

Webequie Supply Road Project

Webequie First Nation

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APPENDIX H: WEBEQUIE SUPPLY ROAD ASSESSMENT OF GHG EMISSIONS

AtkinsRéalis



WSR
WEBEQUIE
SUPPLY ROAD



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1. Introduction

Webequie First Nation is completing an Environmental Assessment (EA) under Ontario's *Environmental Assessment Act* (EAA) and Impact Assessment (IA) under Canada's *Impact Assessment Act* (IAA) for the proposed Webequie Supply Road ("the Project", WSR). The proposed Project is a new all-season road of approximately 107 kilometers (km) in length, connecting Webequie First Nation and its airport to existing mineral exploration activities and proposed future mining development in the McFaulds Lake area. As part of both the provincial and federal assessments, the proponent (Webequie First Nation) must outline and discuss how the Project will impact the level of greenhouse gases (GHG) emissions in the atmosphere and the carbon sinks disturbed during the construction phase. More specifically, this study is carried out to comply with the requirements from the Impact Assessment Agency of Canada (IAAC) in the Tailored Impact Statement Guidelines for WSR (TISG Section 15.5 – Climate Change).

This report was prepared pursuant to the Climate Change and Air Quality Work Plan prepared by AtkinsRéalis and submitted to the IAAC and the Ministry of Environment, Conservation and Parks in June 2020 for review and validation that it meets the federal requirements in the TISG and approved Terms of Reference for the provincial EA. The work plan was developed at the time considering the general guidelines provided in the draft "Technical guide related to the Strategic Assessment for Climate Change (SACC): Guidance on quantification of net GHG emissions, impact on carbon sinks, mitigation measures, net-zero plan and upstream GHG assessment" from Environment and Climate Change Canada (ECCC). The work plan was accepted by the provincial and federal authorities, aside from modifications that were stated in the letter from IAAC to Chief Wabasse on January 5, 2023, regarding the use of the updated technical guidance and best practices after the work plan was issued in 2020.

The main results standing out from this study will be documented in the Environmental Assessment Report/Impact Statement (EAR/IS) for the Project, which will meet the requirements of both the federal TISG and the provincially approved Terms of Reference.

1.1 Project Overview

The proposed WSR is a new two-lane all-season road within a cleared right-of-way (ROW) of approximately 35 metres (m) in width and approximately 107 km in length. The preliminary recommended preferred route for the road consists of a northwest-southeast segment running 51 km from the Webequie First Nation Reserve to a 56 km segment running east-west before terminating near the McFaulds Lake within the mineralized deposit area known as the Ring of Fire. A total of 17 km of the WSR is within the Webequie First Nation Reserve lands, with the remainder of the road located on un-surveyed Ontario Crown lands.

The proposed WSR is located in north-western Ontario approximately 525 km northeast of the City of Thunder Bay. The WSR is intended to facilitate the movement of materials, supplies and people from Webequie to the mineral exploration areas near McFaulds Lake area. It is expected to accommodate an annual average daily traffic of less than 500 vehicles consisting of light to medium personal vehicles, commercial vehicles and heavier trucks hauling industrial supplies and equipment.

The northwest-southeast segment of the road (51 km) resting mostly over mineral soil will be cleared of all vegetation across the 35 m ROW to accommodate the two-lane all-season road. Shoulders, ditches, and berms of stripped organic materials on the outside will also be shaped along this segment.

The segment of the WSR running in an east-west direction is located within the Hudson Bay Lowlands Ecozone that includes James Bay ecoregion and is composed mostly of peatland (muskeg) having a depth of 2-4 m of waterlogged organic soil, which represents poor to very poor conditions for building a road. A floating road design is therefore



considered by adding an underlying layer of aggregates (along with geotextile fabrics or geogrids) that will compress the peat resulting in settlement and consolidation. A surface layer of crushed stone will be added to complete the road that is expected to lay 1.2 m above the surrounding lowland areas.

For the west half of the WSR in stable soil conditions, the surface layer of the road that represents the driving surface for vehicles will be a chip seal treatment, which is similar to asphalt pavement, and consists of a tar slurry and gravel. For the east half of the road in the peatlands with poor soil conditions, it is proposed the driving surface be initially gravel. During the operation phase, monitoring of the east half of the WSR in the peatlands will be conducted to assess performance/settlement, serviceability, and safety issues/concerns related to dust along the corridor. Depending on the outcome of this monitoring, the gravel driving surface may be replaced in a timeframe of approximately 3 to 5 years with a surface treatment such as chip seal treatment, or asphalt pavement. Other project components will include bridges and culverts to cross waterbodies, road cross-culverts for local drainage, aggregate pits/quarries, rest and maintenance areas along the WSR, and a permanent Maintenance and Storage Facility (MSF) for operation and maintenance of the WSR once operational.

1.2 Report Objectives

This report is intended to provide an estimate, using the best data and calculation tools available, about the net yearly GHG emissions prompted by the construction and operation of the WSR. More specifically and in line with the requirements from IAAC's TISG and ECCC's technical guidelines when preparing an Impact Statement, this report will provide:

- A description of each of the project's main sources of GHG emissions.
- The estimated annual GHG emissions for each source, including calculation methods, assumptions and related parameters that would enable calculations to be reproduced.
- An estimate of yearly net GHG emissions during the project lifetime, including a discussion on the uncertainty associated with the assessment.
- A description, if any, of large sources of GHG emissions that may be the consequence of accidents or malfunctions.
- A qualitative description of the project's positive or negative effects on carbon sinks, including the removal and alteration of wetlands and forests.
- A discussion on how the project may contribute to Canada's efforts to reduce GHG emissions, if applicable.
- A discussion on how the project could impact global GHG emissions and if it is expected to displace emissions internationally.

1.3 Report Structure

This report covers and discusses the following items, in order:

- **Section 2:** The scope of study including the GHG emissions assessment boundary, the identification of activities generating GHG emissions, the considered GHGs, and the results presentation plan.
- **Section 3:** Presentation of GHG quantification methods for each source based on recognized methods.
- **Section 4:** Presentation of Project's GHG emissions assessment and discussion about the estimates' uncertainties.
- **Section 5:** Discussion on the impact of the project on the Canadian GHG emissions and Canada's ability to meet its climate change commitment. The impact of the project on carbon reservoirs and sinks will also be assessed along with potential mitigation measures currently considered.



2. Scope of Study

As part of the EA/IA, the project proponent is required to estimate the yearly net GHG emissions based on maximum design considerations with details about the level of uncertainty associated with it. ECCC's technical guide also requires its breakdown with respect to the following GHG emissions categories: the sum of direct GHG emissions and indirect GHG emissions from acquired energy minus the sum of avoided GHG emissions from CO₂ capture and storage, avoided domestic GHG emissions, and usage of offset credits. Only direct GHG emissions are considered in this analysis for the following reasons:

- **Indirect GHG emissions from acquired energy** (electricity, heat, steam, cooling or hydrogen gas) from a third-party are not expected due to the absence of an electrical grid (at least outside the community of Webequie). All energy used as part of the Project either during the construction or operation phase is categorized as direct GHG emissions. Electrical power will come from generator sets.
- **Avoided GHG emissions from CO₂ capture and storage** are not relevant to road construction projects.
- **Avoided domestic GHG emissions** do not relate to the Project since the WSR does not replace an existing emission source (i.e., another road or another mean of transportation in the region) and that the lack of project would not result in additional GHG emissions elsewhere in Canada. Moreover, if the WSR or other road projects in area do not come to fruition, the proposed future mining developments near McFaulds Lake may not proceed.
- **Offset credits** will not be purchased to compensate the residual emissions resulting from the construction phase since the proponent is not required to do so by regulation. The proponent does not expect to implement additional voluntary initiatives that are not already integrated in the Project during its lifespan that would help mitigate the GHG emissions knowing that the emissions are out of the control of the proponent.
- Direct GHG emissions will therefore be estimated for the construction phase and the operation phase respectively using recognized calculation methods with best of our knowledge inputs. The decommissioning phase is not included in this analysis since the WSR lifespan is unspecified. Currently, the intention is to operate the WSR beyond the life span of the proposed mineral exploration activities in the McFaulds Lake area.
- Upstream GHG emissions which cover all domestic and non-domestic emissions from all stage of production from the point of resource extraction to the project site (ECCC, 2020) are also excluded from consideration in this study since materials and consumables used to build the road and other supporting infrastructures will be mostly limited to fuel, geotextile, geogrid, structural steel for bridges, concrete, culverts, and the material and equipment at the MSF and used to operate and maintain the road. Altogether, these emissions will not result in upstream GHG emissions exceeding 500,000 tonnes (t) CO₂e¹ per year during the construction phase, which is expected to last five years, and the operation phase. Also, the WSR TISG does not require this specific analysis.

2.1 Project Description

The construction and commissioning of the WSR is expected to occur within an approximately 60-month period. Webequie First Nation is the proponent of the WSR for the purposes of the EA/IA and associated early planning and design of the Project. The proponent for the construction, and operation and maintenance phases of the Project are not known at this time and is part of future discussions and agreement between Webequie First Nation and the Government of Ontario. It is likely the proponent in the future will retain a Contractor for detail design and construction of the Project. The Contractor will use its own employees and sub-contractors to construct the WSR. The proponent will

¹ Carbon dioxide equivalent (CO₂e) quantifies GHG emissions in terms of their total global warming potential relative to that of CO₂.



also have its representatives working directly on the Project to oversee the Contractor's compliance with applicable regulations, standards, and guidelines.

Construction of the WSR will be conducted all-year round by team of workers that will set camp at one of four locations planned along the 107 km WSR. A portion of workers will come from Webequie, but a majority of the workforce will be mobilized by air. The direct workforce is expected to range between 30 and 120 employees depending on the time of year and construction planning. As for the construction materials and consumables (i.e., geogrid, fuel, structural steel, culverts) and equipment (i.e., heavy trucks, excavators), they will arrive at location via a winter road linking Webequie (and the first construction camp) and Pickle Lake.

The detailed construction staging and sequencing of the Project construction will be determined in the Detail Design phase through discussions between Indigenous communities and the construction contractor. It is anticipated that road construction will be linear starting from the first construction camp (expected to be located at 15 km south-east from Webequie) running west towards Webequie and then running east towards McFaulds Lake. The workers will commute daily from the construction camp to work area.

2.1.1 Road Construction

The WSR will consist of two distinct segments, one of 51 km from Webequie running south-easterly and then of 56 km running east until it reaches the McFaulds Lake area. The first segment (western half of the WSR) over mineral soil will be cleared of all vegetation within the 35 m ROW to accommodate the two-lane road. Shoulders, ditches (as enhanced grass swales) and berms of stripped organic materials on the outside will also be shaped along this segment to form the full road platform. Cut and fill work will be needed to adjust the vertical alignment of the road by either lowering or raising the existing grades. An underlying layer of aggregates and a surface layer of crushed stone will then be conveyed by trucks from a nearby quarry and compacted on-site by heavy machinery.

The eastern segment of the WSR being located within the Hudson Bay Lowlands Ecozone is composed mostly of peatland (muskeg) having a depth of 2-4 m of waterlogged organic soil, which represents poor to very poor conditions for building a road. A floating road design is being recommended by adding an underlying layer of aggregates (along with geogrids) that will compress the peat resulting in settlement and consolidation. A surface layer of crushed stone will be added to complete the road that is expected to lay 1.2 m above the surrounding lowland areas. Cross-culverts will be integrated within the road structure at regular intervals to ensure that the hydraulic conductivity of the peatlands is maintained.

2.1.2 Bridges and Culverts

Six watercourse crossings will require steel-concrete bridges that will include a substructure composed of a foundation, abutments and piers supporting the superstructure consisting of steel plate girders, the deck and side barriers with railings. Natural revegetation, seeding and/or planting will be done on and around the road embankments once the bridge is completed. There are 25 culverts that will be constructed to cross minor watercourses. This will include designs such as corrugated steel pipes, corrugated steel arch culverts and open bottom steel arch culverts. The latter, being the most elaborate, consists of corrugated steel and can be fabricated for a full arch width over a waterbody or can be assembled and bolted together with plate sections at time of construction. The corrugated steel pipes and corrugated steel arch culverts will be embedded or counter sunken below the existing stream bed.



2.1.3 Maintenance and Storage Facility

The WSR will undergo regular maintenance over its expected 75 years lifespan and so amenities will be constructed to facilitate that work. A permanent MSF will be erected near the WSR with the purpose of storing the equipment and materials used for inspection, maintenance, and repair activities. The MSF layout will be determined during the detailed design phase but is expected to include an office building, a parking area, garages, winter material storage facilities, an outside aggregate storage and loading area, and an inside salt storage and loading area.

Activities occurring at the MSF will mainly include equipment maintenance and repair mostly inside garages and the loading of trucks transporting aggregates. The MSF will be powered with diesel generators. Otherwise, the maintenance team will regularly conduct inspections and maintenance work to ensure the road meets the minimum standards for roadside safety. The main activities that will occur during the maintenance and operations phase of the Project include:

- Visual patrols and inspections of the road;
- Vegetation management;
- Repair and/or rehabilitation of culverts and bridges at waterbody crossings;
- Resurfacing and repair to road surface and shoulders;
- Aggregate and rock extraction and processing, including asphalt/chipseal production at ARA-4 site;
- Dust control;
- Road drainage system maintenance and repairs – drainage cross-culverts, ditches and inlet/outlet areas;
- Access road maintenance;
- Winter maintenance – snow clearing;
- Spills and emergency response; and
- Waste and excess materials management.

2.1.4 Aggregate Quarry

Aggregates and crushed rock will come from two source locations, one of which will be used exclusively during the construction phase (ARA-2) and another (ARA-4) which lifespan will extend during the operation phase to provide aggregates for operations and maintenance of the road. Production activities will include hole drilling, blasting, and rock conveyance to a nearby crushing plant that should include a primary crusher, a secondary crusher, a screening plant, diesel generators, conveyors, a control tower and supporting mobile loaders. The ARA-4 quarry, being in an area approximately 5 km from the WSR, will necessitate the clearing and construction of an access road, which will include the crossing of a waterbody. Operations will be carried out periodically on an as-needed basis (outside the winter season) as aggregates will be stockpiled.

2.1.5 Site Rehabilitation

Progressive rehabilitation work will be carried out along the WSR as well as at the ARA-2 quarry and the construction camps during the construction phase. Typical rehabilitation measures will be implemented for the WSR including the establishment of suitable vegetation to control erosion during grading and drainage activities. The aggregate pit will first be cleaned up by removing waste and contaminated soil and reconfigured using rock tiers into the quarry to reduce the steepness of the wall and depth.

The closure of temporary construction camps and laydown areas will involve its clean-up (material, waste, and contaminated soil removal) followed by the levelling and trimming the areas to encourage natural revegetation.



2.2 GHG Emissions Assessment Boundary

2.2.1 Construction Phase

This assessment covers direct GHG emission sources occurring on-site during the construction phase for the WSR including the aggregate pits and the access road. The assessment includes emissions related to fuel combustion but also from the removal of carbon stock from vegetation clearing activities. Construction activities will mainly consist of:

- Vegetation clearing, grubbing and disposal (limited burning);
- Setup of storage and laydown yards, and construction camps;
- Earth stripping along the ROW, the aggregate pits, and the access road;
- Aggregate production (crushing and screening) including hauling to site;
- Road construction including grading, aggregate placement, ditching, geotextile installation, ditch seeding, and chip seal placement;
- Bridge construction and culvert installation including the operation of concrete batching plant;
- Construction of buildings and storage areas at the MSF;
- Maintenance of environmental structures / measures (e.g., erosion and sediment control measures), including drainage management features on access roads;
- Management and/or disposal of wastewater and sewage, waste oil, lubricants, and solid wastes; and
- Clean-up and site restoration, including the dismantling of temporary infrastructures.

The assessment of GHG emissions during the construction phase will include a period of five years and will include the mobilization / demobilization of workers to Webequie and their daily commute from the construction camps to the work area. The mobilization of construction equipment and consumables and demobilization of equipment and disposable materials at the end is also accounted for in this inventory. For this assessment, mobilization and demobilization include travelling from the last point of departure or first point of arrival.

2.2.2 Operation Phase

For the operation phase, the following GHG emitting activities will be occurring on an annual basis:

- Daily traffic of vehicles using the WSR;
- Trucks and equipment used for road maintenance; and
- Net GHG emissions caused by land-use changes along the road.

2.3 Identification of GHG Emission Sources

The GHG emission sources are related to activities that are within the assessment boundary defined in **Section 2.2**. For the construction phase, GHG emissions would come from the following categories that will be detailed accordingly in **Section 3**:

- Mobile land equipment including excavators, bulldozers, graders, rubber tire loaders, cranes, compactors, forklifts, and off-road service trucks not used for transportation purpose.



- Stationary fuel combustion equipment namely all internal combustion engines used to operate the generator sets, the crushing and screening plant, the concrete batching plant, the tower lights, and the water pumps. Heating systems used during winter are included in this category.
- Crew vehicles used to transport workers, mainly from construction camps to their work area.
- Heavy-duty transport trucks used to haul materials on-site including filling materials and aggregates from quarries to site. Geotextile and geogrids transportation to location are included in this category.
- Land mobilization and demobilization including the shipment of equipment and consumables via a winter road linking Pickle Lake to Webequie.
- Air travel for mobilizing and demobilizing workers living outside the Webequie community. A helicopter will be used to transport camp supplies and personnel to and from Webequie during summer. It will also be used to support the movement of personnel and material to the area where the WC-26 bridge crossing of the Muketei River will be constructed.
- Carbon stock removal from living biomass (trees, shrubs) and the management of dead organic matter. It also includes related CH₄ and N₂O from the controlled burning of these biogenic material.

For the operation phase, direct GHG emissions would come from the following sources:

- Private / commercial and heavy-duty vehicles commuting on the road on a daily basis.
- Road maintenance equipment (mobile, truck).
- Generator sets used at the aggregate pit (ARA-4) and the MSF for power supply.
- Net GHG emissions changes from mineral soil and peatland due to disturbances caused by the Project.

2.3.1 Exclusions

Given the breadth of activities required to build a road in a natural setting, other emission sources may occur but are excluded considering that they would be minor when compared to the main activities described above. The following potential GHG emission sources are therefore excluded from the analysis:

Construction Phase

- Small watercrafts will be mobilized to Webequie to transport personnel across larger waterbodies (i.e., Winisk Lake, Muketei River) when needed. They will be used on a “as-needed” basis.
- Portable tools with a small engine like chainsaws.
- Blasting at quarries: Most of the aggregates at pits/quarries will come from geological formations (eskers) that do not require blasting. The ARA-2 quarry contains however a portion of bedrock (126,000 m³) that will require blasting. Assuming an elevated powder factor of 1 kg ammonium nitrate-fuel oil (ANFO) explosive per m³ (usually in the range of 0.2–0.6 kg/m³) and a CO₂ emission factor of 192 g/kg ANFO, the total GHG emissions would remain low (i.e., 126,000 m³ x 1 kg ANFO/m³ x 192 g CO₂/kg ANFO = 25 t CO₂).
- Hauling of culverts and materials used to build bridges considering that the number of culverts will be limited to 25 (with one to a couple of trucks transporting them on-site) and five (5) short-span bridges (with trucks transporting the cement, other concrete mixtures, and structural steel). Smaller sized drainage cross-culverts would be included in this category, but the required number is not currently known. Overall, the number of trips will be marginal when compared to hauling of aggregate and earth cut/fill material that would require an estimated 290,000 trips.
- A portion of timber from clearing activities (± 10%) will be recovered by the Webequie community, but as for the previous source, hauling would remain limited compared to the overall picture.
- Incinerator located at camps that will be used to dispose of construction and camp wastes. The volume of combustible wastes (other than cleared vegetation) is unknown but is not assumed to be substantial.



- Induced release of CH₄ trapped in waterlogged organic soil when filling material and aggregates will be placed over the muskeg during road construction is possible. This source depends on the amount of CH₄ already present in the soil matrix, and so can vary depending on the type of wetland and time of year (i.e., temperature). That said, it is expected to be lower than 5% of the total GHG emissions related to construction (63,237 t CO₂; see **Section 4**) when assuming a maximum CH₄ concentration of 35 g CH₄/m³ which corresponds to the maximum solubility of CH₄ in very cold water (35 g CH₄/m³ x 56,000 m long x 15 m wide x 2 m deep x 28 t CO₂e/t CH₄ = 1,650 t CO₂e). At higher temperature, the maximum solubility is lower. Also, in this case, the CH₄ gas will already be generated when the road is being built so it can be considered already emitted since the peatland is not permanently frozen (in a permafrost zone) along the WSR.
- The activities associated with chip seal or asphalt treatment of the road and the construction of the MSF are excluded given that design is unknown at this time.

Operation Phase

- Non-regular road maintenance activities such as repairs of culverts and bridges, road resurfacing (other than grading), road drainage system maintenance, and spills and emergency responses considering that they are expected to be non-recurring annual activities.
- Small maintenance equipment like chainsaws, riding mowers, etc.

Accidents or Malfunctions

- No discussions will be provided about the potential GHG emissions from accidents or malfunctions mainly because the final project infrastructure (a road) will not use or operate materials that could potentially result in emissions, through spills (i.e., pipeline dig-ins) or unexpected burning (i.e., fire). A wildfire caused by the Project remains a possibility but to the extent that cannot be foreseen (localized or not) and quantified.

2.4 Considered GHGs

GHGs considered in this analysis are those associated with fuel combustion: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). The emissions for each gas are added as a « carbon dioxide equivalent » (t CO₂e) based on the global warming potentials (GWP) as set up in the *Greenhouse Gas Pollution Pricing Act* (GGPPA): CO₂ = 1; CH₄ = 28, and N₂O = 265 t CO₂e per tonne which were developed in the 5th Intergovernmental Panel on Climate Change (IPCC) assessment report published in 2014 (IPCC, 2014).

The other GHGs from the GGPPA like sulfur hexafluoride (SF₆), nitrogen trifluoride (NF₃), the hydrofluorocarbons (HFC), and the perfluorocarbons (PFC) are not considered considering that they are not manipulated, produced, or converted on-site or at least in very small amounts, if any.

Table 2-1 lists the GHG emission factors considered in this study per source category presented in **Section 3**. They were extracted from the most recent National Inventory Report (NIR) produced annually by ECCC. For the assessment, diesel fuel and gasoline are set to contain 3% of biodiesel (B3) and 7% of ethanol (E7), respectively. These percentage represent the average found in Canadian fuel stocks in 2021 according to a study prepared annually by Navius Research (2022). Biogenic CO₂ from the combustion of biodiesel and ethanol is compiled separately using the following emission factors from the NIR: 2,472 g CO₂/L of biodiesel and 1,508 g CO₂/L of ethanol.



Table 2-1: Emission Factors Considered in the GHG Emissions Assessment

Source Category	Fuel	GHG Emissions Factor (g/L)				Reference
		CO ₂ ⁽¹⁾	CH ₄	N ₂ O	CO ₂ b ⁽²⁾	
Off-road mobile equipment	Diesel (B3)	2,601	0.073	0.12 ⁽³⁾	74	ECCC NIR 1990:2021 (Annex A6.1.6)
Stationary fuel combustion	Diesel (B3)	2,601	0.078	0.022	74	ECCC NIR 1990:2021 (Annex A6.1.2)
Crew vehicles including light-duty trucks	Gasoline (E7)	2,146	0.43	0.20	106	ECCC NIR 1990:2021 (Annex A6.1.6)
Heavy-duty transport trucks including mobilization / demobilization	Diesel (B3)	2,601	0.14	0.082	74	ECCC NIR 1990:2021 (Annex A6.1.6)
Air travel	Turbo Fuel	2,560	0.018	0.071	0	ECCC NIR 1990:2021 (Annex A6.1.6)

(1) Corresponds to the CO₂ emission factor multiplied by 0.97 for diesel and 0.93 for gasoline to consider the presence of biodiesel and ethanol, respectively in Canadian fuel stocks in average.

(2) Corresponds to the CO₂ emission factor for biodiesel or ethanol multiplied by 0.03 and 0.07, respectively.

(3) The N₂O emission factors for Tier 1-3 and Tier 4 engines were averaged, as the actual equipment fleet is unknown.

2.5 Results Presentation and Analysis

Calculation methods (**Section 3**), selected inputs (**Section 3**), and results (**Section 4**) for each direct GHG emissions will be presented per source category as defined above. For the construction phase, which is expected to last about 60 months (5 years), the annual emissions will be subdivided in accordance with the planning developed by Sigfusson Northern Ltd. as part of their budgetary cost estimate for the WSR project (Sigfusson, 2023). **Table 2-2** summarizes the activities presented in Sigfusson’s report per work phase and the planned realization and time required within that period to achieve the work. For the operation phase, a single annual GHG emissions value is provided applicable to all future years based on the best information available at this time. The results are presented in absolute values (t CO₂e/a) and not in net GHG emissions intensity as no reference value can be derived for this type of project. For reference, **Figure 2.1** presents the layout of the WSR with the identification of the main components mentioned in **Table 2-2**.

