of the groundwater level resulted from site grading/ground hardening is likely to occur (probable).

8.5.2.1.3 Alteration of Groundwater Flow Directions and Pathways and Lowering of Groundwater Levels due to Blasting of Rocks

The effect of blasting of rocks on groundwater resources (alteration of flow directions and pathways, and lowering groundwater levels in some cases) is considered to be negative as the alteration of formation permeability, groundwater flow rates, directions and pathways may result in changes to groundwater levels in some specific areas, which may affect the functions of groundwater dependent ecosystems (e.g., wetlands), water supply capacity and baseflow contribution to waterbodies. The magnitude of the effect is low to moderate as the change in groundwater levels is anticipated to be less than or within the range of seasonal variations.

The effect's geographic extent will be limited to the quarry areas within the Project Footprint, where rocks will be extracted for road construction. The effect may happen during blasting activities in construction and operations phases. This could happen either in dry or non-dry seasons. The effect is permanent in duration. Although rock blasting is an intermittent activity, the alteration of permeability, flow directions and pathways is permanent (irreversible).

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels in shallow aquifers are expected and this effect is irreversible. Once the formation permeability changes (creating more fractures), it will not likely change back, resulting in irreversible changes to the groundwater flow directions, pathways, and levels. The effect of rock blasting on groundwater resources is likely to occur (probable).

8.5.2.1.4 Alteration of Groundwater Flow Directions and Pathways and Lowering of Groundwater Levels due to Extraction, Cut, Excavation, and Backfilling

The effect of extraction, cut, excavation, stockpiling and backfilling on groundwater resources (alteration of groundwater flow directions and pathways) is considered to be negative as the alteration of natural groundwater flow directions and pathways may result in lowering of groundwater levels in some specific areas, which may affect the functions of groundwater dependent ecosystems (e.g., wetlands), water supply capacity and baseflow contribution to waterbodies. The magnitude of the effect is characterized as moderate to high because in the aggregate sites and cut areas of the road the landscape and topography will likely experience substantial changes.

The effect's geographic extent will be limited within the Project Footprint. The effect may happen in both construction and operation and maintenance phases. This could happen either in dry or non-dry seasons. The effect is permanent in duration. The effect is predicted to be intermittent for foundation excavations. However, it will be continuous for aggregate sites, where the operation is needed throughout construction and operation phases.

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels in shallow aquifers are expected and this effect is irreversible. Once the landscape and topography are changed, they will not likely change back, resulting in irreversible changes to groundwater flow directions, pathways, and levels. The effect is likely to occur (probable).



8.5.2.1.5 Lowering of Groundwater Levels due to Dewatering/Pumping

The effect of dewatering / pumping on groundwater resources (lowering of groundwater levels) is considered to be negative as the lowering of groundwater levels may affect the functions of groundwater dependent ecosystems (e.g., wetlands), water supply capacity and baseflow contribution, particularly within the ZOI. The magnitude of the effect is moderate to high as the change in groundwater tables is expected to be within or more than the range of seasonal variations, especially at the dewatering centres (e.g., aggregate sites, foundation excavations for bridges and culverts, pumping wells at construction camps and MSF).

The effect's geographic extent will extend beyond the Project Footprint, but generally within the LSA. The maximum ZOI may extend slightly beyond the LSA. However, the effect (lowering of groundwater level) outside the LSA is anticipated to be negligible or low. The extent depends on a few factors including groundwater drawdown, hydraulic conductivity, duration, etc. The ZOI could range from a few metres to a few hundred metres. The effect may happen during dewatering/pumping operations. Once dewatering stops, the groundwater levels are expected to recover to baseline conditions. The recovery time could be a few hours, or a couple of weeks depending on the groundwater drawdown and hydraulic conductivity. This could happen either in dry or non-dry seasons. The effect is medium-term in duration. The effect is predicted to be intermittent for construction dewatering including construction of structural foundations and operation of aggregate sites. The effect is anticipated to be continuous for water supply wells at construction camps and MSF.

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels are expected and this effect is reversible. Once the dewatering / pumping is terminated, the groundwater levels are expected to recover to baseline conditions. The effect will occur (certain) during dewatering/pumping.

8.5.2.1.6 Alteration of Groundwater Level and Flow Direction due to Road Construction

The effect of road construction on groundwater resources (alteration of groundwater level and flow direction) is considered to be negative as the changes of groundwater levels and flow directions may affect the functions of groundwater dependent ecosystems (e.g., wetlands). The magnitude of the effect is low as the changes are expected to be less than the range of seasonal groundwater variations.

