PR 304 to Berens River All-Season Road Environmental Impact Assessment – Greenhouse Gas Emissions Assessment *DRAFT Report*

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Project No. 10-3402

Prepared For:

East Side Road Authority

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EXECUTIVE SUMMARY

A greenhouse gas (GHG) assessment of the PR 304 to Berens River All-Season Road (ASR) project (Project) was conducted in support of the EA approvals process. The GHG assessment estimated the total direct and indirect GHG emissions due to the Project and compared this estimate with the GHG emissions (direct and indirect) under the business as usual Baseline scenario (i.e., without the Project). The assessment was conducted over the time period 2010 to 2023 inclusive which includes up to four (4) years of construction and 10 years of operation of the ASR.

The Baseline scenario resulted in a total of approximately 136 kt CO_2e being emitted from 2010 to 2023 inclusive. The Project scenario was estimated to emit a total of approximately 163 kt CO_2e over the same time period which is roughly 19% more than the Baseline emissions. The net change in GHG emissions due to the Project was therefore estimated to be approximately +27 kilo-tonnes (kt) CO_2e over the time period 2010 to 2023. The significant portions of the GHG emission are due to the construction of the ASR (approximately 33% of the total). The construction of the ASR was estimated to increase the Province's construction based GHG emissions by approximately 13 % based on the 2008 estimates of 0.098 Mt CO_2e. This increase is temporary so that once construction of the ASR has been completed it would result in the reduction of the Province's construction-based GHG emissions. Another increase is the estimated vehicular traffic between Winnipeg and Berens River. However the anticipated improvements in future vehicular technology that result in emissions reductions have not been included in this assessment. The GHG emissions due to the road transportation with the ASR in place was estimated to be less than 0.2% of the Province's total GHG emissions of 5.13 Mt CO_2e due to road transportation in 2008.

Recommendations on the potential GHG emissions abatement and / or offsets during the construction and operational phases of the Project were suggested. In particular, construction best management practices would help to reduce the GHG emissions associated with this phase of the Project. For the operational phase of the project, maintenance of the wetland areas surrounding the ASR, increased reforestation of the ROW, potential participation in carbon offsets, and paving the ASR may potentially reduce the GHG emissions during this phase of the Project. Recommendations on developing mitigation plans and policies, monitoring and data collection, and verification were provided. This will help to verify the initial estimates of the GHG emissions associated with the Project provided in this report and assist in positioning the Province to participate in future provincial, regional and federal carbon trading mechanisms.

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1. Introduction

1.1 Background

A greenhouse gas assessment of the PR 304 to Berens River All-Season Road (ASR) project is required as part of the environmental impact assessment. The Canadian Environmental Assessment Agency (2003) in its guidance document recommends that practitioners address greenhouse gas (GHG) considerations that include:

1. Preliminary scoping for GHG considerations. This preliminary scoping assesses whether there are likely GHG considerations associated with the project.
2. Identify GHG considerations. This process considers the potential GHG emissions profile of the project in comparison to the industry profile.
3. Assess GHG considerations. This process determines the direct and indirect GHG emissions of the project, the impacts on carbon sinks, and comparison with industry, provincial / territorial and national inventories.
4. GHG management plans. Development of a GHG management plan to mitigate and / or offset emissions if the project results in medium or high emissions.
5. Monitoring, follow-up and adaptive management. This process monitors and verifies the GHG emissions forecast and determines the effectiveness of the GHG abatement / offset measures. Modification of the GHG management plan may be required during this process.

This GHG assessment addresses CEAA considerations 1, 2 and 3 above. Given that this project is an adaptation response to climate change Items 4 and 5 are not necessary.

1.2 Greenhouse Gas Considerations

The proposed PR 304 to Berens River All-Season Road project (Project) will have GHG emissions associated with the construction and operational (vehicular emissions from the use of the ASR) phases of the Project.

The Project involves the construction and operation of the all-seasons road (ASR) from PR 304 to Berens River. The total distance of the proposed ASR is approximately 155 km. The Manitoba Infrastructure and Transportation (MIT, 2010a) constructs and maintains approximately 19,000 km of all-weather roads and 2,200 km of winter roads. The Project will contribute to an increase of less than 1 % of the total roads in Manitoba.

Environment Canada (2010) provides annual national and provincial GHG emissions per sector since 1990. The most recent GHG inventory year of 2008 indicated that for construction activities in Manitoba, approximately 0.098 Mt CO_2e were emitted in 2008 and the total emissions for road transportation in the province was approximately 5.13 Mt CO_2e. Since 1990, the GHG emissions due to construction have increased in Manitoba by approximately 56 % and for road transportation the increase has been approximately 31 %.

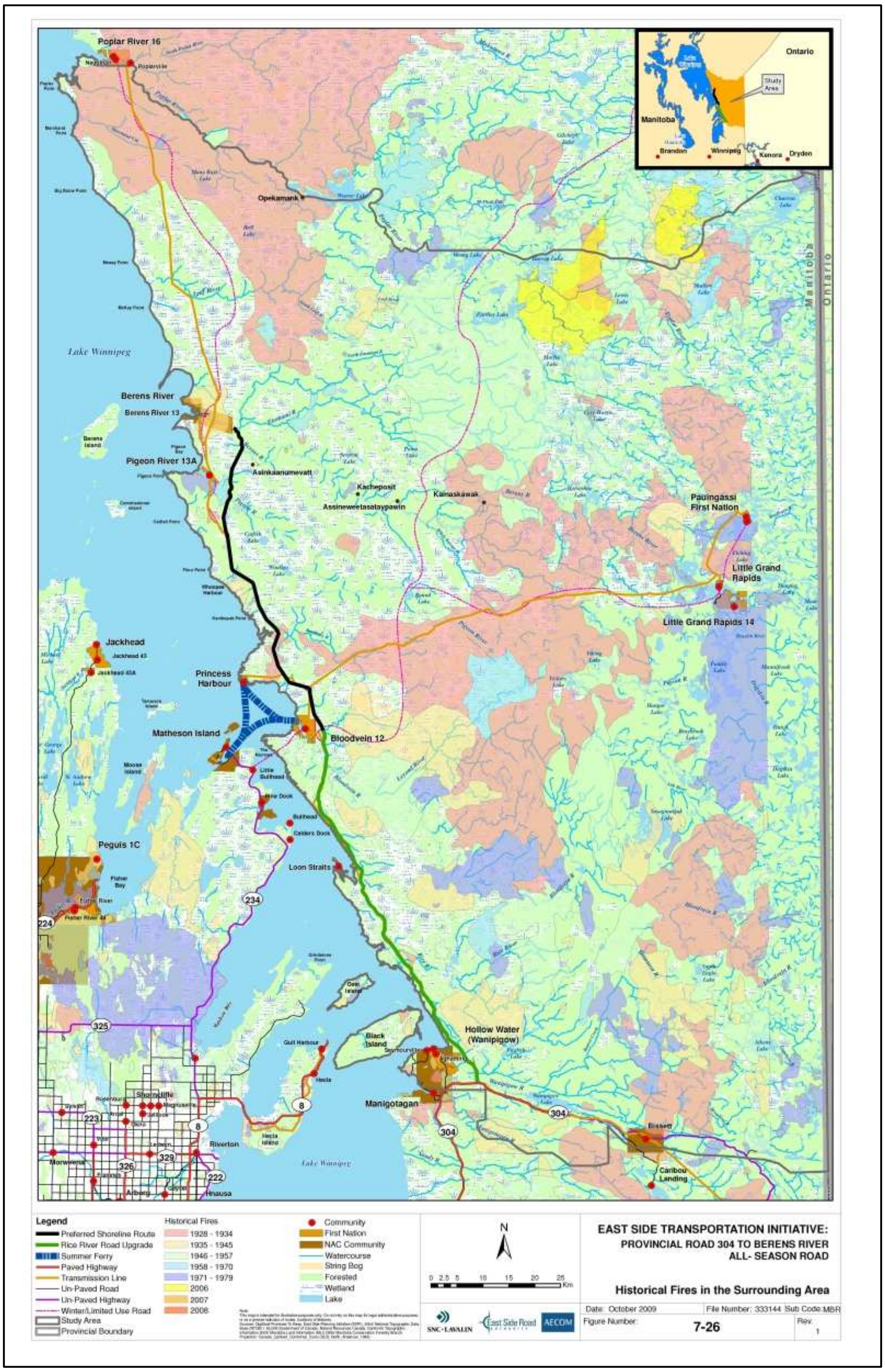
Nationally, GHG emissions from the construction sector in 2008 was estimated to be approximately 1.26 Mt CO_2e, and for the road transportation sector it was estimated at approximately 135 Mt CO_2e (Environment Canada, 2010). The emissions due to construction decreased in 2008 by 33 % from 1990 levels and for the road transportation sector there was an increase of approximately 37 %. Manitoba contributed less than 8 % to the national GHG emissions due to construction and less than 4 % to the national road transportation GHG emissions in 2008.