Table 2-2: Scheduled WSR Construction Planning

Project Phase	Activities		Timeline	
	Type	Area of Activities ⁽¹⁾	Period	Duration ⁽²⁾
Winter #1	Preparation work	Setup of construction camps near Webequie and ARA-2 quarry	February-March	1
		Clearing and development of ARA-2 quarry site	March	1
		Installation of temporary bridge at WC-27	April-May	1
		Subgrade material hauling from Webequie to WB-1	March-April	1
	Clearing / grubbing	From Webequie to ARA-4	March-May	2
	Burning	Vegetation piles burning	May-June	1

Table 2-2 (Cont'd): Scheduled WSR Construction Planning

Project Phase	Activities		Timeline	
	Type	Area of Activities ⁽¹⁾	Period	Duration ⁽²⁾
Summer #1	Aggregate production	ARA-2 quarry drilling and blasting	February-August	6
		ARA-2 crushing and screening	March-December	9
	Grading / stripping	From WC-3 to WB-1, from Webequie to WB-1, and from WC-3 to ARA-4	April-August	4
	Ditching	From Webequie to WB-1, from WC-3 to WB-1, and from WC-3 to ARA-4 access road intersection	May-January	7
	Geotextile installation	From Webequie to WB-1, from WC-3 to WB-1, from WC-3 to ARA-4 access road intersection and then to WC-27	May-January	6
	Aggregate placement ⁽³⁾	From Webequie to WC-3 from ARA-2 quarry	May-October	4
	Bridge construction	WB-1 bridge	June-March	10
		WC-3 bridge	June-December	6
	Culvert installation	WC-2 culverts	August	1
		WC-4 culvert	December	1
Winter #2	Preparation work	Setup of construction camp near ARA-4 quarry	February-March	1
		Clearing and development of ARA-4 quarry site	March	1
	Clearing / grubbing	From ARA-4 access road intersection to Camp 4B	February-March	2
	Burning	Vegetation piles burning	March	1
	Aggregate production	ARA-2 crushing and screening	December-March	3
	Culvert installation	WC-5 to WC-9 culverts	February-April	2
Summer #2	Aggregate production	ARA-4 crushing and screening	April-October	7
	Grading / stripping	From ARA-4 access road intersection to WC-6	April-June	2
	Ditching	From ARA-4 access road intersection to WC-6	April-May	1
	Geotextile installation	From ARA-4 access road intersection to WC-16	May-August	3
	Aggregate placement ⁽³⁾	From Webequie to WC-27 from ARA-2 quarry	April-August	3
		From WC-4 to WC-27, and from ARA-4 access road intersection to WC-16 from ARA-4 quarry	April-December	8
		From WC-6 to WC-16 from ARA-4 quarry (filling material)	May-November	6
	Bridge construction	WC-27 bridge	April-August	4
		WC-10 bridge	May-December	7
WC-13 bridge		June-December	6	



Table 2-2 (Cont'd): Scheduled WSR Construction Planning

Project Phase	Activities		Timeline	
	Type	Area of Activities ⁽¹⁾	Period	Duration ⁽²⁾
Winter #3	Preparation work	Setup of construction camp 4B	February	1
	Aggregate production	ARA-4 crushing and screening	October-May	7
	Aggregate placement ⁽³⁾	From WC-6 to WC-16 from ARA-4 quarry (filling material)	November-May	5
	Culvert installation	WC-11, 12, 14, 15, 16 culverts	November-January	1
Summer #3	Aggregate production	ARA-4 crushing and screening	May-October	4
	Geotextile installation	From WC-16 to camp 4B	May-November	6
	Aggregate placement ⁽³⁾	From ARA-4 to WC-16 from ARA-4 quarry	April-September	5
		From WC-16 to camp 4B from ARA-4 quarry (filling material)	May-November	6
	Bridge construction	WC-26 bridge	April-October	6
Culvert installation	WC-17 to WC-21 culverts	May-July	1	
Winter #4	Aggregate placement ⁽³⁾	From WC-16 to camp 4B from ARA-4 quarry (filling material)	October-May	6
Summer #4	Aggregate placement ⁽³⁾	From WC-16 to camp 4B from ARA-4 quarry	April-October	6
Winter #5	Culvert installation	WC-22 to WC-25 culverts	October-December	1
Summer #5	Aggregate placement ⁽³⁾	From WC-16 to camp 4B from ARA-4 quarry	April-October	6

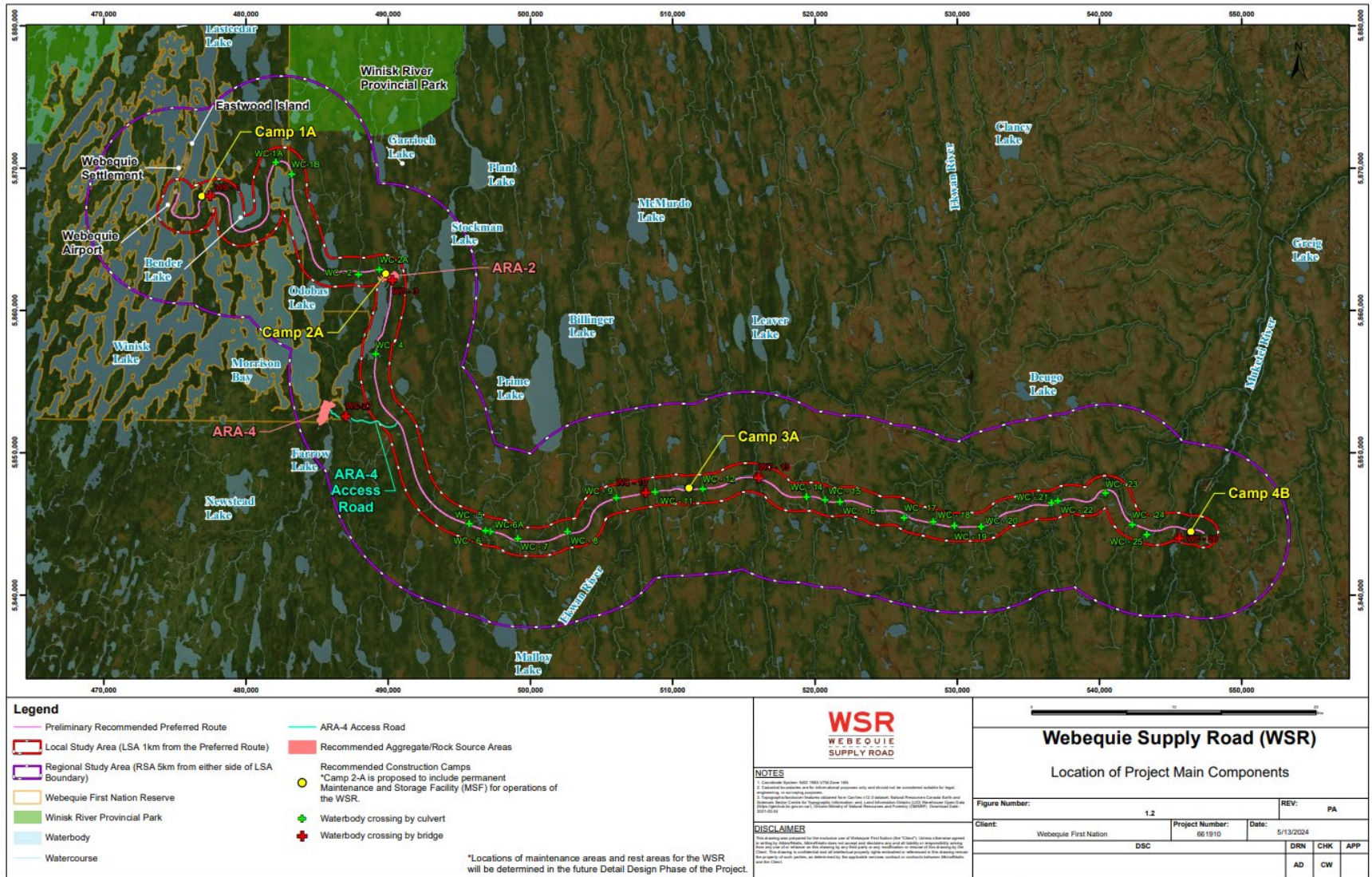
(1) **ARA-2:** site of a temporary quarry; **ARA-4:** site of the permanent quarry; **WB and WC:** water crossings where culverts or bridges will be constructed.

(2) Durations were inferred from Sigfusson's report schedule per activity rounded to the nearest number of months.

(3) Include loading of aggregates at the quarry, hauling and placement on-site but excludes chip seal treatment.



Figure 2.1: Overview of WSR Layout



Scale: 1:10,000. Source: Mapbox/Mapbox Streets, OpenStreetMap contributors, and the GIS User community.

Document Path: \\0607\Projects\2024\061910\061910 - Webeque First Nation Supply Road - Environmental_OIL_Design\061910\061910 - WSR - A11_Project\061910\2_001_2024.rvt



The following elements are discussed following the presentation of the inventory results.

- **Section 4.3** – An **uncertainty assessment** based on the quality of inputs, models, emission factors and any other data used to calculate the estimates in accordance with the level of planning and understanding of required work at this stage. Uncertainty ratings (i.e., $\pm 30\%$) will be attributed to each input to calculate an overall uncertainty based on the Level 1 procedure suggested in IPCC guidelines (2006).
- **Section 5** – A discussion about the **Project’s contribution to Canada’s GHG emissions** based on the inventory by looking at its magnitude compared to Canadian-wide totals per GHG category. GHG emissions estimates linked to the WSR project will be put into perspective with Canada’s effort to curb the adverse effects of climate change. The discussion also considers the mitigation measures considered at this time to mitigate GHG emissions and the commitments by the proponent to reduce the impacts of the WSR Project on climate change over time (**Section 5.2**).
- **Section 5.1** – A **qualitative assessment of the Project impact on carbon reservoirs and sinks** is conducted by describing the anticipated affected forest and peatland area, the forest type, and soil type and defining the initial carbon stocks in living biomass, dead biomass, and soils on land directly impacted by the Project over the course of the project lifetime. The fate of carbon stocks will be specified as well.

No discussions will be provided about the potential GHG emissions from accidents or malfunctions mainly because the final project infrastructure (a road) will not use or operate materials that could potentially result in emissions, through spills (i.e., pipeline dig-ins) or unexpected burning (i.e., fire). A wildfire caused by the Project remains a possibility but to the extent that cannot be foreseen (localized or not) and quantified.

Similarly, the WSR Project will not have an impact on global GHG emissions, at least it will not displace emissions internationally, since it remains an infrastructure project intended to provide access to the Webequie community and future nearby mining exploration and proposed future mining sites.



3. GHG Emissions Quantification

This section provides details about the methods, inputs and hypotheses considered for the calculation of GHG emissions expected over a period of five years during the construction phase and annually for the operation phase.

3.1 Construction Phase

3.1.1 Mobile Land Equipment

This category covers the emissions from heavy machinery for the construction of the WSR including the two aggregate pits. **Table 3-1** lists the equipment per activity on an annual basis and related inputs needed for the calculation of GHG emissions using the following equation. Applicable emission factors and GWP were specified in **Section 2.4**.

$$E_{k,i} = P_k \times LF_k \times BSFC_k \times T_k \times EF_i \times GWP_i / 10^6 \quad (1)$$

$E_{k,i}$	total emissions of GHG i (i = CO ₂ , CH ₄ , N ₂ O) for equipment k (t CO ₂ e)
P_k	rated power of equipment k (hp)
LF_k	average engine load factor of equipment k (-)
$BSFC_k$	brake-specific fuel consumption of equipment k (L/hp-h)
T_k	total operation time for equipment k (h)
EF_i	emission factor for GHG i (i = CO ₂ , CH ₄ , N ₂ O) for the combustion of diesel fuel (g/L)
GWP_i	global warming potential for GHG i (t CO ₂ e / t)

The list of equipment was inferred from the budgetary cost estimate prepared by Sigfusson to build the WSR over a 5-year period distributed into ten phases (winter phases generally from January to April, and summer phases for the rest of the year). Each equipment was attributed to an activity during a phase, so the expected time in operation could be estimated based on the activity timeline in months (**Table 2-2**), the number of equipment units and their expected monthly usage rate as specified in Sigfusson's report (if available, otherwise it has been estimated). Both the average engine load factors per equipment type (i.e., dozer, excavator, crane) and the specific fuel consumption were extracted from United States Environmental Protection Agency's (US EPA, 2010, 2023) Nonroad model. The following BSFCs were applied:

- 0.216 L/hp-h for engines with rated power lower than 100 hp based on the default value from the US EPA and adjusted for 3% of biodiesel since biodiesel has about 8% less energy than diesel, hence requiring more fuel in the engine (NRCan, 2022).
- 0.194 L/hp-hp for the other engines with the same correction.

Table 3-1: Mobile Land Equipment During Construction

Activity	Equipment ⁽¹⁾		Expected Time in Operation (hr) ⁽²⁾				
	Type and Model	Power (hp)	Y1	Y2	Y3	Y4	Y5
Preparation work (camp setup and quarry development)	CAT 140 grader	250	600	600			
	CAT TH 83 telehandler	105	400	200	200		
	CAT 329 excavator	200		300			
	Volvo SD100 compactor	125		300			
Clearing and grubbing	CAT 329 excavator	202	1,200				
	CAT 350 excavator	413	1,200				
	CAT D5K dozer	100	800	600			
	CAT D6R dozer	179	2,400	1,200			
	CAT D7 dozer	265	1,600	600			
	CAT D8 dozer	354	800				
	JD 843L feller buncher	270	1,800				
	JD 648L skidder	237	1,800				
Grading and stripping	CAT 329 excavator	202	1,200	1,200			
	CAT D6 dozer	215	1,600	1,200			
	CAT 14G grader	180		600			
Ditching	CAT 316 excavator	105	2,100	300			
	CAT D5K dozer	100	2,100	300			
	JD 8760 tractor	240	2,100				
Geotextile and geogrid installation	CAT 325 excavators	172	1,800	1,800	3,600		
Aggregate production at quarries	Furukawa HCR900 drills	225	3,600				
	CAT 329 excavators	393	2,700	2,100	4,500	5,400	3,600
	CAT 980 loaders	541	2,700	6,650	3,850		
	CAT 988 loaders	225	2,700	6,650	3,850		
	Scissor lifts	150	1,080	780	660	720	360
Aggregate placement	CAT D6R dozers	179	7,000	11,200	8,700	7,200	5,400
	CAT 140 graders	250	2,400	2,400	5,100	7,200	3,600
	CAT D8 dozers	354	2,400	2,400	1,500		
	Volvo SD150 compactors	185	3,600	5,600	5,100	7,200	3,600
	CAT 350 excavators	413		2,400			

(1) **CAT**: Caterpillar; **JD**: John Deere.

(2) Total time in operation for each year: number of units x number of months required for each phase (winter and summer) x monthly usage (h/month) for each phase



Table 3-1 (Cont'd): Mobile Land Equipment During Construction

Activity	Equipment ⁽¹⁾		Expected Time in Operation (hr) ⁽²⁾				
	Type and Model	Power (hp)	Y1	Y2	Y3	Y4	Y5
Aggregate placement	CAT 950 loaders	225		2,400			
	CAT 966 loaders	321		2,400			
	CAT 325 excavators	172			1,500		1,800
	Tandem water trucks	325			5,400	3,600	
	CAT TH 83 telehandlers	105	600	480	360		
Culvert installation	CAT 350 excavators	413	400	600	600		300
	80T rough terrain cranes	164	120	120	660		120
	CAT 950 loaders	225	400	600	500		200
	CAT 966 loaders	321	400	600	500		200
	CAT 316 excavators	105		600	600		300
Bridge construction	80T rough terrain cranes	164	600	4,800	360		
	CAT TH 83 telehandlers	105	600	480	360		
Crew support	Off-road service trucks ⁽³⁾	430	5,880	6,240	6,240	6,240	6,000
	Polaris site rangers	45	720	720	1,080	1,080	900

(1) CAT: Caterpillar; JD: John Deere.

(2) Total time in operation for each year: number of units x number of months required for each phase (winter and summer) x monthly usage (h/month) for each phase.

(3) Comprises fuel, mechanic, and service trucks.

3.1.2 Stationary Fuel Combustion

This category covers heaters and internal combustion engines providing energy to non-mobile equipment when in operation including generator sets, tower lights, the crushing and screening plants and the concrete and asphalt batching plants. **Table 3-2** lists the equipment and related inputs needed for the calculation of GHG emissions using **equation 1** extracted from the Sigfusson’s report.

The same approach described for mobile land equipment was applied for non-mobile equipment with engines. For the heaters, diesel fuel consumption was established at 0.088 L/hp-h at a 100% load factor (assuming a heating value of 38 MJ/L diesel and 80% efficiency). Applicable emission factors for stationary fuel combustion units and GWP were specified in **Section 2.4**.



Table 3-2: Stationary Fuel Combustion Equipment During Construction

Activity	Equipment		Expected Time in Operation (hr) ⁽¹⁾				
	Type and Model	Power (hp)	Y1	Y2	Y3	Y4	Y5
Aggregate production	Crusher power van	804	3,150	4,550	3,850		
Aggregate placement	Plate compactors	9		300			1,200
	Jumping Jack compactor	10		90		540	540
Culvert installation	Plate compactors	9	400	600	500		300
	Jumping Jack compactor	10	180	180	180		90
Bridge construction	Concrete batching unit	67	1,200	960	720		
Crew support	5 kW portable gen sets	7	2,200	2,400	2,400	2,400	2,000
	50 kW gen sets	67	20,700	15,600	14,400	14,400	12,000
	Heaters	153	1,200	7,000			
	Light plants	27	18,150	26,400	26,400	26,400	14,400
	3-inch water pumps	10	5,250	6,000	6,000	7,200	6,000
	6-inch water pumps	25	2,400	3,000	3,000	3,600	3,000

(1) Total time in operation for each year: number of units x number of months required for each phase (winter and summer) x monthly usage (h/month) for each phase.

3.1.3 Crew Vehicles

This category covers the vehicles that are used mainly to transport personnel from construction camps to work areas during the day. **Table 3-3** lists the vehicles and related inputs extracted from Sigfusson report needed for the calculation of GHG emissions using **equation 2**. The total distance travelled during a work phase was inferred from the number of vehicles on-site (according to Sigfusson’s report), the total number of days during that phase, and an estimated average distance to travel each day per vehicle based on a round-trip from starting camp location to a mid-point along the work area during the phase. An additional 20% contingency is added to cover daily movements.

It is assumed that these vehicles will use gasoline with consumption rates according to Natural Resources Canada (NRCan, 2023) for the specified models in **Table 3-3**. Applicable emission factors and GWP were specified in **Section 2.4**.

$$E_{k,i} = D_k \times FC_k \times N_k \times EF_i \times GWP_i / 10^6 \tag{2}$$

- $E_{k,i}$ total emissions of GHG i (i = CO₂, CH₄, N₂O) for vehicle k (t CO₂e)
- D_k average distance travelled daily for vehicle k (km/day)
- FC_k specific fuel consumption for vehicle k (L/km)
- N_k number of days using vehicle k (day)
- EF_i emission factor for GHG i (i = CO₂, CH₄, N₂O) for the combustion of gasoline (g/L)
- GWP_i global warming potential for GHG i (t CO₂e / t)

Table 3-3: Crew Vehicles to be Used During Construction

Vehicle		Total Distance Travelled (km) ⁽¹⁾				
Type	Fuel Consumption Rate (L/km)	Y1	Y2	Y3	Y4	Y5
1 ton crew trucks (Ford F-250)	0.18	27,531	80,256	49,896	24,528	19,920
Pick-up trucks (Ford F-150)	0.15	128,898	304,128	342,468	122,640	99,600
Crew vans (Ford Transit)	0.10	55,062	99,072	131,544	73,584	59,760

(1) Estimated based on the number of vehicles on-site, the total number of days during the work phase, and an estimated average distance to travel for each truck daily based on camp locations and work sector during each phase.

3.1.4 Heavy-duty Trucks

This category involves on-site transportation of materials (aggregates, filling materials, geotextile, and geogrid) with heavy-duty trucks (side dump trucks and flatbed trucks). The materials and total travelling distance are based on the amount (in m³ for bulk materials and m² for geotextile/geogrid rolls) specified in Sigfusson's report, an average payload per truck and an estimated average distance per trip depending on the material's origin and its destination according to the expected work area during a given phase. The resulting total distance per material and year of construction is provided in **Table 3-4**. More details are available in **Appendix A**.

$$E_{k,i} = \frac{M_k}{P_k} \times D_k \times FC \times EF_i \times GWP_i / 10^6 \quad (3)$$

- $E_{k,i}$ total emissions of GHG i (i = CO₂, CH₄, N₂O) for conveyed material using route k (t CO₂e)
- M_k total amount of conveyed material using route k (m³ of aggregates or m² of geotextile/grid)
- P_k average truck payload for conveyed material using route k (m³ or m² / trip)
- D_k average one-way distance for conveyed material using route k (km one-way/trip)
- FC fuel consumption rate of heavy-duty trucks (L/km one-way)
- EF_i emission factor for GHG i (i = CO₂, CH₄, N₂O) for the combustion of diesel (g/L)
- GWP_i global warming potential for GHG i (t CO₂e / t)

Table 3-4: Material Transport Activities During Construction

Vehicle			Total Distance Travelled One-way (km) ⁽¹⁾				
Type	Origin	Truck Payload ⁽²⁾	Y1	Y2	Y3	Y4	Y5
Granular material	ARA-2	10 m ³	175,979	297,536			
	ARA-4	10 m ³		542,531	1,054,958	1,844,880	1,673,952
Filling material	ARA-4 ⁽³⁾	10 m ³	3,081	740,471	1,204,356	726,825	
Geotextile	Webequie area	2,000 m ²	6,489	9,974	23,101		
Geogrid	Webequie area	1,500 m ²		8,745	30,802		

(1) Estimations based on the total amount of material divided by payload and multiplied by an estimated average on-way distance from the material point of origin and its destination according to Sigfusson's report work plan.

(2) Estimated average payload to carry bulk material (in volume) and geotextile / geogrid (in total surface of material in rolls).

(3) During Y1, the material will come instead from Webequie community pit.



Fuel consumption of 0,392 L/km is selected representing a typical rate for class VII and VIII trucks constructed between 2010 and 2020. This value was extracted from a United States Energy Information Administration (US EIA, 2020) summary document exposing the consumption rate tendency of road vehicles according to their type and year of production. An empty return of trucks to the point of origin is included in the analysis (hence FC = 2 x 0,392 L/km one-way). Applicable emission factors and GWP applicable in **equation 3** were specified in **Section 2.4**.

3.1.5 Land Mobilization and Demobilization

This category concerns the mobilization of equipment and materials used to build the WSR. The demobilization of equipment between years and at the end of the project is also included. **Table 3-5** gives the number of trucks estimated to transport the materials via the winter road and the method to come to this end.

$$E_{k,i} = N_k \times D \times FC \times EF_i \times GWP_i / 10^6 \tag{4}$$

- $E_{k,i}$ total emissions of GHG i (i = CO₂, CH₄, N₂O) for material category k (t CO₂e)
- N_k total number of trucks transporting material category k (-)
- D total distance between Pickle Lake and Webequie via the winter road (km one-way)
- FC fuel consumption rate of heavy-duty trucks (L/km one-way)
- EF_i emission factor for GHG i (i = CO₂, CH₄, N₂O) for the combustion of diesel (g/L)
- GWP_i global warming potential for GHG i (t CO₂e / t)

The fuel consumption rate specified in **Section 3.1.4** for heavy-duty trucks is applied while the distance between Pickle Lake and Webequie via the winter road is estimated to be 292 km. Applicable emission factors and GWP applicable in **equation 4** were specified in **Section 2.4**.

Table 3-5: Land Mobilization and Demobilization during Construction

Category	Approach to Estimate the Number of Trucks	Number of Trucks				
		Y1	Y2	Y3	Y4	Y5
Equipment mobilization ⁽¹⁾	One truck per equipment unit specified in Sigfusson report for Y1 ⁽²⁾ Additional mobilization for future years is based on the year's requirements compared to availability on-site from the previous year.	203	36	4	0	9
Equipment demobilization	Equipment units not required for a given year is considered demobilized to Pickle Lake.	0	22	43	34	153
Fuel	Transportation of the expected fuel consumption from crew vehicles, heavy-duty trucks, and mobile/stationary equipment during the year using 20,000 L tankers.	115	205	206	189	90
Geotextile and geogrid	Based on the required surface area of geotextile and geogrid during the year transported with trucks with a payload of 10,000 m ² for geotextile and 3,750 m ² for geogrids (being heavier).	74	100	184	0	0
Culverts and cross-culverts	Based on number of major culverts (2 trucks per culvert as hypothesis) and an estimated number of trucks (200 in total) transporting cross-culverts which number in currently undetermined.	4	10	85	65	73
Bridge components	Based on total bridge deck area (m ²) to be built during the year requiring an estimated 0.9 t/m ² of materials (i.e., steel and cement) transported by trucks with 15 t payloads as an estimation.	216	54	15	0	0

- (1) Include trucks, vehicles, machinery, the crushing and screening plant, fuel tanks and all equipment that is expected to return to Pickle Lake following work completion.
- (2) One truck per unit is considered as an average since for some instance, multiple trucks will be needed but for other cases, multiple units will be put in the same truck.