The effect's geographic extent will extend slightly beyond the Project Footprint and within the LSA. The effect may happen during both construction and operation phases. This could happen either in dry or non-dry seasons. The effect is permanent in duration (unless the road is decommissioned and restored to pre-construction conditions). The effect is predicted to be continuous in frequency.

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels are expected and the effect is irreversible. The likelihood of occurrence of the predicted effect is possible.

8.5.2.2 Change in Groundwater Quality

8.5.2.2.1 Alteration of Groundwater Quality due to Blasting of Rocks

The effect of blasting of rocks on alteration of groundwater quality is considered to be negative as the introduction of substances with the use of explosives may result in reduction of groundwater quality in the vicinity of the blasting locations. The magnitude of the effect is low to moderate as the change in groundwater quality is anticipated to be less than or within the range of seasonal variations.



The effect's geographic extent will be limited to the quarry areas within the Project Footprint, where rocks will be blasted for the extraction of road construction materials. The effect occurs during blasting activities in construction and operations phases. This could happen either in dry or non-dry seasons. The effect is medium-term in duration. The effect is predicted to be intermittent in frequency as it only happens when rock blasting occurs.

For ecological context, the effect is categorized as sensitive as measurable changes in groundwater levels in shallow aquifers are expected. The effect is reversible. The groundwater quality can be restored to pre-development conditions by natural attenuation. The effect may occur (possible) when rock blasting occurs.

8.5.3 Summary

A summary of the characterization of predicted net effects is provided in **Table 8-20**.



Table 8-20: Summary of Predicted Net Effects on Groundwater Resources VC

Predicted Net Effect	Project Phase	Net Effects Characterization								
		Direction	Magnitude	Geographic Extent	Timing	Duration	Frequency	Context	Reversibility	Likelihood of Occurrence
Change in Groundwater Quantity										
Increase of groundwater levels due to vegetation clearing and grubbing	Construction	Positive	Low to Moderate	Project Footprint	Non-sensitive to sensitive	Short-term	Frequent	Sensitive	Reversible	Probable
Lowering of groundwater levels due to site grading/ground hardening	Construction	Negative	Low to Moderate	Project Footprint	Non-sensitive to sensitive	Short-term	Frequent / Continuous	Sensitive	Reversible	Probable
Alteration of groundwater flow directions and pathways and lowering of groundwater levels due to blasting of rocks	Construction and Operations	Negative	Low to Moderate	Quarry Areas (ARA-2 – LSA)	Non-sensitive to sensitive	Permanent	Frequent	Sensitive	Irreversible	Probable
Alteration of groundwater flow directions and pathways and lowering of groundwater levels due to extraction, cut, excavation, and backfilling	Construction and Operations	Negative	Moderate to High	Project Footprint	Non-sensitive to sensitive	Permanent	Frequent / Continuous	Sensitive	Irreversible	Probable
Lowering of groundwater tables due to dewatering / pumping	Construction and Operations	Negative	Moderate to High	LSA	Non-sensitive to sensitive	Medium-term	Frequent / Continuous	Sensitive	Reversible	Certain



Predicted Net Effect	Project Phase	Net Effects Characterization								
		Direction	Magnitude	Geographic Extent	Timing	Duration	Frequency	Context	Reversibility	Likelihood of Occurrence
Change in Groundwater Quality (Cont'd)										
Alteration of groundwater level and flow direction due to road construction	Construction and Operations	Negative	Low	LSA	Non-sensitive to sensitive	Permanent	Continuous	Sensitive	Irreversible	Possible
Blasting of Rocks	Construction and Operations	Negative	Low	Quarry Areas (LSA)	Non-sensitive to sensitive	Medium-term	Frequent	Sensitive	Reversible	Possible

Note: Refer to **Table 8-19** for definitions of categories for net effects characterization.



8.6 Determination of Significance

Several methodologies can be used to determine whether an adverse environmental effect is significant or not significant, as outlined in the Interim Technical Guidance Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the *Canadian Environmental Assessment Act* (CEA Agency, 2018), and relevant to the *Impact Assessment Act* (2019). As presented in Section 5.2.6 and Table 5-7, a qualitative aggregation method is used for determination of significance based on the sequential interactions among the magnitude, geographic extent, and duration criteria for the net effects. The net effects criteria are presented in Table 8-19. Consideration is also given to potential management concerns and concerns of Indigenous communities and groups that the public, government agencies and stakeholders raised during the engagement and consultation activities conducted for the Project (Table 8-2 and Table 8-3).

As summarized in Table 8-20, there are no situations where a predicted net effect on the Groundwater VC is considered high in magnitude, regional in extent, and long-term to permanent in duration. Therefore, it is concluded that the predicted net effects of construction and operations of the Project on Groundwater VC are not significant.