The Project will contribute to an increase in annual GHG emissions for the Province. Therefore, in order to determine the magnitude of the GHG emissions associated with the Project, a GHG assessment is needed.

2. The Project

The Project study area, shown in **Figure 2.1**, is along the eastern shoreline of Lake Winnipeg and extends from the southern limit of the Hollow Water traditional lands north to Poplar River and east to Pauingassi and Little Grand Rapids First Nation on the Ontario border. The study area encompasses all First Nations traditional lands.

Figure 2.1 – Study Area



Source: Figure 7-26 in East Side Road Authority (2010).

2.1 Existing Conditions

The area to the north and east of Lake Winnipeg is not currently served by an all-season road (ASR) (East Side Road Authority, 2010). The remoteness of communities in the area, their size and lack of economic development has resulted in a costly and limited transportation system. These communities included the Southeast Tribal Council (SERCA) communities of Poplar River, Berens River, Bloodvein, Little Grand Rapids, and Pauingassi, and the communities of St. Theresa Point, Wasagamack, Garden Hill, and Red Sucker Lake. For the communities of Bloodvein and Berens River, this transportation system relies on air service, seasonal ferry service during the non-winter months, and a seasonal winter road. The other more remote communities rely on air service and a seasonal road during the winter.

The air service is from Winnipeg and from Matheson Island. Ferry and barge service to Bloodvein occurs from April / May to October inclusive and is from Islandview and Pine Dock harbours. The seasonal road consists of an ice road from the mainland near Pine Dock to Bloodvein, and a winter road from Bloodvein to Berens River and then onto Poplar River. Another winter road runs from Bloodvein to Little Grand Rapids and Pauingassi. This winter road is also connected to another winter road that connects the communities of the ILTC. All winter roads meet at Bloodvein and an ice road connects Bloodvein to Pine Dock across Lake Winnipeg. Matheson Island, Islandview and Pine Dock can be accessed from Winnipeg via Provincial Trunk Highway (PTH) 8 and Provincial Road (PR) 234. PR 234 is a gravel road.

The study area is covered by boreal forest, wetlands, and small rivers and lakes. The predominant forest cover is black spruce with some jack pine. Logging occurs near Hallow Water.

2.2 Project Description

The Project consists of building an ASR between Manigotagan and Berens River (East Side Road Authority, 2010). This entails upgrading the existing Rice River forestry road from Manigotagan / PR 304 northwards and extending it to Bloodvein, and constructing an ASR from Bloodvein to Berens River. The distance from Manigotagan / Bloodvein is approximately 88 km with the extension from the Rice River forestry road to Bloodvein following the winter road and hydro alignment. The distance from Bloodvein to Berens River is approximately 56 km.

The proposed ASR will be a gravel road for the entire length from PR 304 to Berens River. The roadway will be 10 m in width with two 3.7 m wide lanes, 1.0 m shoulders and a 0.3 m shoulder rounding allowance. The roadway will be centred within a 100 m right of way (ROW) and the cleared limit of the roadway will be 60 m within this ROW. Further clearing will be on as required basis to maintain line of sight. In an effort to minimise land clearing, where applicable, the alignment will follow the existing winter road and Manitoba Hydro distribution line ROW. The proposed ASR will also entail the construction of a number of bridges in order to cross named and unnamed water courses.

The construction of the proposed ASR is anticipated to be completed within four (4) years. Construction is proposed to commence in the fall of 2010 and the majority of the works expected to be completed by March 2014 (East Side Road Authority, 2010). There will be borrow and quarry areas near the proposed ASR to support construction, operations, and maintenance needs.

3. GHG Emissions Assessment Methodology

In order to evaluate the change in GHG emissions due to the Project, the estimated annual GHG emissions for the Baseline scenario without the Project was compared to the scenario with the Project. In both scenarios the annual GHG emissions was projected 14 years from 2010 inclusive (i.e., to 2023). This projection of 14 years includes four years for construction of the ASR followed by 10 years of operation of the ASR. The ASR will impact the communities of Berens River and Bloodvein and transportation activities between these communities and Winnipeg. The other communities in the study area will not be impacted as they will still rely on air and seasonal road transportation. Hence this assessment focuses on the GHG implications associated with the transportation infrastructure linking Berens River, Bloodvein and Winnipeg. The natural ecosystem sources and sinks are also included to demonstrate their contribution to the overall GHG implications of the Baseline and Project scenarios. The following described in detail the two scenarios considered for this assessment.

3.1 Baseline Scenario

The Baseline scenario assumed the existing conditions and projects 14 years into the future to 2023. The scenario further assumes that the existing climatic conditions will prevail to 2023 as the impacts of climate change to the study region cannot be exactly predicted and is beyond the scope of this GHG assessment. The changes in climate are expected to impact the transportation patterns of the study region.

The Baseline scenario estimated the GHG emissions and sinks / removals and the resulting cumulative GHG emissions by:

Annual Baseline GHG Emissions (tonnes CO_2e/yr) =

Carbon sequestration due to forest cover along the proposed ASR (tonnes CO_2e/yr)
+ Net GHG emissions due to wetlands along the proposed ASR (tonnes CO_2e/yr)
+ GHG emissions due to air travel to Bloodvein and Berens River (tonnes CO_2e/yr)
+ GHG emissions due to ferry crossing from Islandview/Pine Dock to Bloodvein (tonnes CO_2e/yr)
+ GHG emissions due to transportation between Winnipeg and Islandview/Pine Dock (tonnes CO_2e/yr)
+ GHG emissions due to the construction and maintenance of seasonal road (tonnes CO_2e/yr)
+ GHG emissions due to vehicular travel during winter (tonnes CO_2e/yr).

Details on the above sources and sinks / removals are given in the following sections.