3.1.6 Air Travel

This category regroups two separate activities: the mobilization and demobilization of personnel by air to (from) Webequie, and the use of a helicopter supporting the movement of personnel and material to and from construction camps, especially during summertime when land access to Webequie will not be possible.

Regarding air mobilization, the number of passengers is estimated assuming that 60% of total workforce listed in Sigfusson report will originate from outside Webequie and that each employee will remain on-site eight weeks at the time before returning home. The total distance travelled by air (**Table 3-6**) is then calculated assuming that all employees will come from Winnipeg, MB which is considered the most likely origin of the workforce.

As for the helicopter, it is assumed that it will be used once per day to support the movement of personnel and supplies from Webequie to construction camps when they will not be accessible by road during the first and third year. It is assumed that it will transport four (4) people at a time along with supplies.

$$E_{k,i} = N_k \times D_k \times FC_k \times EF_i \times GWP_i / 10^6 \tag{5}$$

- $E_{k,j}$ total emissions of GHG i (i = CO₂, CH₄, N₂O) for category k (t CO₂e)
- N_k total number of passengers travelling by air for category k (psg)
- D_k distance travelled by air for category k (km)
- FC_k specific fuel consumption rate for airplanes or the helicopter (L/psg-km)
- EF_i emission factor for GHG i (i = CO₂, CH₄, N₂O) for the combustion of turbo fuel (g/L)
- GWP_i global warming potential for GHG i (t CO₂e / t)

Applicable emission factors and GWP applicable in **equation 5** were specified in **Section 2.4**. Applied fuel consumption rates are specified in **Table 3-6**. They are pulled from distance-based emission factors suggested by the British Columbia Ministry of Environment (BC MOE, 2020).

Table 3-6: Air Travel During Construction

Category	Distance Travelled by Air (km)	Fuel Consumption Rate (L/psg-km) ⁽¹⁾	Expected Number of Passengers				
			Y1	Y2	Y3	Y4	Y5
Crew members air travel	750 (Winnipeg to Webequie)	0.035	547	408	791	375	423
Helicopter ⁽²⁾	15 (Web to ARA-2) 75 (Web to camp 4B)	0.173	980		980		

- (1) Obtained from “2020 B.C. Best Practices Methodology for quantifying Greenhouse Gas Emissions” (BC MOE, 2020). For helicopters, it is assumed that it will carry four (4) passengers at a time.
- (2) Only includes the projected use of the helicopter between camps.

3.1.7 Biomass Clearing

This section deals with the carbon stock along the WSR that will be cleared including both quarries and the construction camps. This includes land clearing of living biomass (i.e., trees and shrubs) and the management of dead organic matter (DOM) including dead trees and litter. Take note that the excavation and spreading of mineral soil during road construction is included in the operation phase given that no carbon will be removed during construction. The same applies to the organic soil portion (i.e., bogs, fens) considering that it will not be drained nor excavated during construction. The carbon contained in organic soil will remain in place, although it will be disturbed by the placement of filling material and aggregates. This action will push the water and compact the peat under the roadbed until it reaches stability.

3.1.7.1 Living Biomass

The quarries and part of the ROW for the road are composed of trees and low-lying vegetation that will be cleared in the initial phase of construction. It is expected, although not confirmed, that a quarter of trees will be hauled to the Webequie community for their own use while the remaining vegetation (trees, branches, etc.) will be piled and burned on-site under controlled conditions, or chipped and reused as mulch as part of the site rehabilitation.

The following equation is applied which is based on IPCC's approach (2006, 2019) which objective is to assess the variation of carbon in forest biomass at a macroscopic level. The loss of this reservoir corresponds to CO₂ that has been captured over the years by the biomass that will be re-released in the atmosphere, at least in part.

$$E_{k,i} = S_k \times AG_k \times (1 + BG) \times EF_i \times GWP_i / 10^3 \quad (6)$$

$E_{k,i}$	total emissions of GHG i (i = CO ₂ , CH ₄ , N ₂ O) for sector k (t CO ₂ e)
S_k	treed area to be cleared for sector k (ha)
AG_k	above-ground living biomass density in treed area for sector k (t dry/ha)
BG	below-ground to above-ground biomass ratio (-)
EF_i	applicable emission factor for GHG i (i = CH ₄ , N ₂ O, biogenic CO ₂) (kg/t dry)
GWP_i	global warming potential for GHG i (t CO ₂ e / t)

No field measurements specific to the WSR study area in terms of biomass density were carried out and so the present calculations rely on results from third party measurements and studies that are applicable to the Boreal Shield and Hudson Plains ecological zones. In fact, the above-ground living biomass density was inferred from assessment data available from Canada's National Forest Inventory (NFI) for photo plots located in and around Webequie which is composed of a mixture of conifers, mixed woods, and shrubs. For the road section mainly composed of wetlands, data from photo plots located in and around this area were used instead resulting in a lower living biomass density compared to the western part of the road. **Table 3-7** provides, along with total areas to be cleared, applied above-ground living biomass densities consisting of the average of results from these photo plots. Given that the NFI provides total biomass densities, a correction to remove the standing dead trees portion was also applied (see next section).

The other variables from **equation 6** were selected as follow:

- **Below-ground to above-ground biomass ratio:** A value of 0.25 is applied. It was inferred from a study about carbon in Canada's boreal forests (Kurz et al., 2013) by dividing the average carbon content in below-ground biomass with the average carbon content in above-ground biomass resulting from their study.
- **Biogenic CO₂ emission factor:** 1,702 kg CO₂/t dry calculated considering the following hypotheses: 0,51 t C/t dry wood from conifers x 44/12 x 91%. The latter factor considers that 90% of the wood will be burned on-site or in Webequie. In this case, ECCC recommends converting 90% of total carbon into CO₂. On the other hand, the harvested portion of wood (10%) is to be fully converted into CO₂ during the year of removal (i.e., 0.9 x 0.9 + 0.1 = 0.91).
- **CH₄ and N₂O emission factors:** They represent, respectively, 0.36% and 0.017% of the maximum CO₂ emissions from wood combustion (6.8 kg CH₄/t dry wood, and 0.32 kg N₂O/t dry wood), as suggested in ECCC SACC technical guidelines. For CH₄, the emission factor takes into consideration that 1% of the carbon contained in wood is released as CH₄ during combustion.

Table 3-7: Areas to be Cleared and Estimated Biomass Reservoirs per Sector

Project Phase	Affected Sector	Cleared Area (ha) ⁽¹⁾	Above-ground Biomass (t dry/ha) for Vegetated Land Only			Total DOM (t dry/ha)	
			Total	Dead portion ⁽²⁾	Living	Dead wood ⁽³⁾	Litter
Winter #1	Camp 1A (near Webequie)	7.6	76	20%	60	30	112
	ARA-2 quarry and camp 2A	26					
	ROW (Webequie to ARA-4 access road intersection)	42					
Winter #2	ARA-4 quarry and camp 3A	69	22	14%	19	6.3	112
	ROW (ARA-4 access road intersection to WC-10)	1.3					
	ROW (WC-10 to camp 4B)	7.4					
	Camp 4B (near McFaulds Lake)	4.4					

(1) Includes treed and trinket swamp areas that are vegetated. It therefore excludes all non-vegetated areas affected by the Project.

(2) The portion of standing dead trees was inferred from NFI's biomass calculator tool for merchantable stands.

(3) Half is associated with snags while the other half are lying dead trees.

3.1.7.2 Dead Organic Matter

Forest land typically contains DOM on the floor that will be piled during clearing and burned on-site under a controlled conditions along with the cleared biomass. There may be some DOM that will not be burned in the process being left to decompose or buried during road construction, but it is expected to remain a small portion only. The following equation is applied to estimate the amount of GHG emissions associated with the disturbance and burning of DOM which is associated with standing dead trees, lying dead trees and vegetation litter.

$$E_{k,i} = S_k \times DOM_k \times EF_i \times GWP_i / 10^3 \tag{7}$$

$E_{k,i}$ total emissions of GHG i (i = CO₂, CH₄, N₂O) for sector k (t CO₂e)

S_k treed area to be cleared for sector k (ha)

DOM_k total dead organic matter density for sector k (t dry/ha)

EF_i applicable emission factor for GHG i (i = CH₄, N₂O, and biogenic CO₂) (kg/t dry)

GWP_i global warming potential for GHG i (t CO₂e / t)

Table 3-7 summarizes the total DOM density used in calculations for each sector under construction. They were inferred as follow. The same emission factors as for living biomass are used.

- **Standing dead trees:** Estimated based on the total above-ground biomass density used in the previous section while considered that 20% are snags (i.e., 76 t dry/ha x 20% dead = 15 t dry/ha). The percentage was estimated based on data from the NFI biomass calculator web tool for merchantable stands (NRI, 2023) and tree species found in the area including mainly Black spruce but also White spruce, Balsam fir, Balsam poplar, Trembling aspen, and White Birch.
- **Lying dead trees:** It is considered equivalent to standing dead trees (i.e., 15 t dry/ha) on basis that the ratio of total dead wood over living above-ground biomass (i.e., (15+15)/60 = 0.50) matches the same ratio presented in Kurtz et al. (2013) study discussing about carbon content in Canadian boreal forests in general.

- **Vegetation litter:** Litter content is highly dependent on the type of vegetation and trees and its density. A value of 57 t C/ha (equivalent to 112 t dry/ha) is considered which corresponds to the average density obtained from multiple measured plots in boreal forests in eastern Canada dominated with Black spruce (Soucemarianadin et al., 2015) which is the main species along the WSR.

3.2 Operation Phase

3.2.1 Vehicular Traffic

Based on the low population density, proposed road usage and the intended stated purpose of the WSR, an average annual daily traffic volume of less than 500 vehicles is projected. It is expected that traffic during the operation phase will comprise primarily of light to medium personal, but also commercial vehicles and heavier trucks carrying industrial (mining) supplies. This category also includes road maintenance vehicles used, for instance, for visual patrols, to reach sectors for vegetation mowing and local work, etc. The WSR traffic operations will not include mineral ore or mine product hauling/transport.

For this assessment, it is assumed that an average of 250 passages (50% of projected maximum) will occur daily linking the Webequie community to the mining sector near McFaulds Lake area and the intersection with the proposed Northern Road Link (NRL) going southward at about 100 km. Three-quarters of the vehicles are considered as light-duty trucks (subdivided amongst Ford F-150, F-250, and Transit models) while the remaining 25% would be heavy-duty trucks. Based on the fuel usage rates (L/km) specified in **Table 3-3** for light-duty trucks and **Section 3.1.4** for heavy-duty trucks, an average rate of 0.21 L/km is obtained which is then multiplied by 9,125,000 km/a (250 passages/day x 100 km x 365 days). Applicable emission factors and GWP specified in **Section 2.4** for light-duty and heavy-duty trucks are applied. It is assumed that light-duty vehicles will use gasoline while heavy-duty trucks use diesel fuel.

3.2.2 Road Maintenance Equipment

A maintenance team will regularly conduct inspections and maintenance work to ensure the road meets the minimum standards for roadside safety. A list of required equipment (**Table 3-8**) was inferred from the expected maintenance activities provided in **Section 2.1.3** dealing with aggregate production at ARA-4 quarry, dust control, snow removal, road maintenance, and the MSF power requirements. For the latter, in absence of specific designs, it is assumed that 20% of the projected 4 ha footprint of the MSF will be adequate to place offices, garages, and storage buildings that will require power from a dedicated generator set. Annual power requirements of the MSF is based on a benchmark value of 0.99 GJ/m²/a (Energy Star, 2023) for non-refrigerated warehouses in Canada which is then converted into diesel fuel consumption from the generator set.

The assumptions used to estimate annual diesel fuel consumptions for each equipment are synthesized in **Table 3-8** which are then used with the relevant emission factors (trucking, mobile equipment, or stationary fuel combustion) and GWP specified in **Section 2.4**.

Table 3-8: Main Road Maintenance Equipment During Operation

Activity	Equipment		Assumptions
	Type and Model	Fuel (L/a)	
Road circulation	Sand trucks	19,260	60 days of snow removal x 6 passages per day over the length of the road (107 km); 0.50 L/km ⁽¹⁾
	Water trucks	21,935	103 days of potential dust control requirements x 4 passages per day over the length of the road (107 km); 0.50 L/km ⁽¹⁾
	Aggregate hauling	73,402	2,675 trips (26,750 m ³ with 10 m ³ payloads) from ARA-4 quarry to any point on the road (70 km round-trip in average); 0.39 L/km
Mobile equipment (aggregate production)	CAT 980 loader	48,140	1,070 h of operation (26,750 m ³ of aggregates annually at a rate of 1,200 m ³ per day) ⁽²⁾
	Komatsu PC600	53,790	535 h for crushing activities + 685 h for truck loading estimated at 2 h per day in average outside the aggregate production period ⁽²⁾
Mobile equipment (road maintenance)	CAT 14G grader	9,311	325 h of use from April to November with 2 passages over the road length every 10 days at a speed of 15 km/h ⁽²⁾
	CAT 14G grader	37,092	60 days of snow removal from November to May with 3 equipment operating at 10 hr each snow day
	John Deere 6140r	2,526	Estimated at 2 h per business day in average ⁽²⁾
	CAT 336 excavator	4,625	
Stationary fuel combustion	Crusher power van	35,889	535 h of operation (26,750 m ³ of aggregates annually at a rate of 1,200 m ³ per day) ⁽²⁾
	MSF generator set	1,430,042	Estimated based on 8,000 m ² of building area x 0.99 GJ/m ² /a (benchmark for Canadian non-refrigerated warehouses) and diesel generator set efficiency of 40%. ⁽³⁾

(1) The specific consumption rate is higher because of the slow truck movements.

(2) The applicable rated power, engine load factor and specific fuel consumption (in L/hp-h) applicable to the equipment model and needed to calculate diesel consumptions were specified in **Section 3.1.1** for the construction phase.

(3) From these assumptions, the total power of the generator set is equivalent to 841 hp applied throughout the year (8,760 h/a).

3.2.3 Land-Use Change Emissions

3.2.3.1 Disturbed Mineral Soil

A 27 m wide band will be stripped along the western portion of the WSR for about 48 km. Construction of ditches will also see additional soil being excavated to be put in berms (or equivalent) on each side of the WSR along with the stripped material. The estimated volume of soil that will be disturbed in the process is summarized in **Table 3-9**. Based on IPCC's and ECCC SACC guidance, it can be assumed that 20% of organic carbon (SOC) in disturbed soil letting place to settlements (i.e., WSR) will be lost and converted into CO₂ over a period of 20 years (%L = 1%/a in **equation 8**).

$$E_k = V_k \times TSOC \times \%L / 100 \times 44 / 12 \quad (8)$$

E_k total annual CO₂ emissions related to sector k (t CO₂e/a)
 V_k total mineral soil volume disturbed for sector k (m³)
 TSOC total SOC content in mineral soil (t C/m³)
 %L proportion of total disturbed SOC converted into CO₂ annually (%/a)

In absence of field measurements, the specific SOC content in disturbed mineral soil is set to a single value of 0.021 t C/m³ based on Kurz et al. (2013) study stating that the average SOC in unfrozen mineral soils in Canada's boreal zone is 138 t C per hectare within 1 m depth. This value is then converted by considering that 75% of all carbon is located within the upper layer which is the maximum stripping depth for the project (0.75 x 138 / 10 000 m²/ha / 0.5 m = 0.021 t C/m³).

Table 3-9: Volume of Soil Disturbed During Construction

Project Phase	Affected Sector	Disturbed Soil Volume (m ³)	
		Stripping ⁽¹⁾	Ditching ⁽²⁾
Winter #1	Camp 1A (near Webequie)	16,200	0
	ARA-2 quarry and camp 2A	227,000	0
	ROW (Webequie to ARA-4 access road intersection)	538,650	214,500
Winter #2	ARA-4 quarry and camp 3A	421,000	0
	ROW (ARA-4 access road intersection to WC-6)	141,750	52,500
	ROW (WC-6 to WC-16)	0	134,500
	Camp 4B (near McFaulds Lake)	16,400	0

(1) Consists of the disturbed area stripped at 0.5 m depth for the road and quarries. For the camps, 0.2 m deep stripping is considered.

(2) Corresponds to 5 m³ of excavated soil per metre of road according to Sigfusson's report.

3.2.3.2 Net Living Biomass Carbon Accumulation Loss

Tree and vegetation clearing during the construction phase will result in the removal of a carbon sink (or inversely the addition of a GHG emissions source associated to the project). To estimate the resulting loss in CO₂ uptake from the atmosphere, the following equation was applied which considers the amount of living biomass removed in the process (as determined in **Section 3.1.7.1**), the age distribution of trees in the area, and a specific biomass growth rate per age class.

$$S_B = \sum_n [GR_n / 100 \times (CB_U \times P_{n,U} + CB_L \times P_{n,L})] \times CC \times 44 / 12 \quad (9)$$

S_B total annual CO₂ emissions not captured due to the removal of a carbon sink (t CO₂e/a)
 GR_n biomass growth rate for trees of age class n (%/a)
 CB_U total cleared living biomass in the upland area of the WSR (t dry)
 $P_{n,U}$ fraction of trees of age class n in the upland area of the WSR (-)
 CB_L total cleared living biomass in the lowland area of the WSR (t dry)
 $P_{n,L}$ fraction of trees of age class n in the lowland area of the WSR (-)
 CC carbon content of dry wood (= 0.51 t C/t dry)

The total cleared living biomass in the upland area (western part of the WSR related to the Boreal Shield ecozone) and the lowland area (eastern part related to the Hudson Plains ecozone) is obtained from **Table 3-7** (total surface area x above-ground living biomass x below-ground to above-ground biomass ratio).



The distribution of trees per age class is not specifically known for the areas that will be cleared as part of the project. Hence, the average distribution for trees in the Boreal Shield and Hudson Plains ecozones according to the latest statistical summary available from the NFI (2024) is applied and considered representative for the site. The resulting distribution is provided in **Table 3-10**.

The biomass growth rate (in % of actual biomass volume per year) varies depending on age class and so, different values were developed for each of them. Data developed by Payandeh (1991) based on Plonski yield metric for Black spruce (which is the dominating species in the area) as function of stand age were used to develop the growth rates from **Table 3-10**. Since this approach provides a yield per year, an average growth rate was further developed based on these results for each 20-years interval.

Table 3-10: Age Class Distribution per Ecozone and Related Biomass Growth Rate

Age Class (year)	Distribution		Total Biomass Growth Rate (%/a)
	Upland (Boreal Shield)	Lowland (Hudson Plains)	
1 – 20	2.6%	0.34%	10%
21 – 40	9.5%	6.9%	6.5%
41 – 60	17%	12%	3.3%
61 – 80	23%	12%	1.8%
81 – 100	25%	10%	1.0%
101 – 120	11%	23%	0.60%
121 – 140	10%	30%	0.36%
141 – 160	1.5%	5.4%	0.22%
161 – 180	0.39%	0.20%	0.13%
181 – 200	0.068%	0%	0.082%
201+	0.034%	0%	0.050%

3.2.3.3 Peatlands Net GHG Emissions

The construction of the road over the eastern segment of the WSR will have a certain impact on the annual GHG emissions attributed to the anaerobic and aerobic decomposition of organic materials in peatlands. With the floating road design, filling material, geogrid and geotextile will first be placed over the waterlogged soil allowing it to compress under the weight. Addition of the crushed stones up to a height of 1.2 m above surrounding lowland area will help stabilize the road. No water drainage nor ditching along this part of the road is planned. In these conditions, it is assumed that the organic soil compressed under the roadbed will stop or least slow down its decomposition (in absence of water and microorganisms) which would result in GHG emission reductions. On the other hand, it will also result in the removal of a carbon sink.

Table 3-11 presents an estimation of the net annual GHG emissions specific to the compressed organic soil in reference conditions (without the Project). It uses wetland ecosystems distribution data from field measurements in the Project Local Study Area (LSA). Each ecosystem is attributed to a specific peatland category (bog, fen, swamp) for which net CH₄ and biogenic CO₂ fluxes are applied. For the latter, it corresponds to the net carbon ecosystem exchange (NEE) balancing the amount of CO₂ uptake from the atmosphere and the CO₂ emissions from peatland respiration. A negative NEE means that more CO₂ is captured then released and vice versa if the value is positive.

These fluxes were obtained from Webster et al. (2018) which mapped the net CH₄ and CO₂ emission fluxes from peatlands by ecozones based on their review of multiple studies on that topic. During growing season, the NEE for bogs and fens in the Hudson Plains are both negative. The growing season is however short (estimated at 160 days) and when combined with net CO₂ emissions during non-growing days, the NEE increases resulting in a positive annual NEE for fens (**Table 3-11**). Meanwhile, the CH₄ emission flux of 4-6 g/m² per year in the Hudson Plains is generally lower than the CH₄ emission fluxes found in other Canadian ecozones according to Webster et al. (2018). Peat swamps are also known to generate CH₄ emissions and have a specific NEE but there appears to be a lack of data on these wetlands on that regard (Bona et al., 2020). For that reason, the average value from bogs and fens is applied as an approximation.

Based on this analysis, the peatland ecosystems directly impacted by the road footprint currently generates CH₄ that will be prevented by the Project (-124 t CO₂e) while a net 203 t of CO₂ per year would be avoided (+203 t CO₂).

Table 3-11: Expected Annual GHG Emissions Fluxes from Disturbed Peatlands

Peatland Ecosystem Category	Percentage of Affected Area ⁽¹⁾	Net Annual GHG Emissions Rates (g/m ² /a) ⁽²⁾		Annual Flux (t CO ₂ e/a) ⁽³⁾	
		NEE (CO ₂ e)	CH ₄	CO ₂ b	CH ₄
Bog	38	-424	6.0	-136	54
Fen	17	41	4.2	6	16
Swamp	45	-192	5.1	-73	54

(1) The distribution is based on the wetland ecosystems found within the LSA as determined during past years field plots and cruising surveys. Each of the twenty (20) identified wetland ecosystems was attributed to one of the three (3) broad peatland categories from this table.

(2) These fluxes were extracted from Webster et al. (2018) providing, according to their analysis, average CH₄ and NEE values for bogs and fens for the Hudson Plains ecozone.

(3) Total disturbed surface area is estimated by considering the total length of the road in this area (56 km) having a width of 15 m which englobes the road, shoulders, and embankments towards the lowland level.



4. GHG Emissions Inventory Results

This assessment was developed according mainly to ECCC's technical guide requirements. For WSR Project, only direct GHG emissions were included since there are no indirect GHG emissions from acquired energy, nor avoided GHG emissions from CO₂ capture. It will not have an impact (other than negligible) on current domestic GHG emissions since the WSR will not replace an existing emission source (i.e., another road or another mean of transportation in the region) and that the lack of project would not result in additional GHG emissions elsewhere in Canada. Moreover, if the WSR does not come to fruition, the proposed future mining operations near McFaulds Lake may not proceed.

4.1 Construction Phase

The assessment specific to the construction phase considered the following sources. Most of the calculation input were inferred based on quantities and planning developed by Sigfusson Northern Ltd. as part of their budgetary cost estimate for the WSR project (Sigfusson, 2023). Other inputs came from recognized sources, technical studies, and hypotheses when needed.

- Mobile land equipment used to clear the ROW, quarries and construction camps; to produce aggregates at quarries; to build the road including stripping, ditching and geotextile installation; to build the bridges and install the culverts; and for crew support.
- Stationary fuel combustion equipment including mainly generator sets, tower lights, water pumps and the power generator unit at quarries.
- Crew vehicles for commuting between construction camps and work areas.
- Trucking of aggregates from quarries, geotextile, and geogrid at road locations.
- Mobilization and demobilization of equipment to Webequie via the winter road.
- Air mobilization of works to site including the use of a helicopter on-site.
- Removal of carbon reservoirs (living and dead biomass) and related emissions from on-site combustion.

Table 4-1 summarizes the net GHG emissions expected during the construction phase subdivided amongst the planned five years of activities according to the method described in **Section 3**. The total GHG emissions (CO₂, CH₄ and N₂O) presented in CO₂-equivalent (CO₂e) are provided, as well as the biogenic CO₂ emissions, presented separately, linked to either the combustion of biofuel (ethanol, biodiesel) in fuel stocks but most importantly from biomass (living and dead) clearing and burning. The total emissions per gas are also available in **Appendix A**.

A total of **52,493 t CO₂e** was calculated with the second year showing the highest emissions (**15,605 t CO₂/a**) with about 80% coming from on-site fossil-fuel combustion (mobile, stationary, and trucking) and most of the remaining 20% coming from the burning of biomass and DOM generating CH₄ and N₂O. Overall, the GHG emissions are expected to come from, in order of importance: land mobile equipment (**38%**), heavy-duty trucks (**33%**), DOM combustion (**12%**), and others (**17%**).