8.7 Cumulative Effects

In addition to assessing the net environmental effects of the Project, the assessment for the Groundwater Resources VC also evaluates and assesses the significance of net effects from the Project that overlap temporally and spatially with effects from other past, present and reasonably foreseeable developments (RFDs) and activities (i.e., cumulative effects).

For a valued component that has identified net effects where the magnitude was determined to be higher than negligible, it is necessary to determine if the effects from the Project interact both temporally and spatially with the effects from one or more past, present RFDs or activities, since the combined effects may differ in nature or extent from the effects of individual Project activities. Where information is available, the cumulative effects assessment estimates or predicts the contribution of effects from the Project and other human activities on the criteria, in the context of changes to the natural, health, social or economic environments.

For this Groundwater Resources VC assessment, the net effects in **Section 8.5** that are characterized as having a likelihood of occurrence of “probable” or “certain” and a “moderate” to “high” magnitude have been carried forward to the cumulative effects assessment. Net effects with this characterization are most likely to interact with other RFD and activities.

The cumulative effects assessment for the Project is completed at the regional scale (i.e., VC specific RSA). The cumulative effects assessment for each VC is primarily qualitative and describes how the interacting effects of human activities and natural factors are predicted to affect indicators for each VC. The assessment is presented as a reasoned narrative describing the outcomes of cumulative effects for each VC.

Change in groundwater quantity is the predicted net effect of the Project on the Groundwater Resources VC that is carried forward for the assessment of cumulative effects within the Groundwater Resources RSA.



Results of the cumulative effects assessment for the Groundwater Resources VC with consideration of RFDs and activities are presented in Section 21.

8.8 Prediction Confidence in the Assessment

The confidence in the net effects assessment for Groundwater Resources VC is moderate considering that the mitigation measures described in **Section 8.4** and Appendix E (Mitigation Measures) are based on industrial BMP that are well-understood, accepted, and have been applied to typical transportation/road construction projects. Although there are some uncertainties in the assessment, they have been minimized or reduced by making some conservative assumptions and using professional judgements based on past experiences in other transportation projects. The results of this assessment can be used as guidance on further hydrogeological studies during the detail design phase.

8.9 Predicted Future Condition of the Environment if the Project Does Not Proceed

The Project lies within un-surveyed/un-developed Ontario Crown lands and Webequie First Nation Reserve lands. There are existing mineral exploration activities (particularly near the east end of the proposed WSR) and it is predicted/assumed that there will be other proposed future mining developments in the area, which is referred to as the Ring of Fire area. Therefore, it is likely that other road construction projects would occur to support the current and future mining activities in the Ring of Fire area if this Project would not proceed.

Future road construction projects are anticipated to have similar effects on groundwater resources. Should the project area remains un-developed, the predicted future conditions of groundwater resources would be relatively unchanged from the existing conditions of groundwater resources (e.g., groundwater quantity and quality conditions would follow the natural seasonal variations/fluctuations) as summarized in **Section 8.2.2** and described in detail in Appendix F – NEEC Report. However, groundwater resources could change dramatically (outside the typical seasonal variations) over time due to climate change.

8.10 Follow-Up and Monitoring



The Project invites community members to participate in developing and implementing programs, which includes water quality monitoring programs.



Indigenous community members will have an active role in developing and implementing management plans.

The purposes of the follow-up and monitoring programs are to:

- Verify environmental effects predictions made during the EA/IA for the Project;
- Provide data with which to evaluate the effectiveness of mitigation measures and modify or enhance these measures, where necessary;



- Provide data with which to implement adaptive management measures for improving future environmental protection activities;
- Document additional measures of adaptive measures to improve future environmental protection activities; and
- Document compliance with required conditions as stipulated in permits, approvals, licenses and/or authorizations.

The recommended monitoring program related to Groundwater Resources VC are described as follows:

- Conduct a pre-construction survey (e.g., prior to blasting, dewatering/pumping, etc.) of the identified private well on the Webequie First Nation Reserve land. The well survey will include completion of well questionnaires to obtain baseline conditions about the well, and collection and analysis of water samples. The well water sampling will continue throughout the construction and post-construction periods on a seasonal basis (e.g., annual, or semi-annual sampling).
- Qualified Environmental Monitors with representation from Indigenous communities will be appointed to guide implementation, monitor, and report on the effectiveness of the construction procedures and mitigation measures.
- Dewatering volumes and discharge water qualities will be monitored, documented, and reported according to terms and conditions of the approved water taking permit (e.g., PTTW or EASR) and others permits, if applicable.
- Groundwater level monitoring on a seasonal basis (e.g., spring, summer and fall) and groundwater sampling on an annual basis will be conducted using available monitoring wells including piezometers installed in the peatland areas. The monitoring and sampling programs will span pre-, during and post-construction periods (e.g., three years after construction is complete).