3.1.1 Carbon Sequestration of Forest Cover

Canada's National Forest Inventory (NFI, 2010) has classified the ecozone in which the study area is located in as Boreal Shield. For the study area, the NFI (2010) plot statistics indicated that the predominant tree species in the study area was Black Spruce followed by Jack Pine based on a 2006 forest inventory. In order to estimate the carbon sequestration rate of the forest cover, the total carbon stock of the forest cover along the proposed ASR was calculated in addition to an estimate of the age of the forest cover.

The methodology used in estimating the total carbon stock was based on the Tree Canada (2009) protocol for calculating the above and below ground carbon stock of the forest cover. The above ground carbon (C) stock can be estimated using the following relationship:

Above Ground C-stock (tonnes CO_2) = above ground tree volume (m^3/ha) × biomass expansion factor (C/m^3) × project area (ha) × C-CO_2 conversion (tonne CO_2/tonne C);

where the *above ground tree volume* × *biomass expansion factor* = *above ground dry biomass (tonnes/ha)*, and the *C-CO_2 conversion* is 44/12.

The below ground C-stock can be estimated by:

Below Ground C-stock (tonnes CO_2) = root-shoot ratio × *Above Ground C-stock*;

where the *root-shoot ratio* is dimensionless and is 0.18 for spruce and 0.23 for other hardwoods in Manitoba's boreal shield (Tree Canada, 2009).

The data on the total dry biomass (above ground and below ground) of the forest cover was provided by NFI (2010) and partitioned into the respective above and below ground fractions based on the root-shoot ratio for spruce and hardwoods. The conversion from the dry tree biomass to tree biomass C is 0.5 (tonne C/tonne dry biomass) (Tree Canada, 2009).

The proposed ASR has a 60 m right of way (ROW) running from Manigotagan (PR 304) to Bloodvein and from Bloodvein to Berens River. The land cover statistics along the ROW for the length of the ASR was provided by the Manitoba Floodway and East Side Road Authority (2010). These data provided the spatial coverage of softwoods and hardwoods along the ROW of the proposed ASR which were approximately 246 ha and 117 ha, respectively.

3.1.2 Net GHG Emissions from the Land Cover

The route of the proposed ASR will cover both wetlands and forested areas. Boreal wetlands and uplands (forested areas) are known natural sources and sinks of methane (e.g., Bubier et al., 2005, and Potter et al., 2001) and carbon dioxide (Potter et al., 2001, and Trumbore et al., 1999).

The following methodology was used in estimating the net GHG emissions from the wetlands impacted by the ASR:

Net GHG emissions due to wetlands along the proposed ASR (tonnes CO_2e/yr) = Methane flux from forest soils (tonnes CO_2e/ha) × forest area (ha) + Methane flux from wetlands (tonnes CO_2e/ha) × wetland area (ha) + Carbon dioxide flux from wetlands (tonnes C/ha) × wetland area (ha) × C-CO_2 conversion (tonne CO_2/tonne C).

In a study conducted over a boreal wetland and upland near Thompson MB, Bubier et al. (2005) measured methane (CH_4) emissions over the growing season from wetlands that ranged from 10 – 350 mg CH_4/m^2/day and sinks (removals) from black spruce upland soils that ranged from 0 – 1.0 mg CH_4/m^2/day. The wetland consisted of fens, bogs, and small ponds. The forested areas were mature forests 60 years or more in age (since the last burn). Potter et al. (2001) using a process model, estimated CH_4 emissions from a similar landscape of approximately 2.8 mg CH_4/m^2/day from the wetland (fen) and a sink of approximately 0.5 mg CH_4/m^2/day from an old Black Spruce upland.

In the same study area near Thompson, Trumbore et al. (1999) measured and estimated the annual carbon sink from four differing wetlands and using three different estimation methods that ranged from -2.56 to 180 g C/m^2/yr. The negative value indicated that the wetland was a carbon source during the study. Potter et al. (2001) using the same process model described above estimated the carbon sink for similar wetlands in the same study area ranging from -10.7 to -11.8 g C/m^2/yr indicating a source for carbon emissions into the atmosphere.

For the purposes of this study, the mean CH_4 emissions from the wetlands of the two studies (Bubier et al., 2005 and Potter et al., 2001) was calculated to be 86 mg CH_4/m^2/day and assumed to be representative of the CH_4 emissions from the existing wetlands covered by the proposed ASR. Similarly the mean of the CH_4 sinks / removals by the forested areas from the two studies, calculated to be 0.2 mg CH_4/m^2/day, was assumed to be representative of the CH_4 sink of the forest covered by the proposed ASR. The mean CO_2 sink due to the wetlands of the two studies by Potter et al. (2001) and Trumbore et al. (1999) was calculated to be 205.7 g CO_2/m^2/yr (56.1 g C/m^2/yr) and was assumed to be representative of the CO_2 sink of the existing wetlands impacted by the proposed ASR.

These emissions and removals would occur over the growing season of the study area which were estimated to be from April to October (Environment Canada above 0°C temperature normals for Pine Dock climate station located ~ 17 km southwest of Bloodvein). Total net CH_4 emissions (emissions minus removals) were then estimated from the wetland and forested area data provided by Manitoba Floodway and East Side Road Authority (2010).

It should be noted that CO_2 and CH_4 emissions and removals (i.e., flux) are highly variable and intermittent and are dependant on environmental temperature (growing season), moisture and precipitation. Thompson MB, where the studies of Bubier et al. (2005), Potter et al. (2001) and

Trumbore et al. (1999) were conducted, is approximately 450 km north of the study area and therefore has lower annual environmental temperatures and rainfall (-3.2°C and 348 mm rainfall, Environment Canada climate normals) than the study area (1.1°C and 425 mm rainfall, Environment Canada climate normals for Pine Dock). It is therefore expected that the net CO_2 and CH_4 flux may be higher for the Project's area than the calculated approximations from these research studies. The above estimated wetland CO_2 removals, and CH_4 emissions and forest soil removals for the Project's study area should therefore be considered as an approximation.

3.1.3 GHG Emissions of Air Travel

Under existing conditions, air travel is between Winnipeg and Bloodvein, between Winnipeg and Berens River, between Matheson Island and Bloodvein, and between Matheson Island and Berens River. This air travel provides a vital link to the south for Bloodvein and Berens River. The GHG emissions based on air travel was estimated from these routes of air travel, the total annual number of flights and their distances, and the projected number of such flights to 2023.

The annual GHG emissions due to the air traffic to and from Berens River and Bloodvein can be calculated from:

$$\text{Annual Air Travel GHG Emissions (tonnes } CO_2e/yr) = \sum_{Airport} \{\text{Air Movements} \times \text{Air Movement Fraction} \times \text{Trip Duration (hr)} \times \text{Fuel Consumption Rate (L/hr)} \times EF_{air}\ (g\ CO_2e/L) \times 10^{-6}\ (tonnes/g)\}$$

Where:

Airport refers to the airport at Berens River, and Bloodvein;

Air Movements is the officially recorded total annual air movements given in **Table 3.1-1** at each airport and the estimated annual air movements projected to 2023;

Air Movement Fraction is the 20 / 80 fractional ratio for movements to and from Winnipeg and Matheson Island, respectively;

Trip Duration is the estimated duration of each type of trip;

Fuel Consumption Rate is the estimated average aviation fuel consumption rate for each type of trip; and

EF_{air} = 2607 g CO_2e/L is the aggregated emission factor for aviation turbo fuel (Environment Canada, 2009).