A total of **57,602 tonnes of biogenic CO₂** is also expected coming mostly from the carbon stock in biomass (living and dead) that will be removed from site mainly by combustion but also in part via the harvesting of wood logs by the Webequie community. From this total, 33% would come from the removal of living vegetation during clearing activities, 13% from dead trees, but most importantly 51% from litter as natural boreal forests with conifers tend to accumulate a lot of such material (needles, decomposing wood, foliage, etc.). This assessment considers that all litter will be piled and burned although there will be some litter that will remain to decompose on-site, which extent is impossible to determine.



4.2 Operation Phase

For the operation phase, a single annual GHG emissions value was estimated based on the best information at hand applicable to all future years as there are no specific information available that would allow to modulate the annual emissions over time. The following emission sources were considered.

- Normal traffic on the WSR from light-duty and heavy-duty trucks along the 100+ km road.
- Land mobile equipment and trucks used for road maintenance (mainly aggregate production, grading, excavation, dozing, snow removal, dust control, and aggregates hauling).
- Dedicated generator set for the maintenance facility for power supply.
- Emissions and sinks due land-use changes from the disturbance of mineral soil during the construction phase, the clearing of living biomass and peatland backfilling along the road.

Table 4-2 summarizes the annual GHG emissions for the operation phase which amount to **8,927 t CO₂e/a** with **51%** coming from projected road traffic. The generator set at the new MSF is the second largest source representing **43%** of the total according to the assessment. On the other hand, the net GHG emissions due to land-use changes reach **1,875 t CO₂e** per year combining the net CH₄ and CO₂ emissions from disturbed soil, the loss of living biomass and peatlands backfilling. The oxidation of carbon from disturbed soil into CO₂ is the main source.

4.3 Uncertainty Assessment

The uncertainty level associated with the GHG emission totals presented in **Table 4-1** and **Table 4-2** is provided below based on Level 1 procedure as suggested in the IPCC guidelines (2006). The uncertainty related to an emission source is calculated according to **equation 10** while the overall uncertainty combining the uncertainties from all sources are calculated using **equation 11**.

$$I_k = \sqrt{\sum_n I_n^2} \quad (10)$$

$$I_T = \sqrt{\sum_k (I_k \times E_k)^2} / \sum_k E_k \quad (11)$$

I_T	relative uncertainty on total GHG emissions (%)
I_k	relative uncertainty associated with GHG emissions source k (%)
I_n	relative uncertainty associated with input n needed for the calculation of source k
E_k	total GHG emissions calculated for source k (t CO ₂ e)

Table 4-1: GHG Emissions per Source and Year of Realization for the Construction Phase

Source	Total GHG Emissions (t CO ₂ e) ⁽¹⁾						Total Biogenic CO ₂ Emissions (t CO ₂)					
	Y1	Y2	Y3	Y4	Y5	Total	Y1	Y2	Y3	Y4	Y5	Total
Mobile land equipment	4,449	5,816	4,520	2,978	1,923	19,686	125	164	127	84	54	554
Stationary fuel combustion	1,124	1,504	1,172	501	373	4,674	32	43	33	14	11	133
Crew vehicles	66	155	162	67	54	504	3.1	7.4	7.8	3.2	2.6	24
Heavy-duty trucks	382	3,293	4,763	5,295	3,447	17,179	11	93	134	150	97	485
Land mobilization and demobilization	368	257	323	173	195	1,316	10	7.3	9.1	4.9	5.5	37
Air travel	50	55	119	25	28	278	0	0	0	0	0	0
Living biomass clearing	1,396	1,382	0	0	0	2,778	9,610	9,517	0	0	0	19,127
DOM clearing	2,934	3,143	0	0	0	6,078	17,982	19,262	0	0	0	37,244
TOTAL	10,769	15,605	11,059	9,040	6,020	52,493	27,773	29,093	312	256	170	57,604

(1) Includes the combined emissions of fossil-related CO₂, CH₄ and N₂O. Individual gas emissions are available in **Appendix A**.

Table 4-2: Annual GHG Emissions per Source for the Operation Phase

Source	Annual GHG Emissions ⁽¹⁾ (t CO ₂ e/a)	Annual Biogenic CO ₂ Emissions (t CO ₂ /a)
Road Traffic	4,517	170
Road Maintenance (trucks)	301	8.5
Road Maintenance (mobile equipment)	410	12
Road Maintenance (stationary fuel combustion)	3,824	109
Land-Use Changes (mineral soil disturbance)	0	1,338
Land-Use Changes (biomass carbon accumulation loss)	0	458
Land-Use Changes (peatlands net emissions)	-125	203
TOTAL	8,927	2,297

(1) Includes the combined emissions of fossil-related CO₂, CH₄ and N₂O. Individual gas emissions are available in **Appendix A**.



The relative uncertainty (in % from selected value) associated with each variable required for calculations was established subjectively based on an appraisal of available data, as described in **Table 4-5** for the construction phase. **Table 4-6** applies to the operation phase. Along with this appraisal, an uncertainty rating is selected for which a relative uncertainty is assigned (**Table 4-3**).

Table 4-3: Uncertainty Ratings

Level	Assigned Value	General Description
Very low	5%	Specific value that is not expected to change (i.e., emission factors).
Low	15%	Selection of a standard value(s) for which few uncertainties (bias) are expected.
Low-medium	25%	Selection of a value(s) expected to represent actual project conditions given that the potential range of values remains fairly limited.
Medium	40%	Selection of a value(s) that can be considered as typical but can also be as high as the double or as low of the half depending on the actual conditions in place.
Medium-high	70%	Selection of a value(s) based on a project-related assessment, but that can largely vary in reality depending on the actual conditions in place.
High	100%	Selection of a value(s) based on a professional judgement from available indications, but that can largely vary in reality depending on the actual conditions in place.
Very high	250%	Cases for which there are no indications helping in the selection of value(s) which are only based on a professional judgement (for which a 250% uncertainty is set).

Table 4-4 compiles the resulting overall uncertainty level for each Project phase specific to non-biogenic GHG emissions and biogenic CO₂ emissions. It results in high uncertainty levels (within ±50 – 70%) mostly because the construction phase work plan is not definite and can be subjected to changes compared to the hypotheses used in this assessment. Similarly, for the operation change, the actual impact of the road in term of traffic volumes, maintenance work and impact on net GHG emissions from the land are based on best estimates at this point that can however vary significantly in reality depending on factors like the presence of mining operations (road traffic), the size and design of the maintenance facility (operation of generator set), and meteorological conditions (maintenance). In summary, this assessment can be seen as providing an indication on the extent of GHG emissions to be expected for by the Project.

Table 4-4: Overall Uncertainty on GHG Emissions Estimations

Phase	GHG Emissions			Biogenic CO ₂		
	Total (t CO ₂ e)	Uncertainty	Range (t CO ₂ e)	Total (t CO ₂ e)	Uncertainty	Range (t CO ₂ e)
Construction	52,493	48%	27,400 – 77,500	57,604	49%	29,300 – 85,900
Operation	8,927	52%	4,300 – 13,500	2,297	67%	650 – 3,800

Table 4-5: Uncertainty Assessment for GHG Emissions Sources During the Construction Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Mobile Land Equipment Stationary Fuel Combustion	Equipment usage (hours in activity)	40%	This input was inferred based on the planning and calendar from Sigfusson as part of their high-level cost analysis for the construction project. It attributes a number of months of use per equipment type per activity and a typical monthly usage rate (i.e., 300 h/month). Although it gives a good idea about the equipment requirements based a sound planning for the project at hand, a medium level of uncertainty remains considering that the Sigfusson report was not intended to be the final construction plan that may change according to contractors and further circumstances.
	Engine power usage (kW)	100%	The engine power usage for each hour of operation is based on the rated power of suggested models by Sigfusson (subject to changes in reality) and the default engine load factor suggested by the US EPA. Given that the rated power of a certain category of equipment (i.e., large dozer) can easily vary by 50-100 hp depending on the model and that the actual engine load factor can also largely vary depending on the workload and type of use, high uncertainties are associated with this input.
	Fuel consumption rate (L/kWh)	25%	Although the consumption rates from a recognized source (US EPA) can be considered as representative for compression-ignition engines, they only represent typical values that do not take into consideration the engine model, age, and technologies in place.
	GHG emission factors (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total	111%	According to equation 10
Crew Vehicles	Number of vehicles on site	40%	The number of vehicles available for workers commuting on-site is based on Sigfusson's report and probable experience (15-30 vehicles depending on the project phase). This input can be seen as representative but will evolve when the construction plan will be refined.
	Total distance travelled per vehicle (km)	70%	This input was broadly estimated based on the main camp site locations and the WSR section where work would be ongoing (which extent can be very large compared for example to a single destination). The estimates are therefore considered largely uncertain.
	Fuel consumption rate (L/km)	15%	This input is based on reported data by NRCan for the make and model specified in Sigfusson's report. The weighted average fuel consumption rate approaches 14 L/100 km and should be representative of the reality within ± 2 L/100 km in average.
	GHG emission factors (g/L)	5%	The applied emission factors for diesel fuel and gasoline combustion come from a recognized source.
	Total	82%	According to equation 10



Table 4-5 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Construction Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Heavy-duty Transportation Trucks	Total amount of material to be hauled (m ³ or m ²)	25%	The volume of aggregates, filling materials, geotextiles, and geogrids were extracted from Sigfusson's report which should represent relatively well the actual needs for the road based on current design considerations.
	Truck payloads per trip (m ³ or m ²)	25%	The applied payload for aggregates is 10 m ³ (± 20 t). Variations are to be expected but it should normally remain within 25% of this value when taking the average for all trips.
	Distance travelled per trip (km)	40%	Information is available in Sigfusson's report to attribute distances per trip based on origin (quarries, Webequie) and destination (section of the WSR). That said, given the length of the WSR (100+ km), accurate distances are difficult to obtain without a refined construction work plan.
	Fuel consumption rate (L/km)	25%	Unlike crew vehicles, the fuel efficiency for heavy-duty trucks can vary more widely depending on many factors including payload. The average fuel consumption rate is however expected to range between 0.3 and 0.5 L/km (vs. the applied rate of 0.392 L/km).
	GHG emissions factor (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total		59%
Land Mobilization and Demobilization	Number of trucks on winter road	70%	This input was inferred from the list of equipment and material mobilized on-site according to Sigfusson's report while considering general hypotheses (1 truck per machine; 20 m ³ fuel tankers, etc.). It adds to the uncertainties associated with the projections in equipment and material requirements from Sigfusson's assessment.
	Total distance travelled per trip	5%	As part of this assessment, only the route linking Pickle Lake to Webequie via the winter road is considered which distance is known. Although the material and equipment will come from further away, it is impossible at this stage to establish even ballpark figures for mobilization emissions inbound Pickle Lake (or vice versa) since the contractor(s) may come from all regions of Ontario or Canada. Mobilization / demobilization outside Pickle Lake was therefore excluded from this assessment.
	Fuel consumption rate (L/km)	25%	Refer to Heavy-duty Transportation Trucks.
	GHG emissions factor (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total		75%



Table 4-5 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Construction Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Air Travel	Total number of workers travelling by air (psg)	100%	Many assumptions were considered to establish a total number of passengers over the course of the project, although they were based on indications from Sigfusson's report about the expected required workforce at each stage of the project.
	Distance travelled per trip (km)	200%	The most likely origin of workers is set to be Winnipeg, even though the workers will most likely come from multiple regions.
	Fuel consumption rate (L/psg-km)	40%	The fuel consumption rates for airplanes and helicopters were inferred from a recognized source of information with regard to GHG emissions assessment. Many factors can however impact fuel consumption from this mode of transportation resulting in a medium level of uncertainty.
	GHG emission factors (g/L)	5%	The applied emission factors for kerosene combustion come from a recognized source.
	Total	272%	According to equation 10
Living Biomass Clearing	Treed area to be cleared (ha)	15%	The expected area to be cleared of trees is based on the current location of WSR and its ancillary infrastructures (work camps, quarries) and the presence of above-ground vegetation (or not) at these locations according to a project-related survey.
	Total living biomass density (t dry/ha) (including above-ground and below-ground)	25%	The above-ground biomass densities were selected from photo plot assessments available in NFI's database at locations in and around the WSR location while removing a portion as standing dead trees. The resulting total above-ground densities of 76 t dry/ha for cleared areas in the upland sector of the WSR (Boreal Shield) and 22 t dry/ha for cleared areas in the lowland sector (Hudson Plains) lies within 25% of the average densities for each of these ecozones according to NFI's latest statistical summary. It depicts the Boreal Shield to contain 68 t dry/ha in average (8,844 million tonnes of biomass (dry basis) over 129,712,000 ha of treed land) and the Hudson Plains to contain 16 t dry/ha in average (295 million tonnes over 18,886,000 ha in treed land). ² It is worth noting that the default value from the IPCC guidelines (2019) for natural boreal forests in North America is 63 t dry/ha . A single below-ground biomass ratio of 0.25 was applied for all cleared areas inferred from results of a study analyzing the carbon stock in boreal forests in Canada (Kurtz et al., 2013). This value is within range of default values provided by the IPCC (0.24 – 0.39) depending on the boreal forest type.
	GHG emission factors (g/t dry)	5%	The applied CH ₄ and N ₂ O emission factors for biomass combustion and biogenic CO ₂ emission factor relevant to carbon stock removal comes from a recognized source.
	Total	30%	According to equation 10

² Data extracted from NFI's standard reports: Statistical Summaries for Terrestrial Ecozones – Total above-ground biomass on forest land by forest type, age class and terrestrial ecozones in Canada (table 17.1), and Area of land cover by terrestrial zones in Canada (table 1.1), <https://nfi.nfis.org/en/standardreports>.



Table 4-5 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Construction Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
DOM Clearing	Treed area to be cleared (ha)	25%	Refer to Living Biomass Clearing. The uncertainty is however increased by 10% on the account that some DOM may also be present in the areas that do not require any tree clearing.
	Total DOM density (t dry/ha)	70%	<p>Total DOM comes from forest floor litter and deadwood (both standing and lying). The litter density (57 t C/ha) was inferred from a study analyzing litter content in Black spruce dominated boreal forests in eastern Canada (Soucemarianadin et al., 2015) which is the case for the WSR area. Their study however showed high variability depending on the sampled plot (30 – 85 t C/ha). The selected litter density is 25% greater than the density developed by Kurtz et al. (2013) for all Canadian ecozones with boreal forests (47 t C/ha) containing Black spruces but also other coniferous and broad-leaved trees that generate less litter. The default value from the IPCC guidelines (2019) for boreal coniferous forests is 40 t C/ha.</p> <p>The total deadwood density was calibrated based on the resulting deadwood-to-living biomass ratio of 0.5 (or 33% of total biomass is considered to be deadwood) from Kurtz et al. study, therefore resulting in 30 t C/ha for the upland section of the WSR (Boreal Shield) and 6 t C/ha for the lowland section (Hudson Plains). The main source of deadwood therefore comes from the Boreal Shield sector for which the IPCC guidelines (2019) suggest a default value of 22 t C/ha for coniferous boreal forests.</p> <p>All put together, the level of uncertainty for total DOM density is designated as medium-high given the expected variability of DOM depending on location.</p>
	GHG emission factors (g/t dry)	5%	Refer to Living Biomass Clearing.
	Total	74%	According to equation 10



Table 4-6: Uncertainty Assessment for GHG Emissions Sources During the Operation Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Road Traffic	Daily traffic (vehicles per day)	40%	For this assessment, the daily traffic was fixed constant at 250 passages when the maximum is expected to be 500. The daily traffic will probably be lower at the beginning but increase when and if mining exploration and/or production happens near the McFaulds Lake. This variability results into a medium uncertainty rating for that input.
	Distance per vehicle (km)	15%	The applied distance per trip corresponds to the length of the WSR from Webequie to McFaulds Lake which is also the area where the NRL road will link with the WSR for commuters coming from the south. There would be few other final destinations along the WSR implying that each vehicle would solely travel from Webequie to the eastern end of the WSR.
	Fuel consumption rate (L/km)	25%	This input is based on the following vehicle distribution: 25% of heavy-duty trucks with varying fuel economies and 75% of light-duty vehicles with more constant fuel economies. Given that this distribution could be somewhat different in reality, a low-medium uncertainty rating is considered for this input.
	GHG emission factors (g/L)	5%	The applied emission factors for diesel fuel and gasoline combustion come from a recognized source.
	Total	50%	According to equation 10
Road Maintenance (Trucks)	Annual traffic (passages per year)	100%	Annual requirements in terms of snow plowing, road watering and aggregates hauling were judged based on some indications although indirect in some cases (i.e., projected number of dry days and snow days). High uncertainty is associated with this input.
	Distance per truck (km)	25%	For snow plowing and road watering, the full WSR length was considered while the ARA-4 quarry location was considering with respect to aggregates hauling resulting into a low-to-medium uncertainty rating.
	Fuel consumption rate (L/km)	25%	The fuel efficiency for snow plowing trucks, water trucks and dump trucks varies widely because their use is different. Specific fuel consumption rates were applied for each of them based on professional judgement with an expected uncertainty level of 25%.
	GHG emissions factor (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total	106%	According to equation 10



Table 4-6 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Operation Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Road Maintenance (Mobile Equipment)	Equipment usage (hours per year)	100%	Mobile equipment will be used during aggregates production at the quarry and for road maintenance. For aggregates, a total of 26,750 m ³ is to be produced annually while equipment usage rate is inferred from Sigfusson's report. As for road maintenance, the list of equipment and their requirements is estimated based on best judgement with very high-level of uncertainty (i.e., 250%). When put altogether, a high uncertainty rating is obtained.
	Engine power usage (kW)	100%	Refer to Mobile Land Equipment in Table 4-5 .
	Fuel consumption rate (L/kWh)	25%	Refer to Mobile Land Equipment in Table 4-5 .
	GHG emission factors (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total	144%	According to equation 10
Road Maintenance (Stationary Fuel Combustion)	Equipment usage (hours per year)	15%	The crusher power unit (535 hours to produced 26,750 m ³ of aggregates) and the MSF generator set (expected to be operated all-year long to power the facility) are based on expected requirements.
	Engine power usage (kW)	100%	While the crusher power unit is based on Sigfusson's report, the rating of MSF generator set was solely based on expected building surface area and an energy benchmark value for Canadian warehouses which can involve high inaccuracies given that the MSF design is still unknown at this stage.
	Fuel consumption rate (L/kWh)	25%	Refer to Mobile Land Equipment in Table 4-5 .
	GHG emission factors (g/L)	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	Total	104%	According to equation 10



Table 4-6 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Operation Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Land-Use Change (Mineral Soil)	Disturbed soil volume (m ³)	40%	The volume of topsoil stripped along the WSR, the construction camps and quarries were estimated based on known lateral dimensions and an expected stripping depth of 0.5 m which can somewhat vary depending on-site conditions (at probably ± 25% and more). The volume of soil excavated during ditching was also estimated by Sigfusson using a rule of thumb approach.
	SOC content (t C/m ³)	100%	The carbon content in mineral soil was inferred from results of a study relative to unfrozen boreal forests. Although it can be representative of conditions on-site, high uncertainties should be expected as it also depends on the type of soil and past environmental conditions. For example, the IPCC guidelines suggest default values that are highly different for North American boreal forests depending on the type of soil. Without specific measurements as hand, high uncertainty level is considered for this input.
	Annual carbon release as CO ₂ (%/a)	5%	The use of 1% release per year is suggested by ECCC SACC, hence the minimal uncertainty level applied. In reality, it can vary a lot as it depends on how the soil will be placed and the oxidizing conditions in place.
	Total	108%	According to equation 10
Land-Use Change (net living biomass carbon accumulation loss)	Total living biomass to be cleared (t dry)	25%	Refer to Living Biomass Clearing in Table 4-5 .
	Age class distribution (%)	25%	The age class distribution is based on the average in the Boreal Shield (upland area) and Hudson Plains (lowland area) published by the NFI. Although variations occur from site to site, it is expected to be more or less representative of the actual distribution along the WSR.
	Biomass growth rate per age class (%/a)	100%	A growth rate curve that was developed for Black spruces in the past was applied. Although dominant, it is not the only species and there are many other factors affecting growth rendering this estimation highly uncertain.
	Carbon content of dry wood (t C/t dry)	5%	The carbon content in softwood (Black spruce) shows normally very little variations from site to site.
	Total	106%	According to equation 10



Table 4-6 (Cont'd): Uncertainty Assessment for GHG Emissions Sources During the Operation Phase

Source	Input Variable	Uncertainty Level (%)	Rationale
Land-Use Change (peatlands net GHG emissions)	Total peatland disturbed area (m ²)	25%	No surveys are available specifically for the WSR corridor that will be directly impacted by the project and so, the area was simply inferred from the length of the road crossing the peatland area and an expected disturbance width of 15 m. This estimation is considered a quasi-maximum as it may be a little bit higher but can certainly be much lower.
	Peatland category distribution (%)	15%	Not specific to the WSR corridor but to the LSA. There may be local variations between the LSA and the WSR corridor itself.
	Specific net CH ₄ and CO ₂ emission fluxes per category (g/m ² /a)	70%	Webster et al. (2018) study from which the net CH ₄ and CO ₂ emission fluxes were extracted also report large variations in measurements between studies for the same ecozone, meaning that this parameter is highly dependent of site conditions. For example, an uncertainty level of about ±50% is obtained based on (limited) reported values for the Hudson Plains in their study.
	Total	76%	According to equation 10



5. Project's Impact on Canadian Carbon Footprint

As a new infrastructure in a region where no road system exists, the WSR Project will add means to connect the northern community of Webequie to the proposed mining exploration and developments in the Ring of Fire area with Ontario's road network to the south should the NRL and Marten Falls Community Access Road proceed in the future. The WSR is not intended to improve current traffic conditions and so it will not replace existing GHG emissions, with the exception of air travel to the local air strip in Webequie that may decrease with the new connection to the road network. That said, air travel is more energy efficient than road travel (± 0.035 L/km per passenger vs. ± 0.06 L/km for pick-up trucks with two (2) passengers) and so the presence of the road may potentially add to GHG emissions depending on the extent of modal shift on that respect. Hence, the Project would result in additional GHG emissions over time to an extent that also depends on future mining activities in the region.

Table 5-1 summarizes the projected GHG emissions subdivided amongst relevant categories used in the latest National Inventory Report (NIR 1990:2021) from ECCC. Over a period of 25 years starting with the first year of construction, the project is expected to generate over 330,000 t CO₂e from which 33% is linked to the construction phase. These emissions combine both the fossil-fuel related GHG emissions and the biogenic CO₂ emissions considering that the Project will have an impact on current carbon reservoirs and associated sinks. According to calculations, the biogenic CO₂ emissions represent 32% of total GHG emissions (i.e., 105,000 t biogenic CO₂ over 25-years). In contrast, 68% of emissions are generated mainly from fossil-fuel combustion for the operation of mobile and stationary equipment, trucking, traffic, road maintenance activities, and maintenance facility power supply.

Table 5-1: GHG Emissions Inventory Summary

Project Phase	Source Type	Total GHG Emissions ^{(1) (2)}	Canadian Annual Emissions	
			Relevant NIR Category ⁽³⁾	2021 total
Construction	Fuel combustion (construction including air and land mobilization and demobilization activities)	44,870 t CO₂e [3%] (11,394 t CO ₂ /a)	Transport (Off-Road Manufacturing, Mining and Construction)	18 Mt CO ₂ e/a
	Impact of construction activities on carbon reservoirs	65,227 t CO₂e [86%] (33,305 t CO ₂ /a)	Land-use, land-use change and forestry (Land converted into settlements)	6.5 Mt CO ₂ e/a
Operation	Fuel combustion (road traffic and maintenance activities)	107,420 t CO₂e [4%] (5,371 t CO ₂ e/a)	Transport (Road Transportation)	116 Mt CO ₂ e/a
	Fuel combustion (generator set at the maintenance facility)	78,660 t CO₂e [3%] (3,933 t CO ₂ e/a)	Stationary Combustion Sources (Commercial and Institutional)	35 Mt CO ₂ e/a
	Impact of road on carbon sinks and land emissions	40,154 t CO₂e [100%] (1,874 t CO ₂ e/a)	Land-use, land-use change and forestry (Land converted into settlements)	6.5 Mt CO ₂ e/a
TOTAL (over the construction period and the first 20 years of operation)		336,331 t CO₂e [32%]		

(1) The total GHG emissions cover the 5 years of construction + the first 20 years of operation of the WSR.

(2) The totals combine fossil-fuel combustion emissions and biogenic CO₂. The percentage in bracket represents the proportion of biogenic CO₂ while the value in parenthesis represents the maximum annual emission rate calculated as part of this assessment.

(3) Corresponds to the main GHG category (and smallest sub-category) from ECCC NIR 1990:2021 most relevant to the source type.



On an annual basis, the maximum GHG emissions are expected to occur during the second year of construction generating a total of 44,699 t CO₂e, with 75% coming from the combustion of cleared living and dead organic biomass. For the operation phase, the annual emissions are estimated at 11,178 t CO₂e with about half linked to the projected vehicular traffic on the WSR, and 35% from the generator set required to provide power to the road MSF. Emissions related to land-use change, mainly from the natural oxidation of carbon in mineral soil that will be disturbed during construction, represent 17% of the total annual emissions that will greatly decrease after twenty (20) years (i.e., soil carbon oxidation is projected to stop or greatly diminish after that time period).