For more details on proposed water quality monitoring programs, refer to Section 5.22 (Water Quality Monitoring) in Appendix F – Mitigation Measures. Additional details on the proposed follow-up and monitoring for the Project are described in Section 22 of this EAR/IS, Follow-up and Compliance Monitoring Programs.

8.11 References

- Brownscombe, J.W. and Smokorowski, K.E. 2021. Review of Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment. Fisheries and Oceans Canada. Sci. Advis. Sec. Res. Doc. 2021/079. iv + 55 p.
- Canadian Environmental Assessment (CEA) Agency. 2018. Interim Technical Guidance Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the Canadian *Environmental Assessment Act*. Available at: <https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/determining-project-cause-significant-environmental-effects-ceaa2012.html>
- CANMET. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, Mine Environment Neutral Drainage (MEND) Program, CANMET – Mining and Mineral Science Laboratories, Smithers, British Columbia. December 2009.
- Freeze, R.A. and Cherry, J.A. 1979: Groundwater. Hemel Hempstead: Prentice-Hall International. xviii + 604 pp.



- J.D. Mollard and Associates (2010) Limited. 2020. Webequie Supply Road: July 2020 Exploration of Potential Aggregate Development Sites (Final Report). December 10, 2020.
- Jacob, W.B., Karen, E.S. (Fisheries and Oceans Canada). 2021. Review of Pathways of Effects (PoE) Diagrams in Support of FFHPP Risk Assessment. Research Document 2021/079. National Capital Region.
- McCabe, G.J., and Markstrom, S.L., 2007, A monthly water-balance model driven by a graphical user interface: U.S. Geological Survey Open-File report 2007-1088, 6 p.
https://pubs.usgs.gov/of/2007/1088/pdf/of07-1088_508.pdf
- Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release—Data 126 - Revision 1.
- Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release— Data 128 – Revised.
- Ontario Ministry of Environment (MOE) 2003. Stormwater Planning and Design Manual.
<https://www.ontario.ca/document/stormwater-management-planning-and-design-manual-0>
- Ontario Ministry of Environment (MOE). 2011. Soil, ground water and sediment standards for use under Part XV.1 of the *Environmental Protection Act*. <https://www.ontario.ca/page/soil-ground-water-and-sediment-standards-use-under-part-xv1-environmental-protection-act>
- Ontario Ministry of Environment, Conservation and Parks (MECP). 2019. Ring of Fire Environmental Monitoring Program. Preliminary Report. Report Updated October 2019.
- Peck, A.J. and Williamson, D.R. 1987. Effects of Forest Clearing on Groundwater. *Journal of Hydrology*. Volume 94, Issues 1-2, 15 October 1987, Pages 47-65.
- Singer, S.N. and Cheng, C.K. 2002. An Assessment of the Groundwater Resources of Northern Ontario, Hydrogeology of Ontario Series – Report 2, Ministry of the Environment.
- Smerdon, B.D., T.E. Redding, and J. Beckers. 2009. An overview of the effects of forest management on groundwater hydrology. *BC Journal of Ecosystems and Management* 10(1):22–44.
www.forrex.org/publications/jem/ISS50/vol10_no1_art4.pdf
- SNC-Lavalin Inc. 2022. Preliminary Engineering Report, Webequie Supply Road Project, Webequie First Nation (Draft, Rev. PA). November 30, 2020.
- Tam, A. 2009. Permafrost in Canada’s subarctic region of Northern Ontario. University of Toronto, Toronto, ON.
- Todd, D.K. 1980. *Groundwater Hydrology*, 2nd ed., John Wiley & Sons, New York, 535p.
- True Grit Consulting Ltd. 2015. Design of Environmental Remedial Actions, Phase I: Task 2 – Summary of Site Investigations and Recommended Action Plan.
- U.S. Geological Survey., 2003. Methodology for Estimating Times of Remediation Associated with Monitored Natural Attenuation. Water Resources Investigations Report 03-4057. 2003.
- Webequie First Nation. 2019. Webequie First Nation Draft Community Based Land Use Plan. Version 4.3.
- Webequie First Nation. 2020. Webequie Supply Road Environmental Assessment Terms of Reference. August 2020.



AtkinsRéalis



AtkinsRéalis

191 The West Mall
Toronto, ON M9C 5L6
Canada
416.252.5315

atkinsrealis.com

© AtkinsRéalis except where stated otherwise