The Government of Manitoba's Infrastructure and Transportation (MIT, 2010b) provided data on the number of air movements at the airports of Bloodvein and Berens River. These data were then used to estimate the existing as well as the potential future volumes of air traffic at these two communities for this study. **Table 3.1-1** summarises the officially recorded air movements from 2000 to 2008 and **Figure 3.1-1** illustrates the data. It should be noted however that actual air movements are higher than those officially recorded as aircraft arrive and depart from the airports outside of official hours. Therefore, when estimating the GHG emissions associated with air traffic movement, the reported air movements given in **Table 3.1-1** were increased by 25% to account for the unrecorded air movements. This increase is a first approximation and subject to revision based on the availability of data.

The annual air movements at Berens River from 2000 to 2008 indicated a continuous annual decline in volume which was best fit ($r^2 = 0.89$) with a regression equation of:

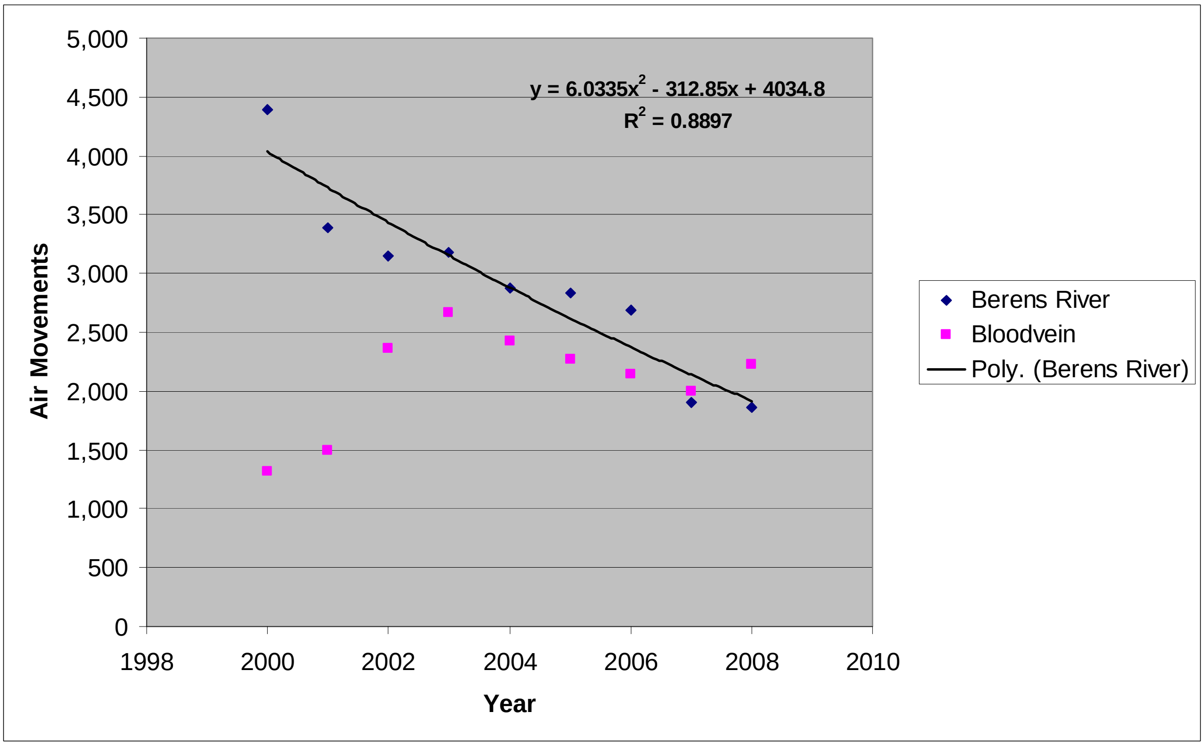
$$\text{Annual Air Movements} = 6.0335 \times (\text{Year} - 2000)^2 - 312.85 \times (\text{Year} - 2000) + 4034.8.$$

Using this equation, it was estimated that by 2023, total air movement at Berens River airport will decline to 31. For Bloodvein, the total annual air movements remained relatively stable between 2002 and 2008 with an average of 2,301 movements. This annual average was assumed to be consistent to 2023 for the purposes of this study.

Table 3.1-1 Total Air Movements at Bloodvein and Berens River Airports from 2000 to 2008

Community	2000	2001	2002	2003	2004	2005	2006	2007	2008
Berens River	4,392	3,394	3,153	3,175	2,881	2,838	2,686	1,902	1,860
Bloodvein	1,319	1,491	2,361	2,668	2,429	2,272	2,144	1,997	2,233

Figure 3.1-1 Total Air Movement at Bloodvein and Berens River Airports



The trend in the movements between Matheson Island and Berens River is indicated with an $r^2 = 0.89$.

The air service providers and types of aircraft received at Berens River (Dillon, 2010) were of the following:

- Perimeter Airlines from Winnipeg using Beechcraft 99 and Fairchild Metroliners;
- Fast Air from Winnipeg using Beachcraft King Air and Piper Navajo;
- Keystone Airlines from Winnipeg using Beechcraft King Air, Beechcraft 99, Piper Navajo and Piper Chieftan; and
- WamAir from Matheson Island using Cessna 206 and 208.

It was assumed that 20% of the total movements were to and from Winnipeg and 80% was to and from Matheson Island. This breakdown was based on communication with Berens River airport management (Dillon, 2010). It was also assumed that the same air service providers and ratio of flights between Winnipeg and Bloodvein and Matheson Island and Bloodvein were similar (i.e., 20 / 80, respectively, Dillon, 2010).

Based on the available performance data on the aircrafts indicated above, the average cruising speed and fuel consumption rate for the aircrafts flying to and from Winnipeg to the two communities were estimated to be approximately 390 km/h and 271 L/h, respectively. For the Cessna 206/208, the average cruising speed was estimated to be 259 km/h and the average fuel consumption was approximately 120 L/h.

The duration of each type of trip can then be estimated based on the cruising speed of the aircraft type and the round-trip distances of:

- Winnipeg and Berens River: 540 km;
- Winnipeg and Bloodvein: 412 km;
- Matheson Island and Berens River: 140 km; and
- Matheson Island and Bloodvein: 35 km.

3.1.4 GHG Emissions of Ferry Crossing

Under existing conditions, the Government of Manitoba's Infrastructure and Transportation operates the M.V. Edgar Wood ferry while a private concern operates another ferry/barge service. These ferry and barge services provide a vital link for the Bloodvein and Princess Harbour communities and those beyond. The M.V. Edgar Wood ferry carries passengers, vehicles and freight to and from Bloodvein. The ferry crossing is primarily from Island View harbour to Bloodvein with service to Princess Harbour upon special request. The GHG emissions based on the ferry crossing was estimated from the total number of round trips per year, the total duration of each round trip, and the projected number of such round trips to 2023.

The annual GHG emissions due to the M.V. Edgar Wood ferry crossing can be calculated from:

Annual Ferry Crossing GHG Emissions (tonnes CO_2e/yr) = Total Annual Number of Round Trips × Duration per Round Trip (hr) × EF_{ferry} (kg CO_2e/hr) × 0.001 (tonnes/kg).