When compared to the Canadian total in 2021 (670 Mt CO₂e according to the NIR) of which 23% comes from Ontario, the added emissions from the WSR Project appears insignificant in the broader scheme of things (+0.0067% maximum). That said, when compared per NIR GHG emissions category (**Table 5-1**), WSR's emission sources, while remaining small for fossil-fuel combustion activities (0.06% and less vs. the Canadian total depending on category), cannot be seen as negligible when compared to the Canadian total regarding land converted into settlements like it is the case for the road project.³ In fact, the results from this assessment show that the maximum annual emissions caused by construction activities on carbon reservoir would generate an equivalent of 0.5% of the corresponding Canadian total for land-use changes into settlements (based on 2021 data from the NIR). Although lower, it would still be substantial for the operation phase (0.03% of the Canadian total).

Other than adding to the Canadian GHG emissions, the presence of the road could also accelerate the development of mines in the region in which ore could be used in smelters (or an equivalent) in Ontario or Canada in replacement of ore coming from abroad. This particular situation would improve Canada's GHG inventory by limiting transportation emissions from abroad. It could also have the reverse effect if the ore is shipped abroad. As such, the additional impact of the WSR on the carbon footprint of the region will depend more on future mining operators than the WSR.

Furthermore, the WSR Project will not have an impact on global GHG emissions, at least it will not displace emissions internationally, since it remains an infrastructure project intended to provide access to the Webequie community and future nearby mining exploration and proposed future mining sites.

5.1 Impact of Project on Carbon Sinks

Table 5-2 provides more details about the disturbed carbon sinks and reservoirs based on inputs and hypotheses specified in **Section 3**. The resulting net GHG emissions over the first twenty-five (25) years (year 1 to 5 in construction + year 1 to 20 in operation) is provided in **Table 5-3**. The GHG emissions expected during the first years of construction from vegetation and DOM clearing are estimated to represent about 60% of all emissions calculated for the first 25-years considering that biomass is projected to be burned on-site in great majority. The remaining 40% is attributed either to the loss of a carbon sink, the net emissions from the land (emissions added – those avoided due to the project), or the net NEE for CO₂ in the peatlands affected by the project. Over +105,000 t CO₂e can be attributed to land disturbance for the first 25 years. That said, the uncertainty on this number remains high, being estimated at ±45% based on the method presented in **Section 4.1**, uncertainty ratings and justifications on inputs provided for the carbon sinks and reservoirs.

³ The "Land converted into settlements" category covers all built-up land: urban, rural residential, and industrial and recreational land; roads, ROW and other transportation infrastructure; and land used for resource exploration, extraction and distribution (mining, oil and gas).



Table 5-2: Disturbed Carbon Sinks and Reservoirs Characteristics

Category	Impacted Area ⁽¹⁾	Composition Overview (as used in this assessment)	Impacting Activity	Initial Carbon Stock (t C) ⁽²⁾	Fate of Carbon Stock
Living Biomass	146 ha in the upland area	Forest relevant to Boreal Shield ecozone dominated with Black spruce	Clearing	5,590	90% burning 10% harvested
	12 ha in the lowland area	Treed areas in the Hudson Plains ecozone dominated with Black spruce	Clearing	143	90% burning 10% harvested
DOM	146 ha in the upland area	11% standing dead trees; 11% lying dead trees; and 78% litter	Clearing	10,575	100% burning
	12 ha in the lowland area	3% standing dead trees; 3% lying dead trees; and 94% litter	Clearing	710	100% burning
Mineral Soil	1,762,500 m ³ in the upland area	Mineral soil from mostly unfrozen boreal forests	Stripping and ditching	7,300	Natural oxidation on-site over time
Peatlands	84 ha in the lowland area	45% swamps; 38% bogs; and 17% fens	Road construction	0	Not applicable ⁽³⁾

(1) Sum of areas attributed to the road footprint, quarries, and construction camps in either the western part of the WSR (upland mostly relevant to coniferous forests in Boreal Shield), and eastern part of the WSR (lowland mostly relevant to peatlands in the Hudson Plains).

(2) Relates only to carbon that will be released in the atmosphere during construction and/or operation.

(3) The peatlands will not be excavated, drained nor managed in a way to directly release the actual carbon into the atmosphere.

Table 5-3 Quantitative Impact of Project on Disturbed Carbon Sinks and Reservoirs

Category	Area	Net CO ₂ Emissions (t CO ₂)			Net CH ₄ and N ₂ O Emissions (t CO ₂ e)		
		Initially ⁽¹⁾	25-Years ⁽²⁾	Total	Initially ⁽¹⁾	25-Years ⁽²⁾	Total
Living Biomass	Upland	18,650 (B)	11,275 (S)	29,925	2,709 (B)	0	2,709
	Lowland	476 (B)	175 (S)	651	69 (B)	0	69
DOM	Upland	34,899 (B)	0	34,899	5,695 (B)	0	5,695
	Lowland	2,345 (B)	0	2,345	383 (B)	0	383
Mineral soil	Upland	0	26,760 (E)	26,760	0	0	0
Peatlands	Lowland	0	5,075 (N)	5,075	0	-3,125 (E)	-3,125
TOTAL		56,370	43,285	99,655	8,856	-3,125	5,731

(B) denotes emissions from burning; (S) loss of a carbon sink; (E) net emissions from land; (N) net NEE for CO₂.

(1) Initial emissions relate to clearing and biomass burning activities.

(2) Includes the net annual emissions for the five (5) years of construction (assuming that living biomass is cleared during the first year) + the 20 first years of operation.



5.2 Mitigation Measures

The inventory herein was developed without consideration of mitigation measures that would reduce the overall carbon footprint of the Project. For the construction phase, electrification of mobile equipment, vehicles or trucks will not be possible nor recommended given that electricity would be produced from generator sets. Therefore, while assuming that the construction planning from Sigfusson report remain valid (excluding optimization measures in logistics and planning reducing fuel usage), available mitigation measures are the ones typical for road construction projects like:

- Eco driving that could lead to fuel savings within the 2-5% bracket depending on drivers. Contractors would need to demonstrate that their operators have followed a training session or have been sensitized to eco driving.
- Optimized equipment maintenance program to make sure that the alignment, tires, and other mechanized features that could impact fuel economy is optimal, so to mitigate the fuel usage by a couple of percent compared to poorly maintained equipment.
- Where practical and applicable, use multi-passenger vehicles for the transport of crews to and from job sites.
- Minimize equipment and vehicles idling or unnecessary operation (i.e., tower light, gen set) that could potentially help save up to a couple of percent of fuel over the course of the project.

The proponent will highly recommend to selected contractors to consider these practices, if not already implemented by them, to minimize fuel consumption and costs in the same token.

The main reduction potential however comes from the combustion of living biomass (aka wood logs and branches) that will generate important quantities of CH₄ and N₂O along with biogenic CO₂. A commitment to mitigate these emissions by using the biomass for other purposes like the production of roundwood and timber that would be used in Webequie for construction projects or woodchips used as mulch for landscaping, erosion control or other application will be analyzed further by the proponent. At this time, there is an objective to burn no greater than 10% of all cleared living biomass and used the wood for such purposes. In such a case, the GHG emissions from burning would be reduced by at least 19,000 t CO₂e (2,500 t CO₂e of CH₄ and N₂O prevented from combustion and 16,500 t emitted as biogenic CO₂). Although timber and mulch can eventually be released as CO₂, not all of the carbon in wood would be released as such. These avoided emissions represent 17% of total emissions during construction and 6% of total emissions when including the operation phase for the first 20 years.

For the operation phase, the main mitigation measure that the proponent can control is the design and operation of the MSF that will be powered by a dedicated generator set. At this point, the MSF design is unknown, but the proponent is committed to discuss and consider designs that would help minimize electric power requirements. It will include energy efficiency measures during operation that could be implemented by the maintenance team.



6. References

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APPENDIX A

Calculation Note

GHG emissions during the construction phase - Summary

Emissions Category	Phase	Total Fuel Usage (L)	Estimated GHG Emissions (t CO ₂ e)				
			CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Mobile land equipment	Winter #1	403 408	1 049	0.82	13	1 063	30
	Summer #1	1 284 748	3 341	2.6	42	3 386	95
	Winter #2	692 136	1 800	1.4	23	1 824	51
	Summer #2	1 514 648	3 939	3.1	50	3 992	112
	Winter #3	628 964	1 636	1.3	21	1 658	47
	Summer #3	1 086 062	2 824	2.2	36	2 862	81
	Winter #4	458 706	1 193	0.94	15	1 209	34
	Summer #4	671 230	1 746	1.4	22	1 769	50
	Winter #5	152 140	396	0.31	5.0	401	11
	Summer #5	577 332	1 501	1.2	19	1 522	43
	TOTAL	7 469 374	19 425	15	246	19 686	554
Stationary fuel combustion	Winter #1	56 033	146	0.12	0.33	146	4.2
	Summer #1	374 888	975	0.82	2.2	978	28
	Winter #2	270 003	702	0.59	1.6	704	20
	Summer #2	306 558	797	0.67	1.8	800	23
	Winter #3	224 743	584	0.49	1.3	586	17
	Summer #3	224 393	584	0.49	1.3	585	17
	Winter #4	66 528	173	0.15	0.39	174	4.9
	Summer #4	125 715	327	0.27	0.73	328	9.3
	Winter #5	46 826	122	0.10	0.27	122	3.5
	Summer #5	96 017	250	0.21	0.56	250	7.1
	TOTAL	1 791 704	4 659	3.9	10	4 674	133
Crew vehicles	Winter #1	10 040	22	0.12	0.53	22	1.1
	Summer #1	19 757	42	0.24	1.0	44	2.1
	Winter #2	27 919	60	0.34	1.5	62	2.9
	Summer #2	42 054	90	0.51	2.2	93	4.4
	Winter #3	17 781	38	0.21	0.94	39	1.9
	Summer #3	55 725	120	0.67	3.0	123	5.9
	Winter #4	9 919	21	0.12	0.53	22	1.0
	Summer #4	20 251	43	0.24	1.1	45	2.1
	Winter #5	4 251	9	0.05	0.23	9.4	0.45
	Summer #5	20 251	43	0.24	1.1	45	2.1
	TOTAL	227 946	489	2.7	12	504	24
Heavy-duty transport trucks	Winter #1	2 380	6	0.0093	0.052	6.3	0.18
	Summer #1	143 054	372	0.56	3.1	376	11
	Winter #2	0	0	0	0	0	0
	Summer #2	1 253 817	3 261	4.9	27	3 293	93
	Winter #3	619 074	1 610	2.4	13	1 626	46
	Summer #3	1 194 487	3 106	4.7	26	3 137	89
	Winter #4	1 139 544	2 963	4.5	25	2 993	85
	Summer #4	876 614	2 280	3.4	19	2 302	65
	Winter #5	0	0	0	0	0	0
	Summer #5	1 312 378	3 413	5.1	29	3 447	97
	TOTAL	6 541 349	17 011	26	142	17 179	485

Land mobilization and demobilization	Winter #1	140 075	364	0.55	3.0	368	10
	Summer #1	0	0	0	0	0	0
	Winter #2	97 804	254	0.38	2.1	257	7.3
	Summer #2	0	0	0	0	0	0
	Winter #3	122 858	320	0.48	2.7	323	9.1
	Summer #3	0	0	0	0	0	0
	Winter #4	65 989	172	0.26	1.4	173	4.9
	Summer #4	0	0	0	0	0	0
	Winter #5	74 437	194	0.29	1.6	195	5.5
	Summer #5	0	0	0	0	0	0
TOTAL	501 164	1 303	2.0	11	1 316	37	
Air Travel	Winter #1	2 347	6.0	0.0012	0.044	6.1	0
	Summer #1	17 008	44	0.0086	0.32	44	0
	Winter #2	5 969	15	0.0030	0.11	15	0
	Summer #2	15 336	39	0.0077	0.29	40	0
	Winter #3	5 030	13	0.0025	0.095	13	0
	Summer #3	41 085	105	0.021	0.77	106	0
	Winter #4	3 219	8.2	0.0016	0.061	8.3	0
	Summer #4	6 573	17	0.0033	0.12	17	0
	Winter #5	2 549	6.5	0.0013	0.048	6.6	0
	Summer #5	8 490	22	0.0043	0.16	22	0
TOTAL	107 607	275	0.054	2.0	278	0	
Living Biomass Clearing	Winter #1	0	0	968	428	1 396	9 610
	Summer #1	0	0	0	0	0	0
	Winter #2	0	0	958	424	1 382	9 517
	Summer #2	0	0	0	0	0	0
	Winter #3	0	0	0	0	0	0
	Summer #3	0	0	0	0	0	0
	Winter #4	0	0	0	0	0	0
	Summer #4	0	0	0	0	0	0
	Winter #5	0	0	0	0	0	0
	Summer #5	0	0	0	0	0	0
TOTAL	0	0	1 926	852	2 778	19 127	
DOM Clearing	Winter #1	0	0	2 034	900	2 934	17 982
	Summer #1	0	0	0	0	0	0
	Winter #2	0	0	2 179	964	3 143	19 262
	Summer #2	0	0	0	0	0	0
	Winter #3	0	0	0	0	0	0
	Summer #3	0	0	0	0	0	0
	Winter #4	0	0	0	0	0	0
	Summer #4	0	0	0	0	0	0
	Winter #5	0	0	0	0	0	0
	Summer #5	0	0	0	0	0	0
TOTAL	0	0	4 213	1 864	6 078	37 244	
GRAND TOTAL		43 163	6 189	3 140	52 493	57 604	
RELATIVE UNCERTAINTY (%)						48%	49%

GHG emissions during the operation phase

Emissions Category	Phase	Total Fuel Usage (L)	Estimated GHG Emissions (t CO ₂ e)				
			CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Traffic on the road	Annually	2 064 857	4 430	15	71	4 517	170
Road Maintenance (trucks)	Annually	114 597	298	0.45	2.5	301	8.5
Road Maintenance (mobile)	Annually	155 485	404	0.32	5.1	410	12
Road Maintenance (stationary combustion)	Annually	1 465 931	3 812	3.2	8.5	3 824	109
Land-Use Change (mineral soil)	Annually	0	0	0	0	0	1 338
Land-Use Change (living biomass)	Annually	0	0	0	0	0	458
Land-Use Change (peatlands)	Annually	0	0	-62	0	-125	203
GRAND TOTAL			8 945	-43	88	8 927	2 297
RELATIVE UNCERTAINTY (%)						52%	67%

Level of Uncertainty Ratings

Level	Assigned value	General description
Very low	5%	Specific value that is not expected to change (i.e., emission factors).
Low	15%	Selection of a standard value(s) for which few uncertainties (bias) are expected.
Low-medium	25%	Selection of a value(s) expected to represent actual project conditions given that the potential range of values remains fairly limited.
Medium	40%	Selection of a value(s) that can be considered as typical but can also be as high as the double or as low of the half depending on the actual conditions in place.
Medium-high	70%	Selection of a value(s) based on a project-related assessment, but that can largely vary in reality depending on the actual conditions in place.
High	100%	Selection of a value(s) based on a professional judgement from available indications, but that can largely vary in reality depending on the actual conditions in place.
Very high	250%	Cases for which there are no indications helping in the selection of value(s) which are only based on a professional judgement (for which a 200% uncertainty is set).

Uncertainty Analysis per Emission Source Category - Construction Phase

Source	Calculation Variable	Uncertainty (%)		Rationale
		Level	Assigned value (%)	
Mobile Land Equipment	Equipment usage (hours in activity)	Medium	40%	This input was inferred based on the planning and calendar from Sigfusson as part of their high-level cost analysis for the construction project. It attributes a number of months of use per equipment type per activity and a typical monthly usage rate (i.e., 300 h/month). Although it gives a good idea about the equipment requirements based a sound planning for the project at hand, a medium level of uncertainty remains considering that the Sigfusson report was not intended to be the final construction plan that may change according to contractors and further circumstances.
	Engine power usage (kW)	High	100%	The engine power usage for each hour of operation is based on the rated power of suggested models by Sigfusson (subject to changes in reality) and the default engine load factor suggested by the US EPA. Given that the rated power of a certain category of equipment (i.e., large dozer) can easily vary by 50-100 hp depending on the model and that the actual engine load factor can also largely vary depending on the workload and type of use, high uncertainties are associated with this input.
	Fuel consumption rate (L/kWh)	Low-Medium	25%	Although the consumption rates from a recognized source (US EPA) can be considered as representative for compression-ignition engines, they only represent typical values that do not take into consideration the engine model, age, and technologies in place.
	GHG emission factors	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			111%
Stationary Fuel Combustion	Equipment usage (hours in activity)	Medium	40%	Refer to Mobile Land Equipment
	Engine power usage (kW)	High	100%	Refer to Mobile Land Equipment
	Fuel consumption rate (L/kWh)	Low-Medium	25%	Refer to Mobile Land Equipment
	GHG emission factors	Very low	5%	Refer to Mobile Land Equipment
	TOTAL			111%
Crew vehicles	Number of vehicles on site	Medium	40%	The number of vehicles available for workers commuting on site is based on Sigfusson's report and probable experience (15-30 vehicles depending on the project phase). This input can be seen as representative but will evolve when the construction work plan will be refined.
	Total distance travelled per vehicle (km)	Medium-high	70%	This input was broadly estimated based on the main camp site location and the WSR section where work would be ongoing (which extent can be very large compared for example to a single destination). The estimates are therefore considered largely uncertain.
	Fuel consumption rate (L/km)	Low	15%	This input is based on reported data by NRCan for the make and model specified in Sigfusson's report. The weighted average fuel consumption rate approaches 14 L/100 km and should be representative of the reality within ± 2 L/100 km in average.
	GHG emission factors	Very low	5%	The applied emission factors for diesel fuel and gasoline combustion come from a recognized source.
	TOTAL			82%

Heavy-duty transport trucks	Total amount of material to be hauled (m ³ or m ²)	Low-medium	25%	The volume of aggregates, filling materials, geotextiles, and geogrids were extracted from Sigfusson's report which should represent relatively well the actual needs for the road based on current design considerations.
	Truck payloads per trip (m ³ or m ²)	Low-medium	25%	The applied payload for aggregates is 10 m ³ (± 20 t). Variations are to be expected but it should normally remain within 25% of this value when taking the average for all trips.
	Distance travelled per trip (km)	Medium	40%	Information is available in Sigfusson's report to attribute distances per trip based on origin (quarries, Webequie) and destination (section of the WSR). That said, given the length of the WSR (100+ km), accurate distances are difficult to obtain without a refined construction work plan.
	Fuel consumption rate (L/km)	Low-medium	25%	Unlike crew vehicles, the fuel efficiency for heavy-duty trucks can vary more widely depending on many factors including payload. The average fuel consumption rate is however expected to range between 0.3 and 0.5 L/km (vs. the applied rate of 0.392 L/km).
	GHG emission factors	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			59%
Land mobilization and demobilization	Number of trucks on winter road	Medium-high	70%	This input was inferred from the list of equipment and material mobilized on site according to Sigfusson's report while considering general hypotheses (1 truck per machine; 20 m ³ fuel tankers, etc.). It adds to the uncertainties associated with the projections in equipment and material requirements from Sigfusson's assessment.
	Total distance travelled per trip	Very low	5%	As part of this assessment, only the route linking Pickle Lake to Webequie via the winter road is considered which distance is known. Although the material and equipment will come from further away, it is impossible at this stage to establish even ballpark figures for mobilization emissions inbound Pickle Lake (or vice versa) since the contractor(s) may come from all regions of Ontario or Canada. Mobilization / demobilization outside Pickle Lake was therefore excluded from this assessment.
	Fuel consumption rate (L/km)	Low-medium	25%	Refer to Heavy-duty Transportation Trucks
	GHG emissions factor (g/L)	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			75%
Air Travel	Total number of workers traveling by air (psg)	High	100%	Many assumptions were considered to establish a total number of passengers over the course of the project, although they were based on indications from Sigfusson's report about the expected required workforce at each stage of the project.
	Distance travelled per trip (km)	Very high	250%	The most likely origin of workers is set to be Winnipeg, even though the workers will most likely come from multiple regions.
	Fuel consumption rate (L/psg-km)	Medium	40%	The fuel consumption rates for airplanes and helicopters were inferred from a recognized source of information with regard to GHG emissions assessment. Many factors can however impact fuel consumption from this mode of transportation resulting in a medium level of uncertainty.
	GHG emissions factor (g/L)	Very low	5%	The applied emission factors for kerosene combustion come from a recognized source.
	TOTAL			272%
Living Biomass Clearing	Treed area to be cleared (ha)	Low	15%	The expected area to be cleared of trees is based on the current location of WSR and its ancillary infrastructures (work camps, quarries) and the presence of above-ground vegetation (or not) at these locations according to a project-related survey.
	Total living biomass density (t dry/ha) (including above-ground and below-ground)	Low-medium	25%	The above-ground biomass densities were selected from photo plot assessments available in NFI's database at locations in and around the WSR location while removing a portion as standing dead trees. The resulting total above-ground densities of 76 t dry/ha for cleared areas in the upland sector of the WSR (Boreal Shield) and 22 t dry/ha for cleared areas in the lowland sector (Hudson Plains) lies within 25% of the average densities for each of these ecozones according to NFI's latest statistical summary. It depicts the Boreal Shield to contain 68 t dry/ha in average (8,844 million tonnes of biomass (dry basis) over 129,712,000 ha of treed land) and the Hudson Plains to contain 16 t dry/ha in average (295 million tonnes over 18,886,000 ha in treed land). It is worth noting that the default value from the IPCC guidelines (2019) for natural boreal forests in North America is 63 t dry/ha. A single below-ground biomass ratio of 0.25 was applied for all cleared areas inferred from results of a study analysing the carbon stock in boreal forests in Canada (Kurtz et al., 2013). This value is within range of default values provided by the IPCC (0.24 – 0.39) depending on the boreal forest type.
	GHG emissions factor (g/L)	Very low	5%	The applied CH ₄ and N ₂ O emission factors for biomass combustion and biogenic CO ₂ emission factor relevant to carbon stock removal comes from a recognized source.
	TOTAL			30%

DOM Clearing	Treed area to be cleared (ha)	Low-medium	25%	Refer to Living Biomass Clearing. The uncertainty is however increased by 10% on the account that some DOM may also be present in the areas that do not require any tree clearing.
	Total DOM density (t dry/ha)	Medium-high	70%	Total DOM comes from forest floor litter and deadwood (both standing and lying). The litter density (57 t C/ha) was inferred from a study analyzing litter content in black spruce dominated boreal forests in eastern Canada (Soucemanadin et al., 2015) which is the case for the WSR area. Their study however showed high variability depending on the sampled plot (30 – 85 t C/ha). The selected litter density is 25% greater than the density developed by Kurtz et al. (2013) for all Canadian ecozones with boreal forests (47 t C/ha) containing black spruces but also other coniferous and broad-leaved trees that generate less litter. The default value from the IPCC guidelines (2019) for boreal coniferous forests is 40 t C/ha. The total deadwood density was calibrated based on the resulting deadwood-to-living biomass ratio of 0.5 (or 33% of total biomass is considered to be deadwood) from Kurtz et al. study, therefore resulting in 30 t C/ha for the upland section of the WSR (Boreal Shield) and 6 t C/ha for the lowland section (Hudson Plains). The main source of deadwood therefore comes from the Boreal Shield sector for which the IPCC guidelines (2019) suggest a default value of 22 t C/ha for coniferous boreal forests. All put together, the level of uncertainty for total DOM density is designated as medium-high given the expected variability of DOM depending on location.
	GHG emissions factor (g/L)	Very low	5%	Refer to Living Biomass Clearing
	TOTAL		74%	

Uncertainty Analysis per Emission Source Category - Operation Phase

Source	Calculation Variable	Uncertainty (%)		Rationale
		Level	Assigned value (%)	
Road Traffic	Daily traffic (vehicles per day)	Medium	40%	For this assessment, the daily traffic was fixed constant at 250 passages when the maximum is expected to be 500. The daily traffic will probably be lower at the beginning but increase when and if mining exploration and/or production happens near the McFaulds Lake. This variability results into a medium uncertainty rating for that input.
	Distance per vehicle (km)	Low	15%	The applied distance per trip corresponds to the length of the WSR from Webequie to McFaulds Lake which is also the area where the NRL road will link with the WSR for commuters coming from the south. There would be few other final destinations along the WSR implying that each vehicle would solely travel from Webequie to the eastern end of the WSR.
	Fuel consumption rate (L/km)	Low-Medium	25%	This input is based on the following vehicle distribution: 25% of heavy-duty trucks with varying fuel economies and 75% of light-duty vehicles with more constant fuel economies. Given that this distribution could be somewhat different in reality, a low-medium uncertainty rating is considered for this input.
	GHG emission factors	Very low	5%	The applied emission factors for diesel fuel and gasoline combustion come from a recognized source.
	TOTAL			50%
Road Maintenance (Trucks)	Annual traffic (passages per year)	High	100%	Annual requirements in terms of snow plowing, road watering and aggregates hauling were judged based on some indications although indirect in some cases (i.e., projected number of dry days and snow days). High uncertainty is associated with this input.
	Distance per truck (km)	Low-medium	25%	For snow plowing and road watering, the full WSR length was considered while the ARA-4 quarry location was considering with respect to aggregates hauling resulting into a low-to-medium uncertainty rating.
	Fuel consumption rate (L/km)	Low-medium	25%	The fuel efficiency for snow plowing trucks, water trucks and dump trucks varies widely because their use is different. Specific fuel consumption rates were applied for each of them based on professional judgement with an expected uncertainty level of 25%.
	GHG emissions factor (g/L)	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			106%
Road Maintenance (Mobile Equipment)	Equipment usage (hours in activity)	High	100%	Mobile equipment will be used during aggregates production at the quarry and for road maintenance. For aggregates, a total of 26,750 m ³ is to be produced annually while equipment usage rate is inferred from Sigfusson's report. As for road maintenance, the list of equipment and their requirements is estimated based on best judgement with very high level of uncertainty (i.e., 250%). When put altogether, a high uncertainty rating is obtained.
	Engine power usage (kW)	High	100%	Refer to Mobile Land Equipment
	Fuel consumption rate (L/kWh)	Low-medium	25%	Refer to Mobile Land Equipment
	GHG emission factors (g/L)	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			144%

Road Maintenance (Stationary Fuel Combustion)	Equipment usage (hours per year)	Low	15%	The crusher power unit (535 hours to produced 26,750 m3 of aggregates) and the MSF generator set (expected to be operated all year long to power the facility) are based on expected requirements.
	Engine power usage (kW)	High	100%	While the crusher power unit is based on Sigfusson's report, the rating of MSF generator set was solely based on expected building surface area and an energy benchmark value for Canadian warehouses which can involve high inaccuracies given that the MSF design is still unknown at this stage.
	Fuel consumption rate (L/kWh)	Low-medium	25%	Refer to Mobile Land Equipment
	GHG emission factors (g/L)	Very low	5%	The applied emission factors for diesel fuel combustion come from a recognized source.
	TOTAL			104%
Land-Use Change (Mineral Soil)	Disturbed soil volume (m3)	Medium	40%	The volume of topsoil stripped along the WSR, the construction camps and quarries were estimated based on known lateral dimensions and an expected stripping depth of 0.5 m which can somewhat vary depending on site conditions (at probably ± 25% and more). The volume of soil excavated during ditching was also estimated by Sigfusson using a rule of thumb approach.
	SOC content (t C/m ³)	High	100%	The carbon content in mineral soil was inferred from results of a study relative to unfrozen boreal forests. Although it can be representative of conditions on site, high uncertainties should be expected as it also depends on the type of soil and past environmental conditions. For example, the IPCC guidelines suggest default values that are highly different for North American boreal forests depending on the type of soil. Without specific measurements as hand, high uncertainty level is considered for this input.
	Annual carbon release as CO ₂ (t C/a)	Very low	5%	The use of 1 % release per year is suggested by ECCC SACC, hence the minimal uncertainty level applied. In reality, it can vary a lot as it depends on how the soil will be placed and the oxidizing conditions in place.
	TOTAL			108%
Land-Use Change (net living biomass carbon accumulation loss)	Total living biomass to be cleared (t dry)	Low-medium	25%	Refer to Living Biomass Clearing
	Age class distribution (%)	Low-medium	25%	The age class distribution is based on the average in the Boreal Shield (upland area) and Hudson Plains (lowland area) published by the NFI. Although variations occur from site to site, it is expected to be more or less representative of the actual distribution along the WSR.
	Biomass growth rate per age class (%/a)	High	100%	A growth rate curve that was developed for black spruces in the past was applied. Although dominant, it is not the only species and there are many other factors affecting growth rendering this estimation highly uncertain.
	Carbon content of dry wood (t C/t dry)	Very low	5%	The carbon content in softwood (black spruce) shows normally very little variations from site to site.
	TOTAL			106%
Land-Use Change (peatlands net GHG emissions)	Total peatland disturbed area (m2)	Low-medium	25%	No surveys are available specifically for the WSR corridor that will be directly impacted by the project and so, the area was simply inferred from the length of the road crossing the peatland area and an expected disturbance width of 15 m. This estimation is considered a quasi-maximum as it may be a little bit higher but can certainly be much lower.
	Peatland category distribution	Low	15%	Not specific to the WSR corridor but to the LSA. There may be local variations between the LSA and the WSR corridor itself.
	Specific net CH4 and CO2 emission fluxes per category (g/m2/a)	Medium-high	70%	Webster et al. (2018) study from which the net CH4 and CO2 emission fluxes were extracted also report large variations in measurements between studies for the same ecozone, meaning that this parameter is highly dependent of site conditions. For example, an uncertainty level of about ±50% is obtained based on (limited) reported values for the Hudson Plains in their study.
	TOTAL			76%

GHG emissions during the construction phase - Mobile land equipment

Applicable emission factors (in g/L) - National Inventory Report (NIR) 1990:2021 (Annex A6.1.6)

Category	CO ₂ [1]	CH ₄	N ₂ O [2]	CO ₂ bio [1]
	1	28	265	1
Off-road diesel > 19 kW (all tiers)	2 601	0.073	0.12	74

[1] It is assumed that the overall stock of diesel used on site will contain 3% of biodiesel on average. The CO₂ emission factor is therefore multiplied by 0.97. In return, the biogenic CO₂ emission factor for biodiesel is multiplied by 0.03.

[2] It is assumed that half of mobile equipment will run with Tier 4 engines and the other half with Tier 1-3 engines. The emission factors from the NIR for both cases are averaged.

Applicable fuel consumption rate (in L/hp-h) - US EPA Non-Road Model in MOVES3.0.2 (2021)

Category	L/hp-hr [1]
Engines with rated power < 100 hp	0.216
Engines with rated power > 100 hp	0.194

[1] The base values taken from US EPA (2021) were converted in L/hp-hr considering a fuel density of 0.86 kg/L and were adjusted for biodiesel content assuming that B100 has about 8% less energy content than diesel, thus requiring more in the engine (NRCAN (2022)).

Mobile Land Equipment List (from Sigfusson budgetary cost estimate)

[1] Based on data and calendar by provided in Sigfusson report per phase for the number of months and the average usage per month when available. Otherwise, assumptions were made.

[2] Based on the equipment model specified by Sigfusson or an hypothesis otherwise.

Phase	Mobile equipment		Number on site	Main activity	Expected usage [1]		Engine [2]		Fuel usage rate (L/hp-h)	Total GHG Emissions (t CO ₂ e)				
	Description	Type			Months	hr/month	Rated power (hp)	Avg load (%)		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	300 size excavator (CAT 329)	Excavator	2	Clearing / grubbing	2	300	202	59%	0.194	72	0.057	0.9	73	2.1
Winter #1	400 size excavator (CAT 350)	Excavator	2	Clearing / grubbing	2	300	413	59%	0.194	148	0.116	1.9	150	4.2
Winter #1	650/D5K size dozer LGP (CAT D5K)	Crawler dozer	2	Clearing / grubbing	2	200	100	59%	0.194	24	0.019	0.3	24	0.7
Winter #1	850/D6R size dozer	Crawler dozer	6	Clearing / grubbing	2	200	179	59%	0.194	128	0.101	1.6	130	3.6
Winter #1	CAT 140 Grader	Grader	1	Preparation work	2	300	250	59%	0.194	45	0.035	0.6	45	1.3
Winter #1	CAT TH 83 zoom boom	Forklift (industrial and rough)	1	Preparation work	2	200	105	59%	0.194	13	0.010	0.2	13	0.4
Winter #1	CAT D7 size dozer	Crawler dozer	4	Clearing / grubbing	2	200	265	59%	0.194	126	0.099	1.6	128	3.6
Winter #1	CAT D8 size dozer	Crawler dozer	2	Clearing / grubbing	2	200	354	59%	0.194	84	0.066	1.1	85	2.4
Winter #1	Off-road service trucks	Off-highway truck	6	Crew support	3	60	430	59%	0.194	138	0.109	1.8	140	3.9
Winter #1	Feller Buncher (JD 843L)	Forest logging equipment	3	Clearing / grubbing	2	300	270	59%	0.194	145	0.114	1.8	147	4.1
Winter #1	Skidder (JD 648 L)	Forest logging equipment	3	Clearing / grubbing	2	300	237	59%	0.194	127	0.100	1.6	129	3.6
Summer #1	200 size excavator (CAT 316)	Excavator	1	Ditching	7	300	105	59%	0.194	66	0.052	0.8	67	1.9
Summer #1	220 size excavator (CAT 325)	Excavator	1	Geotextile installation	6	300	172	59%	0.194	92	0.072	1.2	93	2.6
Summer #1	300 size excavator (CAT 329)	Excavator	1	Grading / stripping	4	300	202	59%	0.194	72	0.057	0.9	73	2.1
Summer #1	300 size excavator (CAT 329)	Excavator	1	Aggregate production	9	300	202	59%	0.194	162	0.128	2.1	165	4.6
Summer #1	400 size excavator (CAT 350)	Excavator	1	Culvert installation	2	200	413	59%	0.194	49	0.039	0.6	50	1.4
Summer #1	650/D5K size dozer LGP (CAT D5K)	Crawler dozer	1	Ditching	7	300	100	59%	0.194	63	0.049	0.8	63	1.8
Summer #1	750/D6N size dozer (CAT D6)	Crawler dozer	2	Grading / stripping	4	200	215	59%	0.194	102	0.080	1.3	104	2.9
Summer #1	80 ton rough terrain crane	Crane	1	Bridge construction	10	60	164	43%	0.194	21	0.017	0.3	22	0.6
Summer #1	80 ton rough terrain crane	Crane	1	Culvert installation	2	60	164	43%	0.194	4	0.003	0.1	4	0.1
Summer #1	850/D6R size dozer	Crawler dozer	5	Aggregate placement	4	350	179	59%	0.194	373	0.293	4.7	378	10.6
Summer #1	950 size loader (CAT 950)	Rubber tire loader	1	Culvert installation	2	200	225	59%	0.194	27	0.021	0.3	27	0.8
Summer #1	966 size loader (CAT 966)	Rubber tire loader	1	Culvert installation	2	200	321	59%	0.194	38	0.030	0.5	39	1.1
Summer #1	980 size loader (CAT 980)	Rubber tire loader	1	Aggregate production	9	300	393	59%	0.194	316	0.248	4.0	320	9.0
Summer #1	988 size loader (CAT 988)	Rubber tire loader	1	Aggregate production	9	300	541	59%	0.194	435	0.342	5.5	441	12.4
Summer #1	CAT 140 Grader	Grader	2	Aggregate placement	4	300	250	59%	0.194	179	0.140	2.3	181	5.1
Summer #1	CAT TH 83 zoom boom	Forklift (industrial and rough)	1	Bridge construction	10	60	105	59%	0.194	19	0.015	0.2	19	0.5
Summer #1	CAT D8 size dozer	Crawler dozer	2	Aggregate placement	4	300	354	59%	0.194	253	0.199	3.2	256	7.2
Summer #1	Furukawa HCR900 drill	Bore/drill rig	2	Aggregate production	6	300	225	43%	0.194	176	0.138	2.2	178	5.0
Summer #1	IR SD150 Smoothdrum/padfoot	Roller	3	Aggregate placement	4	300	185	59%	0.194	198	0.156	2.5	201	5.7
Summer #1	Seeding tractor (JD8760)	Tractor / loader / backhoe	1	Ditching	7	300	240	21%	0.194	53	0.042	0.7	54	1.5
Summer #1	SCISSOR LIFT 35' Rough Terrain	Aerial lift	2	Aggregate production	9	60	150	21%	0.194	17	0.013	0.2	17	0.5

Summer #1	Polaris site ranger	Off-highway truck	3	Crew support	8	30	45	59%	0.216	11	0.008	0.1	11	0.3
Summer #1	Off-road service trucks	Off-highway truck	10	Crew support	8	60	430	59%	0.194	614	0.483	7.8	623	17.5
Winter #2	200 size excavator (CAT 316)	Excavator	1	Culvert installation	2	300	105	59%	0.194	19	0.015	0.2	19	0.5
Winter #2	300 size excavator (CAT 329)	Excavator	1	Preparation work	1	300	202	59%	0.194	18	0.014	0.2	18	0.5
Winter #2	400 size excavator (CAT 350)	Excavator	1	Culvert installation	2	300	413	59%	0.194	74	0.058	0.9	75	2.1
Winter #2	650/D5K size dozer LGP (CAT D5K)	Crawler dozer	1	Clearing / grubbing	2	300	100	59%	0.194	18	0.014	0.2	18	0.5
Winter #2	750/D6N size dozer (CAT D6)	Crawler dozer	1	Clearing / grubbing	2	300	215	59%	0.194	38	0.030	0.5	39	1.1
Winter #2	80 ton rough terrain crane	Crane	1	Culvert installation	2	60	164	43%	0.194	4	0.003	0.1	4	0.1
Winter #2	850/D6R size dozer	Crawler dozer	2	Clearing / grubbing	2	300	179	59%	0.194	64	0.050	0.8	65	1.8
Winter #2	950 size loader (CAT 950)	Rubber tire loader	1	Culvert installation	2	300	225	59%	0.194	40	0.032	0.5	41	1.1
Winter #2	966 size loader (CAT 966)	Rubber tire loader	1	Culvert installation	2	300	321	59%	0.194	57	0.045	0.7	58	1.6
Winter #2	980 size loader (CAT 980)	Rubber tire loader	4	Aggregate production	3	350	393	59%	0.194	491	0.386	6.2	498	14.0
Winter #2	988 size loader (CAT 988)	Rubber tire loader	4	Aggregate production	3	350	541	59%	0.194	676	0.532	8.6	686	19.3
Winter #2	CAT 140 Grader	Grader	2	Preparation work	1	300	250	59%	0.194	45	0.035	0.6	45	1.3
Winter #2	CAT TH 83 zoom boom	Forklift (industrial and rough)	1	Preparation work	1	200	105	59%	0.194	6	0.005	0.1	6	0.2
Winter #2	CAT D7 size dozer	Crawler dozer	1	Clearing / grubbing	2	300	265	59%	0.194	47	0.037	0.6	48	1.3
Winter #2	IR SD100 Smoothdrum/padfoot	Roller	1	Preparation work	1	300	125	59%	0.194	11	0.009	0.1	11	0.3
Winter #2	SCISSOR LIFT 35' Rough Terrain	Aerial lift	2	Aggregate production	3	60	150	21%	0.194	6	0.004	0.1	6	0.2
Winter #2	Off-road service trucks	Off-highway truck	6	Crew support	4	60	430	59%	0.194	184	0.145	2.3	187	5.3
Summer #2	200 size excavator (CAT 316)	Excavator	1	Ditching	1	300	105	59%	0.194	9	0.007	0.1	10	0.3
Summer #2	220 size excavator (CAT 325)	Excavator	2	Geotextile installation	3	300	172	59%	0.194	92	0.072	1.2	93	2.6
Summer #2	300 size excavator (CAT 329)	Excavator	2	Grading / stripping	2	300	202	59%	0.194	72	0.057	0.9	73	2.1
Summer #2	300 size excavator (CAT 329)	Excavator	1	Aggregate production	7	300	202	59%	0.194	126	0.099	1.6	128	3.6
Summer #2	400 size excavator (CAT 350)	Excavator	1	Aggregate placement	8	300	413	59%	0.194	295	0.232	3.7	299	8.4
Summer #2	650/D5K size dozer LGP (CAT D5K)	Crawler dozer	1	Ditching	1	300	100	59%	0.194	9	0.007	0.1	9	0.3
Summer #2	750/D6N size dozer (CAT D6)	Crawler dozer	2	Grading / stripping	2	300	215	59%	0.194	77	0.060	1.0	78	2.2
Summer #2	80 ton rough terrain crane	Crane	2	Bridge construction	8	300	164	43%	0.194	171	0.134	2.2	173	4.9
Summer #2	850/D6R size dozer	Crawler dozer	4	Aggregate placement	8	350	179	59%	0.194	597	0.469	7.6	605	17.0
Summer #2	950 size loader (CAT 950)	Rubber tire loader	1	Aggregate placement	8	300	225	59%	0.194	161	0.126	2.0	163	4.6
Summer #2	966 size loader (CAT 966)	Rubber tire loader	1	Aggregate placement	8	300	321	59%	0.194	229	0.180	2.9	232	6.5
Summer #2	CAT 140 Grader	Grader	1	Aggregate placement	8	300	250	59%	0.194	179	0.140	2.3	181	5.1
Summer #2	CAT 14G Grader	Grader	1	Grading / stripping	2	300	180	59%	0.194	32	0.025	0.4	33	0.9
Summer #2	CAT TH 83 zoom boom	Forklift (industrial and rough)	1	Bridge construction	8	60	105	59%	0.194	15	0.012	0.2	15	0.4
Summer #2	CAT D8 size dozer	Crawler dozer	1	Aggregate placement	8	300	354	59%	0.194	253	0.199	3.2	256	7.2
Summer #2	IR SD150 Smoothdrum/padfoot	Roller	2	Aggregate placement	8	350	185	59%	0.194	308	0.242	3.9	313	8.8
Summer #2	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	7	60	150	21%	0.194	7	0.005	0.1	7	0.2
Summer #2	Polaris site ranger	Off-highway truck	3	Crew support	8	30	45	59%	0.216	11	0.008	0.1	11	0.3
Summer #2	Off-road service trucks	Off-highway truck	10	Crew support	8	60	430	59%	0.194	614	0.483	7.8	623	17.5
Summer #2	980 size loader (CAT 980)	Rubber tire loader	1	Aggregate production	7	350	393	59%	0.194	287	0.225	3.6	291	8.2
Summer #2	988 size loader (CAT 988)	Rubber tire loader	1	Aggregate production	7	350	541	59%	0.194	395	0.310	5.0	400	11.3
Winter #3	200 size excavator (CAT 316)	Excavator	1	Culvert installation	1	300	105	59%	0.194	9	0.007	0.1	10	0.3
Winter #3	220 size excavator (CAT 325)	Excavator	1	Aggregate placement	5	300	172	59%	0.194	77	0.060	1.0	78	2.2
Winter #3	300 size excavator (CAT 329)	Excavator	1	Aggregate production	7	300	202	59%	0.194	126	0.099	1.6	128	3.6
Winter #3	400 size excavator (CAT 350)	Excavator	1	Culvert installation	1	300	413	59%	0.194	37	0.029	0.5	37	1.1
Winter #3	80 ton rough terrain crane	Crane	2	Culvert installation	1	300	164	43%	0.194	21	0.017	0.3	22	0.6
Winter #3	850/D6R size dozer	Crawler dozer	1	Aggregate placement	5	300	179	59%	0.194	80	0.063	1.0	81	2.3
Winter #3	950 size loader (CAT 950)	Rubber tire loader	1	Culvert installation	1	300	225	59%	0.194	20	0.016	0.3	20	0.6
Winter #3	966 size loader (CAT 966)	Rubber tire loader	1	Culvert installation	1	300	321	59%	0.194	29	0.023	0.4	29	0.8
Winter #3	CAT 140 Grader	Grader	1	Aggregate placement	5	300	250	59%	0.194	112	0.088	1.4	113	3.2
Winter #3	CAT TH 83 zoom boom	Forklift (industrial and rough)	1	Preparation work	1	200	105	59%	0.194	6	0.005	0.1	6	0.2
Winter #3	CAT D8 size dozer	Crawler dozer	1	Aggregate placement	5	300	354	59%	0.194	158	0.124	2.0	160	4.5
Winter #3	IR SD150 Smoothdrum/padfoot	Roller	1	Aggregate placement	5	300	185	59%	0.194	83	0.065	1.0	84	2.4
Winter #3	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	7	60	150	21%	0.194	7	0.005	0.1	7	0.2
Winter #3	Polaris site ranger	Off-highway truck	3	Crew support	4	30	45	59%	0.216	5	0.004	0.1	5	0.2
Winter #3	Off-road service trucks	Off-highway truck	6	Crew support	4	60	430	59%	0.194	184	0.145	2.3	187	5.3
Winter #3	980 size loader (CAT 980)	Rubber tire loader	1	Aggregate production	7	350	393	59%	0.194	287	0.225	3.6	291	8.2

Winter #3	988 size loader (CAT 988)	Rubber tire loader	1	Aggregate production	7	350	541	59%	0.194	395	0.310	5.0	400	11.3
Summer #3	200 size excavator (CAT 316)	Excavator	1	Culvert installation	1	300	105	59%	0.194	9	0.007	0.1	10	0.3
Summer #3	220 size excavator (CAT 325)	Excavator	2	Geotextile installation	6	300	172	59%	0.194	184	0.145	2.3	187	5.3
Summer #3	300 size excavator (CAT 329)	Excavator	2	Aggregate production	4	300	202	59%	0.194	144	0.113	1.8	146	4.1
Summer #3	400 size excavator (CAT 350)	Excavator	1	Culvert installation	1	300	413	59%	0.194	37	0.029	0.5	37	1.1
Summer #3	80 ton rough terrain crane	Crane	1	Bridge construction	6	60	164	43%	0.194	13	0.010	0.2	13	0.4
Summer #3	80 ton rough terrain crane	Crane	1	Culvert installation	1	60	164	43%	0.194	2	0.002	0.0	2	0.1
Summer #3	850/D6R size dozer	Crawler dozer	4	Aggregate placement	6	300	179	59%	0.194	384	0.302	4.9	389	10.9
Summer #3	950 size loader (CAT 950)	Rubber tire loader	1	Culvert installation	1	200	225	59%	0.194	13	0.011	0.2	14	0.4
Summer #3	966 size loader (CAT 966)	Rubber tire loader	1	Culvert installation	1	200	321	59%	0.194	19	0.015	0.2	19	0.5
Summer #3	CAT 140 Grader	Grader	2	Aggregate placement	6	300	250	59%	0.194	268	0.211	3.4	272	7.6
Summer #3	CAT TH 83 zoom boom	Forklift (industrial and rough	1	Bridge construction	6	60	105	59%	0.194	11	0.009	0.1	11	0.3
Summer #3	IR SD150 Smoothdrum/padfoot	Roller	2	Aggregate placement	6	300	185	59%	0.194	198	0.156	2.5	201	5.7
Summer #3	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	4	60	150	21%	0.194	4	0.003	0.0	4	0.1
Summer #3	Polaris site ranger	Off-highway truck	3	Crew support	8	30	45	59%	0.216	11	0.008	0.1	11	0.3
Summer #3	Off-road service trucks	Off-highway truck	10	Crew support	8	60	430	59%	0.194	614	0.483	7.8	623	17.5
Summer #3	Tandem water trucks	Off-highway truck	3	Aggregate placement	6	300	325	59%	0.194	522	0.411	6.6	530	14.9
Summer #3	980 size loader (CAT 980)	Rubber tire loader	1	Aggregate production	4	350	393	59%	0.194	164	0.129	2.1	166	4.7
Summer #3	988 size loader (CAT 988)	Rubber tire loader	1	Aggregate production	4	350	541	59%	0.194	225	0.177	2.9	229	6.4
Winter #4	300 size excavator (CAT 329)	Excavator	2	Aggregate production	6	300	202	59%	0.194	216	0.170	2.7	219	6.2
Winter #4	850/D6R size dozer	Crawler dozer	2	Aggregate placement	6	300	179	59%	0.194	192	0.151	2.4	194	5.5
Winter #4	CAT 140 Grader	Grader	2	Aggregate placement	6	300	250	59%	0.194	268	0.211	3.4	272	7.6
Winter #4	IR SD150 Smoothdrum/padfoot	Roller	2	Aggregate placement	6	300	185	59%	0.194	198	0.156	2.5	201	5.7
Winter #4	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	6	60	150	21%	0.194	6	0.004	0.1	6	0.2
Winter #4	Polaris site ranger	Off-highway truck	3	Crew support	4	30	45	59%	0.216	5	0.004	0.1	5	0.2
Winter #4	Off-road service trucks	Off-highway truck	10	Crew support	4	60	430	59%	0.194	307	0.241	3.9	311	8.8
Summer #4	300 size excavator (CAT 329)	Excavator	1	Aggregate production	6	300	202	59%	0.194	108	0.085	1.4	110	3.1
Summer #4	850/D6R size dozer	Crawler dozer	2	Aggregate placement	6	300	179	59%	0.194	192	0.151	2.4	194	5.5
Summer #4	CAT 140 Grader	Grader	2	Aggregate placement	6	300	250	59%	0.194	268	0.211	3.4	272	7.6
Summer #4	IR SD150 Smoothdrum/padfoot	Roller	2	Aggregate placement	6	300	185	59%	0.194	198	0.156	2.5	201	5.7
Summer #4	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	6	60	150	21%	0.194	6	0.004	0.1	6	0.2
Summer #4	Polaris site ranger	Off-highway truck	3	Crew support	8	30	45	59%	0.216	11	0.008	0.1	11	0.3
Summer #4	Off-road service trucks	Off-highway truck	10	Crew support	8	60	430	59%	0.194	614	0.483	7.8	623	17.5
Summer #4	Tandem water trucks	Off-highway truck	2	Aggregate placement	6	300	325	59%	0.194	348	0.274	4.4	353	9.9
Winter #5	200 size excavator (CAT 316)	Excavator	1	Culvert installation	1	300	105	59%	0.194	9	0.007	0.1	10	0.3
Winter #5	400 size excavator (CAT 350)	Excavator	1	Culvert installation	1	300	413	59%	0.194	37	0.029	0.5	37	1.1
Winter #5	80 ton rough terrain crane	Crane	2	Culvert installation	1	60	164	43%	0.194	4	0.003	0.1	4	0.1
Winter #5	950 size loader (CAT 950)	Rubber tire loader	1	Culvert installation	1	200	225	59%	0.194	13	0.011	0.2	14	0.4
Winter #5	966 size loader (CAT 966)	Rubber tire loader	1	Culvert installation	1	200	321	59%	0.194	19	0.015	0.2	19	0.5
Winter #5	Polaris site ranger	Off-highway truck	3	Crew support	4	30	45	59%	0.216	5	0.004	0.1	5	0.2
Winter #5	Off-road service trucks	Off-highway truck	10	Crew support	4	60	430	59%	0.194	307	0.241	3.9	311	8.8
Summer #5	200 size excavator (CAT 316)	Excavator	1	Aggregate placement	6	300	105	59%	0.194	56	0.044	0.7	57	1.6
Summer #5	300 size excavator (CAT 329)	Excavator	2	Aggregate production	6	300	202	59%	0.194	216	0.170	2.7	219	6.2
Summer #5	850/D6R size dozer	Crawler dozer	3	Aggregate placement	6	300	179	59%	0.194	288	0.226	3.7	292	8.2
Summer #5	CAT 140 Grader	Grader	2	Aggregate placement	6	300	250	59%	0.194	268	0.211	3.4	272	7.6
Summer #5	IR SD150 Smoothdrum/padfoot	Roller	2	Aggregate placement	6	300	185	59%	0.194	198	0.156	2.5	201	5.7
Summer #5	SCISSOR LIFT 35' Rough Terrain	Aerial lift	1	Aggregate production	6	60	150	21%	0.194	6	0.004	0.1	6	0.2
Summer #5	Polaris site ranger	Off-highway truck	3	Crew support	6	30	45	59%	0.216	8	0.006	0.1	8	0.2
Summer #5	Off-road service trucks	Off-highway truck	10	Crew support	6	60	430	59%	0.194	461	0.362	5.8	467	13.1

GHG emissions during the construction phase - Stationary fuel combustion equipment

Applicable emission factors (in g/L) - National Inventory Report 1990:2021 (Annex A6.1.2)

Category	CO ₂ [1]	CH ₄	N ₂ O	CO ₂ bio [1]
	1	28	265	1
Diesel - Refineries and Others	2 601	0.078	0.022	74

[1] It is assumed that the overall stock of diesel used on site will contain 3% of biodiesel on average. The CO₂ emission factor is therefore multiplied by 0.97. In return, the biogenic CO₂ emission factor for biodiesel is multiplied by 0.03.