The Government of Manitoba's Infrastructure and Transportation (MIT, 2010c) provided data on the ferry service which was used to estimate the existing and the potential future annual number of trips conducted by the ferry service. The M.V. Edgar Wood provides two round trips per day on Monday and Friday, one round trip per day Tuesday, Wednesday and Thursday, and one round trip per day on alternate Saturdays resulting in a total of 15 round trips every two weeks. Since 2000, the ferry season has been from either the beginning or end of May to end of October.

For the purposes of this study, it was assumed that the season was from beginning of May to end of October which would result in approximately 197 round trips per year. Each round trip lasts approximately 3 hours.

Communication with Captain David Stephanson of the M.V. Edgar Wood (25 May 2010) indicated that the vessel was equipped with two 215 hp inboard diesel engines. The US EPA NONROAD 2005 mobile emission model (US EPA, 2008) was used to predict the emission factor for the ferry's diesel engines. The NONROAD emission model did not provide the exact power rating, therefore to be conservative the emission factor for 300 hp diesel engine was used resulting in a cumulative EF_{ferry} = 82.6 kg CO_2e/hr.

No data were available for the privately operated ferry/barge. Therefore it was assumed conservatively that the annual GHG emissions associated with this private operation was approximately 50% of the emissions due to the M.V. Edgar Wood ferry. This is a first approximation and subject to revision with the availability of data.

3.1.5 GHG Emissions of Transportation between Winnipeg and Islandview/Pine Dock

Overland travel by trucks and personal vehicles under existing conditions to and from Matheson Island/Islandview/Pine Dock would typically be from Winnipeg and communities along PTH 8 and PR 234. These trips would then cross over to and from Bloodvein and Berens River by air or ferry. For the purpose of this study, it was conservatively assumed that all travel originated or terminated from or in Winnipeg. Estimating the travel distances and patterns from other communities along the PTH 8 and PR 234, and other travel patterns that would flow into these roadways was considered beyond the scope of this study.

GHG Emissions due to Vehicles between Winnipeg and Islandview/Pine Dock

The annual GHG emission due to vehicles travelling between Winnipeg and Islandview / Pine Dock was estimated using the following relationship:

Annual GHG Emission Travel between Winnipeg and Islandview/Pine Dock (tonnes CO_2e/yr) = $\sum_{vehicle\ category}$ {Vehicle Category Number of Trips (Trips/yr) × Trip Duration (hr/Trip) × Fuel Use (L/hr) × $EF_{vehicle\ category}$ (g CO_2e/L) × 10^{-6} (tonnes/g)}

The total travel distance from Winnipeg to PR 234 on PTH 8 was estimated to be approximately 165 km one-way and the estimated minimum vehicular speed was 80 km/h (posted speed limit of 100 km/h). This resulted in an estimated travel time of approximately 2.1 hours. PTH 8 is asphalt. PR 234 from PHT 8 to Islandview / Pine Dock is a gravel road with posted speed limit of 90 km/h and assumed minimum speed of 60 km/h. The total distance was estimated to be approximately 75 km (one-way) resulting in a travel time of 1.25 hr.

The fuel consumption rate of 12 L/hr for a typical pickup truck travelling on asphalt road surface was conservatively assumed to represent the fuel economy for the personal cars and pickup truck vehicle category. For the heavy truck category, a fuel consumption rate of 15 L/hr for a typical heavy truck travelling on asphalt road surface was assumed.

Due to the poorer road surface conditions that a gravel road present in comparison to a paved road surface, the US EPA (2006) has estimated that fuel consumption increases by approximately 19.2% for gravel roads versus paved roadways. This deterioration in fuel economy was applied to travel on PR 234.

The cumulative emission factor (includes CO_2, CH_4 and N_2O) for cars and pickup trucks $EF_{cars,\ pickups}$ = 2498 g CO_2e/L, and for heavy trucks $EF_{heavy\ trucks}$ = 2691 g CO_2e/L was used based on the emission factors given in Environment Canada (2009).

The annual total number of cars and pickup trucks, and heavy trucks travelling between Winnipeg and Islandview / Pine Dock was estimated from the air travel and ferry passenger and freight data and includes the approximate increases due to the unreported air movements and ferry/barge service.

Estimated Annual Volume of Vehicles based on Air Travel

Similarly to the pattern in the annual volume of flights, the number of passengers going to and from Berens River has been decreasing annual since 2000 whereas the number of passengers on flights to and from Bloodvein has remained relatively steady since 2002 (MIT, 2010b). These data were then used to estimate the existing as well as the potential future number of passengers travelling by air to and from these two communities for this study. **Table 3.1-2** summarises the reported air travel passenger volumes from 2000 to 2008 and **Figure 3.1-2** illustrates the data.

The reported annual number of passengers at Berens River airport from 2000 to 2008 indicated a continuous annual decline in volume which was best fit ($r^2 = 0.91$) with a regression equation of:

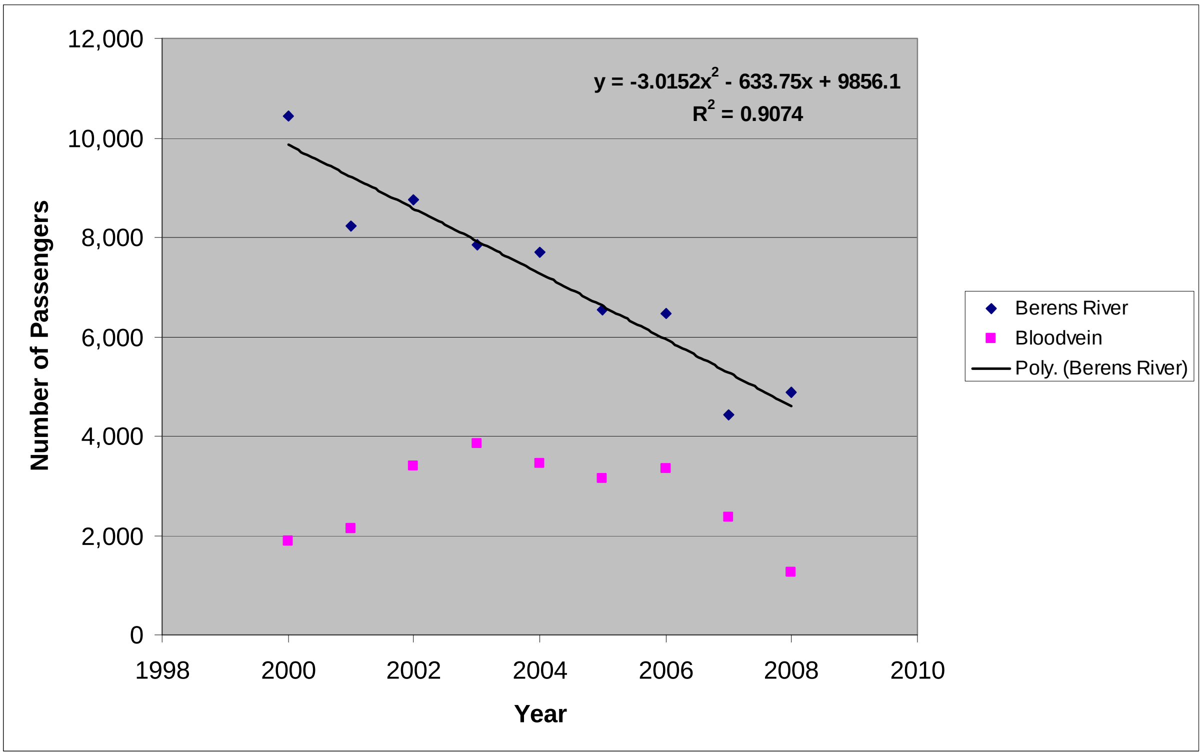
$$\textit{Annual Air Travel Passengers} = -3.0152 \times (\textit{Year} - 2000)^2 + 633.75 \times (\textit{Year} - 2000) + 9856.1$$

Using this equation, it was estimated that by 2015, the total number of passengers using the Berens River airport would be less than zero. It was therefore assumed that the number of passengers would remain at the 2014 estimated volumes of 393 passengers per year till 2023. For Bloodvein, the reported total annual number of passengers remained relatively stable between 2002 and 2008 with an average of 2,761 passengers per year. This annual average was assumed to be consistent to 2023 for the purposes of this study.