Applicable fuel consumption rate (in L/hp-h) - US EPA Non-Road Model in MOVES3.0.2 (2021) and energy balance for heating system

Category	L/hp-hr [1]
Engines with rated power < 100 hp	0.216
Engines with rated power > 100 hp	0.194
Diesel heating system - 80% efficiency	0.088

[1] The base values taken from US EPA (2021) were converted in L/hp-hr considering a fuel density of 0.86 kg/L and were adjusted for biodiesel content assuming that B100 has about 8% less energy content than diesel, thus requiring more in the engine (NRCan (2022)).

Stationary Fuel Combustion Equipment (from Sigfusson budgetary cost estimate)

[1] Based on data and calendar by provided in Sigfusson report per phase for the number of months and the average usage per month when available. Otherwise, assumptions were made.

[2] Based on the equipment model specified by Sigfusson or an hypothesis otherwise.

Phase	Stationary Fuel Combustion Equipment		Number on site [1]	Main activity	Expected usage [1]		Engine [2]		Fuel usage rate (L/hp-h)	Total GHG Emissions (t CO ₂ e)				
	Description	Type			Months	hr/month	Rated power (hp)	Avg load (%)		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	5 kW portable generator	Generator set	1	Crew support	3	200	7	43%	0.216	1	0.001	0.00	1	0.0
Winter #1	50 kW generator	Generator set	7	Crew support	3	300	67	43%	0.216	102	0.086	0.23	102	2.9
Winter #1	Herman Nelson Heater	Heating system	2	Crew support	3	200	153	75%	0.088	32	0.027	0.07	32	0.9
Winter #1	Light Plant	Generator set	5	Crew support	3	90	27	43%	0.216	9	0.007	0.02	9	0.2
Winter #1	Water pumps 3 inch	Generator set	1	Crew support	3	150	10	100%	0.216	3	0.002	0.01	3	0.1
Summer #1	1000 lb plate compactor	Plate compactors	1	Culvert installation	2	200	9	43%	0.216	1	0.001	0.00	1	0.0
Summer #1	5 kW portable generator	Generator set	1	Crew support	8	200	7	43%	0.216	3	0.002	0.01	3	0.1
Summer #1	50 kW generator	Generator set	6	Crew support	8	300	67	43%	0.216	233	0.195	0.52	233	6.6
Summer #1	Crusher power van 600 kW	Crushing equipment	1	Aggregate production	9	350	804	43%	0.194	550	0.461	1.23	551	15.7
Summer #1	Jumping Jack Compactor	Paving equipment	1	Culvert installation	2	90	10	59%	0.216	1	0.001	0.00	1	0.0
Summer #1	Light Plant	Generator set	5	Crew support	8	420	27	43%	0.216	109	0.091	0.24	109	3.1
Summer #1	Water pumps 3 inch	Generator set	4	Crew support	8	150	10	100%	0.216	27	0.023	0.06	27	0.8
Summer #1	Water pumps 6 inch	Generator set	2	Crew support	8	150	25	100%	0.216	34	0.028	0.08	34	1.0
Summer #1	Tria portable concrete batching unit	Generator set	1	Bridge construction	10	120	67	43%	0.216	19	0.016	0.04	19	0.6
Winter #2	1000 lb plate compactor	Plate compactors	1	Culvert installation	2	300	9	43%	0.216	1	0.001	0.00	1	0.0
Winter #2	5 kW portable generator	Generator set	1	Crew support	4	200	7	43%	0.216	1	0.001	0.00	1	0.0
Winter #2	50 kW generator	Generator set	5	Crew support	4	300	67	43%	0.216	97	0.081	0.22	97	2.8
Winter #2	Crusher power van 600 kW	Crushing equipment	2	Aggregate production	3	350	804	43%	0.194	366	0.308	0.82	367	10.4
Winter #2	Herman Nelson Heater	Heating system	5	Crew support	4	300	153	75%	0.088	158	0.133	0.36	159	4.5
Winter #2	Jumping Jack Compactor	Paving equipment	1	Culvert installation	2	90	10	59%	0.216	1	0.001	0.00	1	0.0
Winter #2	Light Plant	Generator set	5	Crew support	4	480	27	43%	0.216	62	0.052	0.14	62	1.8
Winter #2	Water pumps 3 inch	Generator set	2	Crew support	4	150	10	100%	0.216	7	0.006	0.02	7	0.2
Winter #2	Water pumps 6 inch	Generator set	1	Crew support	4	150	25	100%	0.216	8	0.007	0.02	8	0.2
Summer #2	1000 lb plate compactor	Plate compactors	1	Aggregate placement	1	300	9	43%	0.216	1	0.001	0.00	1	0.0
Summer #2	5 kW portable generator	Generator set	1	Crew support	8	200	7	43%	0.216	3	0.002	0.01	3	0.1
Summer #2	50 kW generator	Generator set	4	Crew support	8	300	67	43%	0.216	155	0.130	0.35	156	4.4
Summer #2	Herman Nelson Heater	Heating system	5	Crew support	2	100	153	75%	0.088	26	0.022	0.06	26	0.8
Summer #2	Crusher power van 600 kW	Crushing equipment	1	Aggregate production	7	350	804	43%	0.194	427	0.359	0.96	429	12.2

Summer #2	Jumping Jack Compactor	Paving equipment	1	Aggregate placement	1	90	10	59%	0.216	0	0.000	0.00	0	0.0
Summer #2	Light Plant	Generator set	5	Crew support	8	420	27	43%	0.216	109	0.091	0.24	109	3.1
Summer #2	Water pumps 3 inch	Generator set	4	Crew support	8	150	10	100%	0.216	27	0.023	0.06	27	0.8
Summer #2	Water pumps 6 inch	Generator set	2	Crew support	8	150	25	100%	0.216	34	0.028	0.08	34	1.0
Summer #2	TriA portable concrete batching unit	Generator set	1	Bridge construction	8	120	67	43%	0.216	16	0.013	0.03	16	0.4
Winter #3	1000 lb plate compactor	Plate compactors	1	Culvert installation	1	300	9	43%	0.216	1	0.001	0.00	1	0.0
Winter #3	5 kW portable generator	Generator set	1	Crew support	4	200	7	43%	0.216	1	0.001	0.00	1	0.0
Winter #3	50 kW generator	Generator set	4	Crew support	4	300	67	43%	0.216	78	0.065	0.17	78	2.2
Winter #3	Jumping Jack Compactor	Paving equipment	1	Culvert installation	1	90	10	59%	0.216	0	0.000	0.00	0	0.0
Winter #3	Light Plant	Generator set	5	Crew support	4	480	27	43%	0.216	62	0.052	0.14	62	1.8
Winter #3	Water pumps 3 inch	Generator set	2	Crew support	4	150	10	100%	0.216	7	0.006	0.02	7	0.2
Winter #3	Water pumps 6 inch	Generator set	1	Crew support	4	150	25	100%	0.216	8	0.007	0.02	8	0.2
Winter #3	Crusher power van 600 kW	Crushing equipment	1	Aggregate production	7	350	804	43%	0.194	427	0.359	0.96	429	12.2
Summer #3	1000 lb plate compactor	Plate compactors	1	Culvert installation	1	200	9	43%	0.216	0	0.000	0.00	0	0.0
Summer #3	5 kW portable generator	Generator set	1	Crew support	8	200	7	43%	0.216	3	0.002	0.01	3	0.1
Summer #3	50 kW generator	Generator set	4	Crew support	8	300	67	43%	0.216	155	0.130	0.35	156	4.4
Summer #3	Crusher power van 600 kW	Crushing equipment	1	Aggregate production	4	350	804	43%	0.194	244	0.205	0.55	245	7.0
Summer #3	Jumping Jack Compactor	Paving equipment	1	Culvert installation	1	90	10	59%	0.216	0	0.000	0.00	0	0.0
Summer #3	Light Plant	Generator set	5	Crew support	8	420	27	43%	0.216	109	0.091	0.24	109	3.1
Summer #3	Water pumps 3 inch	Generator set	4	Crew support	8	150	10	100%	0.216	27	0.023	0.06	27	0.8
Summer #3	Water pumps 6 inch	Generator set	2	Crew support	8	150	25	100%	0.216	34	0.028	0.08	34	1.0
Summer #3	TriA portable concrete batching unit	Generator set	1	Bridge construction	6	120	67	43%	0.216	12	0.010	0.03	12	0.3
Winter #4	5 kW portable generator	Generator set	1	Crew support	4	200	7	43%	0.216	1	0.001	0.00	1	0.0
Winter #4	50 kW generator	Generator set	4	Crew support	4	300	67	43%	0.216	78	0.065	0.17	78	2.2
Winter #4	Jumping Jack Compactor	Paving equipment	1	Aggregate placement	6	90	10	59%	0.216	2	0.002	0.00	2	0.1
Winter #4	Light Plant	Generator set	5	Crew support	4	480	27	43%	0.216	62	0.052	0.14	62	1.8
Winter #4	Water pumps 3 inch	Generator set	4	Crew support	4	150	10	100%	0.216	13	0.011	0.03	14	0.4
Winter #4	Water pumps 6 inch	Generator set	2	Crew support	4	150	25	100%	0.216	17	0.014	0.04	17	0.5
Summer #4	5 kW portable generator	Generator set	1	Crew support	8	200	7	43%	0.216	3	0.002	0.01	3	0.1
Summer #4	50 kW generator	Generator set	4	Crew support	8	300	67	43%	0.216	155	0.130	0.35	156	4.4
Summer #4	Light Plant	Generator set	5	Crew support	8	420	27	43%	0.216	109	0.091	0.24	109	3.1
Summer #4	Water pumps 3 inch	Generator set	4	Crew support	8	150	10	100%	0.216	27	0.023	0.06	27	0.8
Summer #4	Water pumps 6 inch	Generator set	2	Crew support	8	150	25	100%	0.216	34	0.028	0.08	34	1.0
Winter #5	1000 lb plate compactor	Plate compactors	1	Culvert installation	1	300	9	43%	0.216	1	0.001	0.00	1	0.0
Winter #5	5 kW portable generator	Generator set	1	Crew support	4	200	7	43%	0.216	1	0.001	0.00	1	0.0
Winter #5	50 kW generator	Generator set	4	Crew support	4	300	67	43%	0.216	78	0.065	0.17	78	2.2
Winter #5	Jumping Jack Compactor	Paving equipment	1	Culvert installation	1	90	10	59%	0.216	0	0.000	0.00	0	0.0
Winter #5	Light Plant	Generator set	5	Crew support	4	480	27	43%	0.216	12	0.010	0.03	12	0.3
Winter #5	Water pumps 3 inch	Generator set	4	Crew support	4	150	10	100%	0.216	13	0.011	0.03	14	0.4
Winter #5	Water pumps 6 inch	Generator set	2	Crew support	4	150	25	100%	0.216	17	0.014	0.04	17	0.5
Summer #5	1000 lb plate compactor	Plate compactors	1	Aggregate placement	6	200	9	43%	0.216	3	0.002	0.01	3	0.1
Summer #5	5 kW portable generator	Generator set	1	Crew support	6	200	7	43%	0.216	2	0.002	0.00	2	0.1
Summer #5	50 kW generator	Generator set	4	Crew support	6	300	67	43%	0.216	116	0.098	0.26	117	3.3
Summer #5	Jumping Jack Compactor	Paving equipment	1	Aggregate placement	6	90	10	59%	0.216	2	0.002	0.00	2	0.1
Summer #5	Light Plant	Generator set	5	Crew support	6	420	27	43%	0.216	81	0.068	0.18	82	2.3
Summer #5	Water pumps 3 inch	Generator set	4	Crew support	6	150	10	100%	0.216	20	0.017	0.05	20	0.6
Summer #5	Water pumps 6 inch	Generator set	2	Crew support	6	150	25	100%	0.216	25	0.021	0.06	25	0.7

GHG emissions during the construction phase - On-road vehicles (crew vehicles, transport trucks and equipment mobilization / demobilization)

Applicable emission factors (in g/L) - National Inventory Report 1990:2021 (Annex A6.1.6)

Category	CO ₂ [1]	CH ₄	N ₂ O	CO ₂ bio [1]
	1	28	265	1
Light-duty gasoline trucks (oxidation catalysts)	2 146	0.43	0.20	106
Heavy-duty diesel vehicles (moderate control)	2 601	0.14	0.082	74

[1] It is assumed that the overall stock of diesel used on site will contain 3% of biodiesel in average. The CO₂ emission factor is therefore multiplied by 0.97. In return, the biogenic CO₂ emission factor for biodiesel is multiplied by 0.03. The same for gasoline with 7% ethanol.

Crew Vehicles Mainly Used for Staff Transportation (from Sigfusson budgetary cost estimate)

[1] Based on data and the calendar by Sigfusson per phase

[2] Assuming an average distance per day based on a round trip from starting camp to a mid-point along the road to the furthest destination + 20% to consider travelling between sites during the day

[3] Inferred from fuel economy numbers provided in NRCan 2023 Fuel Consumption Guide for the vehicle model.

Phase	Vehicle category	Selected type	Route	Number on site [1]	Number of days [1]	Daily distance per vehicle (km) [2]	Fuel usage rate (L/km) [3]	Total GHG Emissions (t CO ₂ e)				
								CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 1A to WC-4	2	120	50	0.18	5	0	0	5	0
Winter #1	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 1A to WC-4	6	120	50	0.15	12	0	0	12	1
Winter #1	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 1A to WC-4	4	120	50	0.10	5	0	0	5	0
Summer #1	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/ARA-4 access	3	245	21	0.18	6	0	0	6	0
Summer #1	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/ARA-4 access	18	245	21	0.15	30	0	1	31	1
Summer #1	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/ARA-4 access	6	245	21	0.10	7	0	0	7	0
Winter #2	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to 4A	4	120	89	0.18	16	0	0	17	1
Winter #2	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to 4A	10	120	89	0.15	34	0	1	35	2
Winter #2	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to 4A	4	120	89	0.10	9	0	0	9	0
Summer #2	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/WC-16	4	245	38	0.18	15	0	0	15	1
Summer #2	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/WC-16	21	245	38	0.15	64	0	2	66	3
Summer #2	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to Web/WC-16	6	245	38	0.10	12	0	0	12	1
Winter #3	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to WC-16	3	120	50	0.18	7	0	0	7	0
Winter #3	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to WC-16	12	120	50	0.15	23	0	1	24	1
Winter #3	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 2A to WC-16	6	120	50	0.10	8	0	0	8	0
Summer #3	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-6	2	245	65	0.18	12	0	0	13	1
Summer #3	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-6	17	245	65	0.15	87	0	2	89	4
Summer #3	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-6	6	245	65	0.10	20	0	1	21	1
Winter #4	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	2	120	34	0.18	3	0	0	3	0
Winter #4	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	10	120	34	0.15	13	0	0	13	1
Winter #4	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	6	120	34	0.10	5	0	0	5	0
Summer #4	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	2	245	34	0.18	6	0	0	7	0
Summer #4	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	10	245	34	0.15	26	0	1	27	1
Summer #4	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	6	245	34	0.10	11	0	0	11	1
Winter #5	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-22	2	120	14	0.18	1	0	0	1	0
Winter #5	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-22	10	120	14	0.15	6	0	0	6	0
Winter #5	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-22	6	120	14	0.10	2	0	0	2	0
Summer #5	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	2	245	34	0.18	6	0	0	7	0
Summer #5	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	10	245	34	0.15	26	0	1	27	1
Summer #5	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Camp 4A to WC-16	6	245	34	0.10	11	0	0	11	1

Material Transportation with Trucks (route and volume from Sigfusson budgetary cost estimate)

[1] Total amount extracted from Sigfusson's report.

[2] For bulk materials, assuming the use of side dump trucks carrying 10 m3 (15-20 t). For geotextile, the payload is in m2 and represents 4 rolls of 5 m per 100 m long. For geogrids, it represents 4 rolls of 5 m per 75 m long.

[3] Average distance single-trip over the course of the route (as presented in Sigfusson's report)

[4] Typical value for class VII and VIII trucks constructed between 2010 and 2020 according to the US EIA (2022). It is multiplied by 2 to take into account an empty return to the point of origin. Equivalent to 6 MPG en average.

Phase	Transported Material	Selected type	Route	Total amount (m³) [1]	Average truck payload (m³) [2]	Distance traveled per trip (km) [3]	Fuel usage rate (L/km) [4]	Total GHG Emissions (t CO ₂ e)				
								CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	Subgrade material	Heavy-duty diesel vehicles (moderate control)	Webequie to WC-01	13 200	10	2.3	0.784	6	0	0	6	0
Summer #1	Granular B	Heavy-duty diesel vehicles (moderate control)	ARA-2 to Web/WC-1	20 700	10	25	0.784	106	0	1	107	3
Summer #1	Granular B	Heavy-duty diesel vehicles (moderate control)	ARA-2 to WC-1/WC-3	102 750	10	12	0.784	252	0	2	255	7
Summer #1	Geotextile	Heavy-duty diesel vehicles (moderate control)	Web to Web/ARA-4 intersection	741 600	2 000	18	0.784	13	0	0	13	0
Summer #2	Granular A	Heavy-duty diesel vehicles (moderate control)	ARA-2 to Web/WC-1	4 600	10	25	0.784	24	0	0	24	1
Summer #2	Granular A + B	Heavy-duty diesel vehicles (moderate control)	ARA-2 to WC-1/WC-3	162 360	10	12	0.784	401	1	3	404	11
Summer #2	Granular A + B	Heavy-duty diesel vehicles (moderate control)	ARA-2 to WC-3/WC-4	62 700	10	2.8	0.784	36	0	0	36	1
Summer #2	Granular A	Heavy-duty diesel vehicles (moderate control)	ARA-2 to WC-4/ARA-4 access	61 600	10	8.2	0.784	103	0	1	104	3
Summer #2	Granular B	Heavy-duty diesel vehicles (moderate control)	ARA-2 to WC-27/ARA-4	15 300	10	14	0.784	44	0	0	44	1
Summer #2	Granular B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to ARA-4 access/WC-6	111 240	10	12	0.784	265	0	2	268	8
Summer #2	Granular B + imported fill	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-6/WC-16	486 435	10	24	0.784	2 350	4	20	2 374	67
Summer #2	Geotextile	Heavy-duty diesel vehicles (moderate control)	Web to ARA-4 access/WC-16	362 700	2 000	55	0.784	20	0	0	21	1
Summer #2	Geogrid	Heavy-duty diesel vehicles (moderate control)	Web to ARA-4 access/WC-16	238 500	1 500	55	0.784	18	0	0	18	1
Winter #3	Imported fill	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-6/WC-16	277 065	10	29	0.784	1 610	2	13	1 626	46
Summer #3	Granular A	Heavy-duty diesel vehicles (moderate control)	ARA-4 to ARA-4/ARA-4 access	7 400	10	10.0	0.784	15	0	0	15	0
Summer #3	Granular A + B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to ARA-4 access/WC-6	24 720	10	24	0.784	119	0	1	121	3
Summer #3	Granular A + B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-6/WC-16	242 300	10	24	0.784	1 171	2	10	1 182	33
Summer #3	Granular A + local filling	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-16/Mine camp	288 000	10	29	0.784	1 691	3	14	1 708	48
Summer #3	Geotextile	Heavy-duty diesel vehicles (moderate control)	Web to WC-16/Mine camp	502 200	2 000	92	0.784	47	0	0	48	1
Summer #3	Geogrid	Heavy-duty diesel vehicles (moderate control)	Web to WC-16/Mine camp	502 200	1 500	92	0.784	63	0	1	63	2
Winter #4	Imported fill + granular B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-6/WC-16	510 000	10	29	0.784	2 963	4	25	2 993	85
Summer #4	Granular B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-6/WC-16	198 250	10	56	0.784	2 280	3	19	2 302	65
Summer #5	Granular A + B	Heavy-duty diesel vehicles (moderate control)	ARA-4 to WC-16/Mine camp	296 800	10	56	0.784	3 413	5	29	3 447	97

Material Mobilization / demobilization

[1] Number of trips estimated as follows:

Mobilization: Based on the maximum number of units during the year minus the units already present on site from previous year

Demobilization: Based on the units from previous year not required for the current year.

Fuel Transport: Based on total fuel usage required during the year transported via 20 m3 tankers.

Geotextile: Based on total surface area of geotextile during the year and a payload of 10 000 m2 (equivalent to 20 rolls of 5 x 100 m)

Geogrid: Based on total surface area of geogrid during the year and a payload of 3 750 m2 (equivalent to 10 rolls of 5 x 75 m)

Culverts and cross-culverts: 2 trucks per major culvert + 200 cross-culverts distributed equally between Year 3 to 5.

Bridge components: Based on an estimated of 4,750 m2 of total bridge deck x an estimated amount of 900 kg/m2 of cement mix and steel transported by trucks with 15 t payloads.

[2] Distance between Pickle Lake and Webequie via the winter road.