Table 3.1-2 Total Air Travel Passengers at Bloodvein and Berens River Airports from 2000 to 2008

Community	2000	2001	2002	2003	2004	2005	2006	2007	2008
Berens River	10,440	8,214	8,752	7,853	7,697	6,553	6,456	4,418	4,892
Bloodvein	1,880	2,140	3,395	3,851	3,434	3,153	3,353	2,377	1,264

Figure 3.1-2 Total Air Travel Passengers at Bloodvein and Berens River Airports



Due to the small size of the aircrafts operated by WamAir from Matheson Island (i.e, Cessnas), it was assumed that the majority of vehicles travelling to and from the airport would be personal vehicles and light duty trucks.

In order to estimate the number of personal vehicles and light duty trucks travelling between Winnipeg and Matheson Island airport, it was assumed that there were two passengers per vehicle. Since 80% of the air movements at Berens River and Bloodvein originate from Matheson Island, it was assumed that 80% of the volume of passengers would arrive or depart from Matheson Island. This would give a first approximation to the volume of passengers using the Matheson Island airport. However it is noted that aircraft from Winnipeg are larger and would potentially carry more passengers. Note that vehicular volumes to the airport were also increased by 25% to match the unreported air movement volumes.

Estimated Annual Volume of Vehicles based on Ferry Travel

MIT (2010d) provided data on the number of passengers, volumes of vehicles and the vehicle classes that used the ferry to cross to and from Islandview harbour and Bloodvein. **Table 3.1-3** summarises the passenger and vehicular statistics for the ferry from 2000 to 2009. There were no trends in the volume of passengers or vehicles using the ferry from 2000 to 2009. Therefore the averages of 910 cars and pickup trucks, and 218 heavy trucks and buses were used to describe the vehicular volumes using the ferry over this period. These volumes were used to project the annual number of such classes of vehicles using the ferry to 2023. Note that the cars and pickup truck category include vehicles up to ¾ -ton trucks and miscellaneous vehicles (motorcycles and all terrain personal vehicles). The heavy truck category included trucks with single and dual axel over ¾-ton, semi-trailers, buses, graders and loaders.

No data on vehicular volumes and types were available for the privately operated ferry/barge. Therefore it was assumed that the additional traffic going to this ferry/barge was 50% of the traffic reported for the M.V. Edgar Wood.

Table 3.1-3 M.V. Edgar Wood Statistics from 2000 – 2009

YEAR	PASSENGERS	CAR AND UP TO 3/4 TON TRUCK	TRUCK-SINGLE AND DUAL AXLE OVER 3/4 TON	SEMI-TRAILER	BUS	LOADER	GRADER	MISCELLANEOUS	TOTAL vehicles
2000	2990	880	140	110	5	1	27	229	1392
2001	2150	674	185	79	4	0	0	205	1147
2002	1940	553	134	25	8	7	0	157	884
2003	3023	805	121	43	20	17	1	94	1101
2004	2301	677	86	23	10	1	3	170	970
2005	2589	745	87	17	4	3	0	245	1101
2006	2365	823	130	57	7	5	1	175	1198
2007	1883	589	170	67	8	9	0	206	1049
2008	1887	611	156	33	7	7	1	237	1052
2009	2823	742	233	101	9	15	7	284	1391
Average	**2395**	**710**	**144**	**56**	**8**	**7**	**4**	**200**	**1129**

3.1.6 GHG Emissions of Seasonal Road Construction and Maintenance

It was assumed that the seasonal road (i.e., winter road and ice road) would be constructed and operated between January and March. The GHG emissions would be associated with the emissions due to the mobile equipment used to construct the winter road and ice road, and the emissions associated with the equipment used in the general maintenance of the seasonal road, i.e.

Annual GHG Emissions Construction and Maintenance (tonnes CO_2e/yr) = Annual GHG Emissions Construction (tonnes CO_2e/yr) + Annual GHG Emissions Maintenance (tonnes CO_2e/yr)

Construction of the Seasonal Road

The GHG emissions associated with the construction of the seasonal road would be estimated by:

Annual GHG Emissions Constructing Seasonal Road (tonnes CO_2e/yr) = $\sum_{equipment\ types}$ {Number of Equipment Type × Duration (hr/year) × $EF_{equipment\ type}$ (g CO_2e/hr) × 10^{-6} (tonnes/g)}

The type and quantity of road construction equipment assumed to be used in the construction of the seasonal road is given in **Table 3.1-4**. It was assumed that the ice road would employ all of the equipment listed in the table and take approximately three days to build resulting in a total of 20 hours. For the winter road, it was also assumed that all of the equipment will be used and the construction would take approximately 15 days for a total of 120 hours.

The cumulative GHG emission factors $EF_{equipment\ type}$ for each type of equipment are listed in **Table 3.1-4**. These emission factors were based on US EPA NONROAD 2005 emission model for non-highway mobile equipment (US EPA, 2006).

Table 3.1-4 Equipment Used in Constructing Seasonal Road and GHG Emission Factors

Equipment Type	Quantity	$EF_{equipment\ type}$ (kg CO_2e/hr)
Diesel Off-Highway Tractors - 750 HP	1	287.0
Diesel Graders - 300 HP	1	73.4
Diesel Tractors/Loaders/Backhoes - 100 HP	1	12.7
Diesel Snowblowers - 300 HP	1	57.4
2-Stroke Snowmobiles - 75 HP	4	40.2

Maintenance of Seasonal Road

A similar approach to estimating the GHG emission due to the construction of the seasonal road was used in estimating the GHG emissions associated with the maintenance of the seasonal road:

Annual GHG Emissions Maintaining Seasonal Road (tonnes CO_2e/yr) = $\sum_{equipment\ types}$ {Number of Equipment Type × Duration (hr/year) × $EF_{equipment\ type}$ (g CO_2e/hr) × 10^{-6} (tonnes/g)}

For the maintenance of the seasonal road, it was assumed that only the grader and snowblower, and the same number of snowmobiles would be employed.

For the ice road, it was assumed that there would be approximately four maintenance events per month with each event lasting for 4 hours. This would result in a total of 32 hours per season. For the winter road from Bloodvein to Berens River, it was assumed that there would also be approximately four maintenance events per month. The duration of each maintenance event was estimated to be approximately 28 hours (three days) based on the length of the winter road and typical speed of snow clearing and grading. The total number of hours per season estimated for the maintenance of the winter was approximately 221 hours.

3.1.7 GHG Emissions of Vehicular Travel During Winter

The GHG emissions associated with vehicular travel during the winter was calculated by:

Annual GHG Emissions of Vehicular Travel in Winter (tonnes CO_2e/yr) = Annual GHG Emissions of Vehicular Travel in Winter Between Winnipeg and Pine Dock (tonnes CO_2e/yr) + Annual GHG Emissions of Vehicular Travel on Seasonal Road (tonnes CO_2e/yr).

Where:

Annual GHG Emissions of Vehicular Travel between Winnipeg and Pine Dock (tonnes CO_2e/yr) = $\sum_{vehicle\ category}$ {Vehicle Category Number of Trips (Trips/yr) × Trip Duration (hr/Trip) × Fuel Use (L/hr) × $EF_{vehicle\ category}$ (g CO_2e/L) × 10^{-6} (tonnes/g)}

and

Annual GHG Emissions of Vehicular Travel on Seasonal Road (tonnes CO_2e/yr) = $\sum_{seasonal\ road\ segment} \sum_{vehicle\ category}$ {Vehicle Category Number of Trips (Trips/yr) × Trip Duration (hr/Trip) × Fuel Use (L/hr) × $EF_{vehicle\ category}$ (g CO_2e/L) × 10^{-6} (tonnes/g)}

Vehicular traffic volumes on the seasonal road were estimated for the communities that the seasonal road would service. These communities included the Southeast Tribal Council (SERCA) communities of Poplar River, Berens River, Bloodvein, Little Grand Rapids, and Pauingassi, and the Island Lake Tribal Council (ILTC) communities of St. Theresa Point, Wasagamack, Garden Hill, and Red Sucker Lake. A winter road runs from Bloodvein to Berens River and then onto Poplar River. Another winter road runs from Bloodvein to Little Grand Rapids and Pauingassi. This winter road is also connected to another winter road that connects the communities of the ILTC. All winter roads meet at Bloodvein and an ice road connects Bloodvein to Pine Dock across Lake Winnipeg.

Table 3.1-5 summarises the heavy duty and light duty winter road traffic volumes to and from these communities. Vehicular traffic volumes on the seasonal road were estimated from the winter freight demand per capita of the communities that the seasonal road services. It should be noted that these volumes are a first approximation and subject to change based on revised data, information and assumptions.

The ice road would receive the entire volume of traffic while the winter road from Bloodvein to Berens River would receive the volume associated with traffic from Poplar River and Berens River. It was assumed that the volume on the ice road would continue from Pine Dock to Winnipeg. Note that the focus of this GHG assessment with respect to Baseline conditions during the winter is the emissions associated with traffic between Winnipeg and Bloodvein and between Bloodvein and Berens River. Emissions associated with traffic on the winter roads going to other communities from Bloodvein and Berens River is not included as it is assumed that these emissions would remain unchanged with the installation of the ASR between Bloodvein and Berens River.

Table 3.1-5 Estimated Winter and Ice Road Traffic Volumes

Community	**Winter Road (60 Day) Heavy Duty Vehicle Volumes**		**Winter Road (60 Day) Light Duty Vehicle Volumes**		**One-Way Daily Traffic to bring in required tonnage**		**2-Way Daily Traffic (in plus return trip)**		**Total 2-Way Traffic**
	Split	Volume	Split	Volume	HDV	LDV	HDV	LDV	
Southeast Tribal Council (SERCA)									
Poplar River	30%	75	70%	3,485	1	58	2	116	119
Berens River	45%	158	55%	3,870	3	64	5	129	134
Total on Berens River to Bloodvein Segment					4	123	8	245	253
Bloodvein	15%	16	85%	1,853	0	31	1	62	62
Little Grand Rapids	30%	69	70%	3,215	1	54	2	107	109
Pauingassi	30%	37	70%	1,723	1	29	1	57	59
Island Lake Tribal Council (ILTC)									
St. Theresa Point	70%	439	30%	3,761	7	63	15	125	140
Wasagamack	70%	253	30%	2,167	4	36	8	72	81
Garden Hill	85%	495	15%	1,747	8	29	16	58	75
Red Sucker Lake	90%	130	10%	290	2	5	4	10	14
Total on Ice Road Segment between Bloodvein and Pine Dock					28	368	56	737	793

Totals may not add due to rounding to the nearest significant figure.

The seasonal road was estimated to be operational for two months from January 1st to March 1st (i.e., approximately 60 days). This assumption provided an estimate on the total number of trips per vehicle category for the season (i.e., year) on a given road segment (ice road or winter road).

It was assumed that travel speed on the ice and winter road would be approximately 30 km/h. The travel distance on the ice road was estimated to be approximately 16 km and the distance of the winter road was approximately 83 km resulting in travel durations of 0.5 hr and 2.8 hr, respectively. The US EPA (2006) estimated that the fuel economy degrades by approximately 20% for travel on snowy gravel roads in comparison to dry paved (asphalt) roads.

For the travel between Winnipeg and Pine Dock, the same assumptions when estimating the GHG emissions during the non-winter seasons were maintained.

3.2 Project Scenario

The Project scenario estimated the GHG emissions associated with four years of construction of the ASR in addition to projecting 10 years to 2023 the emissions associated with the operation of the ASR. As with the Baseline scenario, the Project scenario assumes that the existing climatic conditions will prevail to 2023 and that the impact of climate change is not incorporated into the assessment. The Project scenario also does not assume any growth in the communities of Berens River and Bloodvein or growth in the communities along the route between Winnipeg and Bloodvein. Such growth may potentially impact the traffic volumes on the ASR predicted for the purposes of this GHG assessment and is beyond the scope of this study.

It should be noted that Baseline conditions would persist during the initial construction period and gradually change. For the purpose of assessing the GHG implications of the Project scenario, it is assumed that the Baseline conditions would occur for the first three years of the construction period. From the final (fourth) year of construction, it is assumed that a significant portion of the ASR would be completed and operating so that the Baseline conditions would change significantly and cease to exist.

The Project scenario estimated the GHG emissions and sinks / removals and the resulting cumulative GHG emissions by:

Annual Project GHG Emissions (tonnes CO_2e/yr) =

GHG emissions due to land clearing along the proposed ASR (tonnes CO_2e/yr)
+ Methane emissions due to the wetlands along the proposed ASR (tonnes CO_2e/yr)
+ GHG emissions due to construction of the ASR (tonnes CO_2e/yr)
+ GHG emissions due to air travel to Bloodvein and Berens River (tonnes CO_2e/yr)
+ GHG emissions due to ferry crossing from Islandview/Pine Dock to Bloodvein (tonnes CO_2e/yr)
+ GHG emissions due to transportation on PTH 8 and PR234 (tonnes CO_2e/yr)
+ GHG emissions due to transportation between Winnipeg and Berens River (tonnes CO_2e/yr)
+ GHG sequestration due to reforestation of disturbed land (tonnes CO_2e/yr)

Details on the above sources and sinks / removals are given in the following sections.