Phase	Transported Material	Selected type	Route	Number of trips [1]	Distance traveled per trip (km) [2]	Fuel usage rate (L/km)	Total GHG Emissions (t CO ₂ e)				
							CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	Equipment mobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	203	292	0.784	121	0	1	122	3
Winter #2	Equipment demobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	22	292	0.784	13	0	0	13	0
Winter #2	Equipment mobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	36	292	0.784	21	0	0	22	1
Winter #3	Equipment demobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	43	292	0.784	26	0	0	26	1
Winter #3	Equipment mobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	4	292	0.784	2	0	0	2	0
Winter #4	Equipment demobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	34	292	0.784	20	0	0	20	1
Winter #4	Equipment mobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	0	292	0.784	0	0	0	0	0
Winter #5	Equipment demobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	153	292	0.784	91	0	1	92	3
Winter #5	Equipment mobilization	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	9	292	0.784	5	0	0	5	0
Winter #1	Fuel transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	115	292	0.784	68	0	1	69	2
Winter #2	Fuel transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	205	292	0.784	122	0	1	123	3
Winter #3	Fuel transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	206	292	0.784	122	0	1	124	3
Winter #4	Fuel transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	189	292	0.784	113	0	1	114	3
Winter #5	Fuel transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	90	292	0.784	54	0	0	54	2
Winter #1	Geotextile transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	74	292	0.784	44	0	0	45	1
Winter #2	Geotextile transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	36	292	0.784	22	0	0	22	1
Winter #2	Geogrid transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	64	292	0.784	38	0	0	38	1
Winter #3	Geotextile transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	50	292	0.784	30	0	0	30	1
Winter #3	Geogrid transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	134	292	0.784	80	0	1	81	2
Winter #1	Culverts and cross-culverts	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	4	292	0.784	2	0	0	2	0
Winter #2	Culverts and cross-culverts	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	10	292	0.784	6	0	0	6	0
Winter #3	Culverts and cross-culverts	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	85	292	0.784	51	0	0	51	1
Winter #4	Culverts and cross-culverts	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	65	292	0.784	39	0	0	39	1
Winter #5	Culverts and cross-culverts	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	73	292	0.784	43	0	0	44	1
Winter #1	Bridge components transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	216	292	0.784	129	0	1	130	4
Winter #2	Bridge components transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	54	292	0.784	32	0	0	32	1
Winter #3	Bridge components transport	Heavy-duty diesel vehicles (moderate control)	Pickle Lake - Camp 1A	15	292	0.784	9	0	0	9	0

GHG emissions during the construction phase - Air travel

Applicable emission factors (in g/L) - National Inventory Report 1990:2021 (Annex A6.1.6)

Category	CO ₂	CH ₄	N ₂ O	CO ₂ bio
	1	28	265	1
Aviation turbo fuel	2 560	0.018	0.071	0

Applicable fuel consumption rate (2020 BC Best practice methodologies for quantifying GHGs - Table 28)

Category	Value	Units
Airplane - Medium haul	0.035	L/psg-km
Helicopter	0.173	L/psg-km

Air Travel by Crew members

- [1] According to Sigfusson, the most likely origin of personnel will depart from Winnipeg to Webequie.
- [2] Assuming that 60% of required personnel according to Sigfusson report will come from outside Webequie
- [3] Hypothesis: Each worker would stay 8 weeks before leaving.

Phase	Crew members		Work Phase Duration (weeks)	Mobilized period per worker (weeks) [3]	Number of passengers	Distance per trip (km)	Fuel usage rate (L/psg-km)	Total GHG Emissions (t CO ₂ e)				
	Airport [1]	Number [2]						CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Winter #1	Winnipeg, MB	21	17	8	90	750	0.035	6	0	0	6	0
Summer #1	Winnipeg, MB	52	35	8	457	750	0.035	30	0	0	31	0
Winter #2	Winnipeg, MB	53	17	8	229	750	0.035	15	0	0	15	0
Summer #2	Winnipeg, MB	67	35	8	588	750	0.035	39	0	0	40	0
Winter #3	Winnipeg, MB	45	17	8	193	750	0.035	13	0	0	13	0
Summer #3	Winnipeg, MB	68	35	8	599	750	0.035	40	0	0	40	0
Winter #4	Winnipeg, MB	29	17	8	123	750	0.035	8	0	0	8	0
Summer #4	Winnipeg, MB	29	35	8	252	750	0.035	17	0	0	17	0
Winter #5	Winnipeg, MB	23	17	8	98	750	0.035	7	0	0	7	0
Summer #5	Winnipeg, MB	37	35	8	326	750	0.035	22	0	0	22	0

Helicopter (for camp access only)

Phase	Activity	Total distance (km)	Fuel usage rate (L/km)	Total GHG Emissions (t CO ₂ e)					General comment
				CO ₂	CH ₄	N ₂ O	Total	CO ₂ b	
Summer #1	Camp access and supply	7 350	0.693	13	0	0	13	0	1 daily round-trip transporting 4 persons from Camp 1A to Camp 2A
Summer #3	Camp access and supply	36 750	0.693	65	0	0	66	0	1 daily round-trip transporting 4 persons from Camp 1A to Mine camp

GHG emissions during the construction phase - Biomass Clearing Emissions

Applicable emission factors (in kg/t dry) - National Inventory Report 1990:2021 (Annex A6.6)

Category	CO ₂	CH ₄ [2]	N ₂ O [2]	CO ₂ bio [1]
		1	28	265
Controlled burning of wood waste	0	6.8	0.32	1 870

Carbon content in wood t C/t dry wood

[1] Represents the emission factor for full combustion of totally dry wood from boreal conifers containing 51% of carbon on dry basis (IPCC 2019 guidelines refinement).

[2] Estimated according to ECCC SACC GHG quantification guidance: 1% of carbon converted into CH₄ and N₂O equivalent to 0.017% of CO₂.

Living Biomass Disturbance

[1] Represents the net area containing trees and thicket swamps with trees only that will be cleared during construction.

[2] Living above-ground biomass inferred from data by the NFI collected via photo plots along the WSR (see table below). Portion of the total biomass from NRI analysis is removed as dead trees. It was estimated based on data provided by the NFI biomass calculator web tool per tree species found in the area (see second table below).

[3] Inferred from Kurz et al. (2013) "Carbon in Canada's Boreal Forest - A synthesis". The fraction of carbon found in below ground biomass is divided by the carbon in above-ground biomass (Figure 5 of paper).

[4] It is expected that the community of Webequie will recover about a quarter of the wood for their own use, although a good portion should be use for energy purpose. Hence, it is assumed that 90% of cleared biomass will be burned.

[5] As simplification and as allowed by ECCC SACC, all the carbon from living biomass is considered emitted as CO₂ during the year of removal for piled and harvested biomass. For combustion, SACC recommends using the ECCC NIR approach, where 90% of carbon is converted into CO₂.

Below-ground to above-ground ratio [3]	0.25
Burned biomass ratio [4]	90%

Phase	WSR section	Total cleared area (ha) [1]	Living above-ground biomass (t dry/ha) [2]	Total living biomass (t dry)	Total GHG Emissions (t CO ₂ e)				
					CO ₂	CH ₄	N ₂ O	Total	CO ₂ b [5]
Winter #1	Camp 1A (near Webequie)	7.6	60	572	0	98	43	141	974
Winter #1	ARA-2 quarry including camp 2A	26	60	1 937	0	332	147	479	3 296
Winter #1	ROW (Webequie to ARA-2 access intersection)	42	60	3 138	0	538	238	776	5 340
Winter #2	ARA-4 quarry including camp 3A	69	60	5 215	0	894	395	1 289	8 875
Winter #2	ROW (ARA-4 access to WC-10)	1.3	60	98	0	17	7	24	166
Winter #2	ROW (WC-10 to Mine camp)	7.4	19	174	0	30	13	43	297
Winter #2	Camp 4B (Mine camp)	4.4	19	106	0	18	8	26	180

Total biomass data from NRI photo plots analysis near and around the WSR

WSR section	Location (400 ha plot areas)	Percent area per type of vegetation				Total biomass density (t/ha) per type of vegetation				Avg biomass density of treed areas only (t dry/ha)
		Mixed wood	Coniferous	Broadleaf	Shrubs	Mixed wood	Coniferous	Broadleaf	Shrubs	
From Webequie to ARA-4 intersection (Boreal Shield)	Bender Lake (NRI photo 1129146)	28%	17%	0%	4%	73	99	0	5.0	76
	South of Winisk Lake (NRI photo 1136026)	26%	14%	11%	0%	93	52	130	0	90
	Prime Lake (NRI photo 1129151)	18%	50%	0%	24%	56	63	0	5.0	47
	West of Malloy Lake (NRI photo 1136026)	26%	14%	11%	0%	93	52	130	0.0	90
	AVERAGE	25%	24%	6%	7%	79	67	65	2.5	76
From ARA-4 intersection to Camp 4B (Hudson Plains)	Ekwan River (NRI photo 1129156)	22%	52%	0%	20%	39	69	0	5.0	48
	Muketai River (NRI photo 1129161)	0%	68%	0%	31%	0	7	0	2.0	5
	Greg Lake (NRI photo 1115401)	0%	8%	0%	88%	0	23	0	2.0	4
	North of McMurdo Lake (NRI photo 1122271)	15%	32%	0%	50%	53	60	0	6.0	31
	AVERAGE	9%	40%	0%	47%	23	40	0	3.8	22

Results from NFI Merchandable Stand Biomass Calculator (to estimate the portion of dead trees in total above-ground biomass)

Ecozone	Main Species	Above-ground biomass composition (t dry/ha)					Percentage of dead trees
		Stem	Bark	Branches	Foliage	Dead trees	
Boreal Shield	Black Spruce (main species)	45	6.6	7.4	8.4	15	18%
	White Spruce	45	6.9	9.2	8.1	15	18%
	Balsam Fir	42	7.0	7.8	7.8	0.5	1%
	Balsam Poplar	31	5.1	7.0	1.3	21	32%
	Trembling Aspen	41	8.1	7.1	4.3	27	31%
	White Birch	46	7.8	8.7	4.5	31	31%
	AVERAGE (50% Black Spruce + 50% the rest)	42	6.9	7.9	5.7	18	20%

Hudson Plains	Black Spruce (main species)	45	6.6	7.4	8.4	15	18%
	Tamarak	39	4.7	6.7	4.5	1.9	3%
	AVERAGE (75% Black Spruce + 25% Tamarak)	42	5.7	7.1	6.5	8	14%

Dead Organic Matter (DOM) Management

- [1] Represents the portion of total above-ground biomass from NRI analysis considered as dead trees (snags). It was estimated based on data provided by the NFI biomass calculator web tool per tree species found in the area (see table above).
- [2] Downed dead wood is added by considering a ratio of 1:1 with standing dead wood. It results in a total carbon in deadwood to total carbon in above-ground living biomass of 0.5 which matches the average results from Kurtz et al study on boreal forests (Figure 5 of paper; 40 t C/ha for above-ground biomass vs. 20 t C/ha for deadwood).
- [3] From Soucemanadin et al. "Total and pyrogenic carbon stocks in black spruce forest floors from eastern Canada", Organic Geochemistry, vo. 82, 2015, p.1-11, which has measured multiple plots in Boreal forest dominated with Black Spruce which is the main species along the WSR. The value is about 25% higher than the average value (46 t C/ha) suggested by Kurtz et al study (Figure 5) for boreal forests in Canada.
- [4] It is assumed that 100% of the DOM will be piled with the cleared biomass for controlled burning on site. There may be some DOM that will be buried during road construction, but it should remain small.
- [5] For combustion, SACC recommends using the ECCC NIR approach, where 90% of carbon is converted into CO₂.

Ratio of lying dead wood (vs standing dead wood) [2]	1.0
Forest litter (t C/ha) [3]	57

Phase	Section	Total cleared area (ha)	Standing dead trees (t dry/ha) [1]	Lying dead trees (t dry/ha) [2]	Total DOM carbon (t C/ha)	Total GHG Emissions (t CO ₂ e) [4]				
						CO ₂	CH ₄	N ₂ O	Total	CO ₂ b [5]
Winter #1	Camp 1A (near Webequie)	7.6	15	15	73	0	206	91	297	1 822
Winter #1	ARA-2 quarry including camp 2A	26	15	15	73	0	698	309	1 007	6 168
Winter #1	ROW (Webequie to ARA-2 access intersection)	42	15	15	73	0	1 130	500	1 630	9 991
Winter #2	ARA-4 quarry including camp 3A	69	15	15	73	0	1 879	831	2 710	16 606
Winter #2	ROW (ARA-4 access to WC-10)	1.3	15	15	73	0	35	16	51	311
Winter #2	ROW (WC-10 to Mine camp)	7.4	3.2	3.2	60	0	165	73	238	1 461
Winter #2	Camp 4B (Mine camp)	4.4	3.2	3.2	60	0	100	44	144	884

GHG emissions during the operation phase - On-road vehicles and road maintenance activities

Applicable emission factors (in g/L) - National Inventory Report 1990:2021 (Annex A6.1.6)

Category	CO ₂ [1]	CH ₄	N ₂ O	CO ₂ bio [1]
	1	28	265	1
Light-duty gasoline trucks (oxidation catalysts)	2 146	0.43	0.20	106
Heavy-duty diesel vehicles (moderate control)	2 601	0.14	0.082	74
Off-road diesel > 19 kW (all tiers)	2 601	0.073	0.12	74
Stationary Diesel - Refineries and Others	2 601	0.078	0.022	74

[1] It is assumed that the overall stock of diesel used on site will contain 3% of biodiesel in average. The CO₂ emission factor is therefore multiplied by 0.97. In return, the biogenic CO₂ emission factor for biodiesel is multiplied by 0.03. The same for gasoline with 7% ethanol.

Traffic on the road

- [1] A maximum of 500 passages is expected on a daily basis. For this assessment, 50% of the maximum is applied as an average over the year subdivided equally amongst light trucks, commercial trucks and heavy-duty trucks.
- [2] For this assessment, it is assumed that all passages will correspond to links between Webeque and the mining area near McFaulds Lake and the intersection of the new NRL road going southward and located at 100 km distance from Webeque.
- [3] Inferred from fuel economy numbers provided in NRCan 2023 Fuel Consumption Guide for the vehicle model. Typical value for class VII and VIII trucks constructed between 2010 and 2020 according to the US EIA (2022).

Time period	Vehicle category	Selected type	Route	Daily traffic [1]	Number of days	Daily distance per vehicle (km) [2]	Fuel usage rate (L/km) [3]	Total GHG Emissions (t CO ₂ e)				
								CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Year-long	1 ton crew trucks (Ford F-250 4 x 4)	Light-duty gasoline trucks (oxidation catalysts)	Webeque to McFauld Lake	63	365	100	0.18	881	4.9	22	908	43
Year-long	1/2 ton pick-up trucks (Ford F-150 4x4)	Light-duty gasoline trucks (oxidation catalysts)	Webeque to McFauld Lake	63	365	100	0.15	734	4.1	18	756	36
Year-long	Crew van (Ford Transit)	Light-duty gasoline trucks (oxidation catalysts)	Webeque to McFauld Lake	63	365	100	0.10	489	2.7	12	504	24
Year-long	Heavy-duty trucks	Heavy-duty diesel vehicles (moderate control)	Webeque to McFauld Lake	63	365	100	0.39	2 326	3.5	19	2 348	66

Main Road Maintenance Equipment List

Maintenance trucks traffic on the road

- [1] For each day when dust control or snow plowing is required, a total of 4 passages is considered over the length of the road. For aggregates, based on the hauling of 26,750 m³ per year with 10 m³ trucks.
- [2] Assuming 60 days of snow removal days. For dust control, it corresponds to the number days from May to November without precipitations according to closests meteorological data having climate normals (Pickle Lake). For aggregates, from April to November.
- [3] For this assessment, it is assumed that all passages will correspond to links between Webeque and the mining area near McFaulds Lake at 107 km distance. For aggregates, it corresponds to the round-trip average between ARA-4 quarry and an point on the road.
- [4] Given the slow speeds for these activity, a consumption rate of 0.5 L/km is considered at an approximation.

Time period	Vehicle category	Selected type	Route	Daily traffic [1]	Number of days [2]	Daily distance per vehicle (km) [3]	Fuel usage rate (L/km) [4]	Total GHG Emissions (t CO ₂ e)				
								CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Summer	Water trucks	Heavy-duty diesel vehicles (moderate control)	Webeque to McFauld Lake	4	103	107	0.50	57	0.1	0	58	2
Year-long	Aggregate hauling & spill response	Heavy-duty diesel vehicles (moderate control)	ARA-4 to mid-point WSR	11	244	70	0.39	191	0.3	2	193	5
Winter	Sand Truck	Heavy-duty diesel vehicles (moderate control)	Webeque to McFauld Lake	6	60	107	0.50	50	0.1	0	51	1

Maintenance mobile equipment

[1] Usage requirements estimated as follow:

Aggregate production: Based on 26,750 m3 of aggregates to be produced annually at a rate of 1,200 m3 per day (hypothesis used by Sigfusson to produce Granular A). For the excavator and lift, 2 h per day is added for truck loading outside the aggregate production period.

Grader: Estimated from April to November with 2 passages over the road length every 10 days at a speed of 15 km/h.

Road maintenance equipment: Estimated at 2 h per business day in average over the year.

[2] Based on the specified equipment model.

[3] The base value taken from US EPA (2021) were converted in L/hp-hr considering a fuel density of 0.86 kg/L and were adjusted for biodiesel content assuming that B100 has about 8% less energy content than diesel, thus requiring more in the engine (NRCan (2022)).

Time period	Mobile equipment		Number on site	Main activity	Estimated usage (h/a) [1]	Engine [2]		Fuel usage rate (L/hp-h) [3]	Total GHG Emissions (t CO ₂ e/a)				
	Description	Type				Rated power (hp)	Avg load (%)		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Year-long	Komatsu PC600	Excavator	1	Aggregate production	1 220	385	59%	0.194	140	0.110	1.8	142	4.0
Summer	980 size loader (CAT 980)	Rubber tire loader	2	Aggregate production	535	393	59%	0.194	125	0.098	1.6	127	3.6
Summer	CAT 14G Grader	Grader	1	Road maintenance	325	250	59%	0.194	24	0.019	0.3	25	0.7
Winter	CAT 14G Grader	Grader	3	Snow plowing	600	180	59%	0.194	96	0.076	1.2	98	2.8
Summer	John Deere 6140	Tractor / loader / backh	2	Vegetation Management	200	155	21%	0.194	7	0.005	0.1	7	0.2
Summer	300 size excavator (CAT 336)	Excavator	1	Vegetation Management / Spill	200	202	59%	0.194	12	0.009	0.2	12	0.3

Stationary Combustion Equipment List

[1] Aggregates production time is based on 26,750 m3 of aggregates to be produced annually at a rate of 1,200 m3 per day (hypothesis used by Sigfusson to produce Granular A).

[2] Engine power based on the following:

Crusher power van: Considered equivalent to the power unit used during construction.

MSF generator set: Estimated based on a total surface area of office, garages and others of 8,000 m2 (20% of total 4 ha footprint of MSF) and an energy usage rate of 0.99 GJ/m2 (benchmark from Energy Star for Canadian non-refrigerated warehouses). The diesel generator set efficiency is set to 40%.

[3] The base value taken from US EPA (2021) were converted in L/hp-hr considering a fuel density of 0.86 kg/L and were adjusted for biodiesel content assuming that B100 has about 8% less energy content than diesel, thus requiring more in the engine (NRCan (2022)).

Time period	Mobile equipment		Number on site	Main activity	Estimated usage (h/a) [1]	Engine [2]		Fuel usage rate (L/hp-h) [3]	Total GHG Emissions (t CO ₂ e/a)				
	Description	Type				Rated power (hp)	Avg load (%)		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Summer	Crusher power van 600 kW	Generator set	1	Aggregate production	535	804	43%	0.194	93	0.078	0.2	94	2.7
Year-long	MSF generator set	Generator set	1	MSF power supply	8 760	841	100%	0.194	3 719	3.1	8.3	3 730	106

GHG emissions during the operation phase - Land-Use Change Related Emissions

Mineral Soil Organic Carbon (SOC) Changes

[1] Grading of camps at a depth of 0.2 m while the quarries and ROW are stripped of 0.5 m of topsoil (width of 27 m out of the 35 m ROW). For ditching, it is assumed that 5 m³ of soil will be excavated for each meter of road.

[2] Extracted from Kurtz et al (2013) study stating that the average soil carbon content in unfrozen mineral soils in Canada's boreal zone is 138 t C/ha at 1 m depth. Considering that the maximum stripping depth is 0.5 m, than the SOC value is brought back in t C/m³ like follow: 75 % x 138 C/ha / 0.5 m / 10000 assuming that 75% of the carbon is located in the top half layer.

[3] Approach suggested by the IPCC and ECCE SACC. Considering that 20% of disturbed SOC will be converted into CO₂ over a period of 20 years (or 1% per year).

Topsoil organic carbon (SOC) content (t C/m³) [2]
Carbon released as CO₂ (%/a) [3]

0.021
1.0%

Time period	Section	Disturbed soil volume (m ³) [1]		Total disturbed soil carbon (t C)	Total GHG Emissions (t CO ₂ e/a)				
		Stripping	Ditching		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Annual	Stripping - Camp 1A (near Webequie)	16 200	0	335	0	0	0	0	12
Annual	Stripping - ARA-2 quarry including camp 2A	227 000	0	4 699	0	0	0	0	172
Annual	Stripping - ROW (Webequie to ARA-4 access)	538 650	0	11 150	0	0	0	0	409
Annual	Stripping - ARA-4 quarry including camp 3A	421 000	0	8 715	0	0	0	0	320
Annual	Stripping - ROW (ARA-4 access to WC-6)	141 750	0	2 934	0	0	0	0	108
Annual	Stripping - Camp 4B (Mine camp)	16 400	0	339	0	0	0	0	12
Annual	Ditching - ROW (Webequie to ARA-4 access)	0	214 500	4 440	0	0	0	0	163
Annual	Ditching - ROW (ARA-4 access to WC-6)	0	52 500	1 087	0	0	0	0	40
Annual	Ditching - ROW (WC-6 to WC-16)	0	134 500	2 784	0	0	0	0	102

Net Living Biomass Carbon Accumulation Loss

[1] The applied age distribution represents the average distribution of trees in the Boreal Shield (upland) and Hudson Plains (lowland) according to the latest statistical summary from the NFI.

[2] Calculated from the the sum of total living biomass to be cleared according to results from "C-BiomassClearing" and the distribution per age class.

[3] The growth rate per age class was inferred from a Plonski yield table specific to Black Spruce as reported by Payendeh (1991). The values represent the expected average growth rate in biomass (and thus in C accumulation) across the age class.

Time period	Forest Age Class	Age class distribution (%) [1]		Total living biomass cleared (t dry) [2]		Biomass Growth Rate (%/a) [3]	Total GHG Emissions (t CO ₂ e/a)				
		Upland	Lowland	Upland	Lowland		CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Annual	1-20 years	2.6%	0.34%	288	0.95	10%	0	0	0	0	54
Annual	21-40 years	9.5%	6.9%	1 037	19	6.5%	0	0	0	0	128
Annual	41-60 years	17%	12%	1 885	32	3.3%	0	0	0	0	117
Annual	61-80 years	23%	12%	2 509	35	1.8%	0	0	0	0	84
Annual	81-100 years	25%	10%	2 718	29	1.0%	0	0	0	0	52
Annual	101-120 years	11%	23%	1 245	64	0.60%	0	0	0	0	15
Annual	121-140 years	10%	30%	1 062	84	0.36%	0	0	0	0	7.7
Annual	141-160 years	1.5%	5.4%	159	15	0.22%	0	0	0	0	0.71
Annual	161-180 years	0.39%	0.20%	43	0.56	0.13%	0	0	0	0	0.11
Annual	181-200 years	0.068%	0%	7.4	0	0.082%	0	0	0	0	0.011
Annual	201+ years	0.034%	0%	3.7	0	0.050%	0	0	0	0	0.0035

Peatland Net GHG Emissions

[1] Represents the percentage from all wetland ecosystems within the LSA determined during past years field plots and cruising surveys. Marshes are excluded as they are mostly waterbodies.

[2] General peatland category for which specific GHG emissions fluxes are attributed for estimation purpose.

[3] Represents the length of road to be built on peatlands times a 15 m disturbed width including the road, shoulders, and embankments towards the cross-culverts level.

Total disturbed peatland area (m²) [3] 840 000

Time period	Identified wetland ecosystems for the project LSA	Percentage of total wetland area [1]	Peatland Category [2]	GHG emissions flux (g/m ² /a) [3]		Total GHG Emissions (t CO ₂ e/a)				
				CO ₂	CH ₄	CO ₂	CH ₄	N ₂ O	Total	CO ₂ b
Annual	Poor Conifer Swamp	18	Swamp	-192	5.1	0	22	0	22	-29
Annual	Conifer Swamp	26	Swamp	-192	5.1	0	31	0	31	-42
Annual	Rich Swamps	0.91	Swamp	-192	5.1	0	1	0	1	-1
Annual	Mixedwood Swamps	0.063	Swamp	-192	5.1	0	0	0	0	0
Annual	Burn Low / Sparse Treed Bog / Fen	0.025	Bog	-424	6.0	0	0	0	0	0
Annual	Low-Treed Bog	24	Bog	-424	6.0	0	35	0	35	-87
Annual	Sparse Treed Bog	13	Bog	-424	6.0	0	18	0	18	-46
Annual	Sparse Treed Fen	13	Fen	41	4.2	0	13	0	13	4
Annual	Organic Poor Fen	2.5	Fen	41	4.2	0	2	0	2	1
Annual	Open Bogs	0.71	Bog	-424	6.0	0	1	0	1	-3
Annual	Open Fens	0.50	Fen	41	4.2	0	0	0	0	0
Annual	Open Shrub shore Fen	0.84	Fen	41	4.2	0	1	0	1	0
Annual	Thicket Swamp	0.21	Swamp	-192	5.1	0	0	0	0	0

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