3.2.1 GHG Emissions Due to Land Clearing

GHG emissions associated with land clearing in preparation of the construction of the proposed ASR include the assumed burning of slash and shrubs, emissions due to the decomposition of the root biomass, emissions due to the use of the harvested wood for firewood, and the use of land clearing and construction equipment in the harvesting of the wood and clearing of the land. Total annual GHG emissions are calculated by:

Annual GHG Emissions due to Land Clearing (tonnes CO_2e/yr) = GHG Emissions from Slash and Shrub Burning (tonnes CO_2e/yr) + GHG Emissions from Root Biomass Decomposition (tonnes CO_2e/yr) + GHG Emissions from Firewood (tonnes CO_2e/yr) + GHG Emissions Land Clearing (tonnes CO_2e/yr)

GHG Emissions from Slash and Shrub Burning

The proposed ASR has a 60 m right of way (ROW) running from Manigotagan (PR 304) to Bloodvein and from Bloodvein to Berens River. The land cover statistics along the ROW for the length of the ASR was provided by the Manitoba Floodway and East Side Road Authority (2010). These data provided the spatial coverage of treed and shrub areas along the ROW of the proposed ASR which were approximately 363 ha and 337 ha, respectively. Using the methodology described in **Section 3.1.1**, the total treed biomass and shrub biomass cleared for the ASR was approximately 13,970 tonnes and 1,687 tonnes, respectively.

NRCan (2009) notes that approximately 50% of the harvested tree biomass is converted into durable long lasting products such as wood for construction and the carbon is therefore not readily emitted back into the atmosphere post harvesting. The root fraction of the total tree biomass cover for the ROW of the ASR was estimated to be 16%. Therefore the remaining 34% of the tree biomass was assumed to be subject to burning of which it was assumed that half would be slash burned and half used as firewood. The latter source of emissions is not included in this assessment as this volume of biomass would have been harvested regardless of the project (i.e., would also occur under baseline conditions) and used as firewood by the communities.

The IPCC (2006) methodology was used in estimating the GHG emissions due to slash burning:

> *GHG Emissions from Slash Burning (tonnes CO_2e/yr) = Area of Burn (ha) × Mass of Available Fuel (tonnes/ha) × Cf × EF_{slash} (g/kg dry biomass burnt)*

Where *Cf* is the combustion factor and is considered to be 0.33 for boreal forest post logging slash burn; and EF_{slash} = 1748 g CO2e/kg fuel for extra tropical forests. The Mass of Available Fuel was the sum of the tree biomass available for slash burning and the total shrub biomass cleared for the ASR. The GHG emission due to slash burning was assumed to occur evenly over the four years of construction of the proposed ASR.

GHG Emissions from Root Biomass Decomposition

The total root biomass was estimated to be approximately 16% of the total biomass. Although it may take many years for the root biomass to completely decompose under the climatic environment of the boreal ecozone, it was assumed that the GHG emission due to the decomposition of the root biomass all occurred within the first year of construction for the purposes of this assessment.

The methodology in estimating the GHG emissions from the decomposition of the root biomass was described in **Section 3.1.1**.

GHG Emissions Land Clearing

The GHG emissions associated with the clearing of the land in preparation of the proposed ASR was estimated by:

Annual GHG Emissions Land Clearing (tonnes CO_2e/yr) = $\sum_{equipment\ types}$ {Number of Equipment Type × Duration (hr/year) × Fuel Consumption of Equipment Type (L/hr) × $EF_{equipment\ type}$ (g CO_2e/L) × 10^{-6} (tonnes/g)}

The type and quantity of earth moving, land clearing, and general mobile equipment used in the clearing operation was provided by AECOM (2010) and is given in **Table 3.2-1**. The same equipment was used for mechanical and hand clearing equipment, and mechanical mulching. For mechanical and hand clearing, the equipment were estimated to be employed for 1000 hours per year. For mechanical mulching, the equipment was estimated to be used for 1875 hours per year.

The cumulative GHG emission factors, $EF_{equipment\ type}$, for each type of equipment are listed in **Table 3.2-1**. These emission factors were based on US EPA NONROAD 2005 emission model for non-highway mobile equipment (US EPA, 2006).

Table 3.2-1 Equipment Used in Land Clearing and GHG Emission Factors

Equipment Used	Quantity	Fuel Consumption (L/hr)	Net Power (hp)	$EF_{equipment\ type}$ (g CO_2e/L)
Mechanical/Hand Clearing				
CAT D6 wide pad	1	35	150	2701
GMC Sierra 3500 4x4 Service Truck	0	12	360	2713
GMC Sierra 4x4 Quad Cab Truck	1	12	360	2713
Chain saws	4	4	3	2053
Hydro-Axe Mechanical Mulching Unit	0	50	300	2709
Mechanical Mulching				
CAT D6 wide pad	1	35	150	2701
GMC Sierra 3500 4x4 Service Truck	1	12	360	2713
GMC Sierra 4x4 Quad Cab Truck	1	12	360	2713
Chain saws	4	4	3	2053
Hydro-Axe Mechanical Mulching Unit	1	50	300	2709

3.2.2 Net Methane Emissions from Landcover

The proposed ASR is anticipated to cover approximately 27% of the land cleared for the Project. This estimate was based on the width of the ROW of 10 m and the assumption that there is an additional 3 m on each side of the ROW that will be disturbed and cover the existing land surface. Therefore, it is estimated that the net annual CH_4 emissions under the Baseline scenario would be reduced by 27% due to the coverage of the ASR.

3.2.3 GHG Emissions Due to Construction of the ASR

Construction of the ASR involves the construction of the roadway and bridges. The following was used to estimate the GHG emissions associated with the construction:

Annual GHG Emissions Due to Construction (tonnes CO_2e/yr) = $\sum_{equipment\ types}$ {Number of Equipment Type × Duration (hr/year) × Fuel Consumption of Equipment Type (L/hr) × $EF_{equipment\ type}$ (g CO_2e/L) × 10^{-6} (tonnes/g)}

AECOM (2010) provided data on the list of equipment used in the construction of the ASR, the estimated fuel consumption rate, and the total number of hours of operation for each type of equipment. **Table 3.2-2** summarises the data provided by AECOM (2010) and the $EF_{equipment\ type}$ based on US EPA (2008) NONROAD 2005 emission model results.

Table 3.2-2 Equipment Used in Construction of the Roadway and GHG Emission Factors

Equipment Used	Number of Equipment Used	Fuel Consumption (L/hr)	Annual Hours (hrs/yr)	Net Power (hp)	$EF_{equipment\ type}$ (g CO_2e/L fuel)
Shot Rock Fill					
CAT 740 Articulated Truck	1	45	5156.25	453	2712
CAT D8T Track-Type Tractor Dozer	1	30	5156.25	310 (FP)	2712
CAT 966 H Wheeled Loader	1	27	5156.25	262	2712
CAT 385C L Hydraulic Excavator	1	49	5156.25	513 (NFP)	2713
CAT 450E Backhoe Loader	1	11	5156.25	124	2697
GMC Sierra 3500 4x4 Service Truck	1	12	5156.25	360	2713
GMC Sierra 2500 4x4 Quad Cab	5	12	5156.25	360	2713
Composite Excavation					
CAT D8T Track-Type Tractor Dozer	1	30	4278.75	310 (FP)	2712
CAT 385C L Hydraulic Excavator	1	49	4278.75	513 (NFP)	2713
GMC Sierra 3500 4x4 Service Truck	1	12	4278.75	360	2713
GMC Sierra 2500 4x4 Quad Cab	3	12	4278.75	360	2713
Processed Aggregate Production					
CAT 966 H Wheeled Loader	2	27	6350	262	2712
GMC Sierra 3500 4x4 Service Truck	1	12	6350	360	2713
GMC Sierra 2500 4x4 Quad Cab	3	12	6350	360	2713

Equipment Used	Number of Equipment Used	Fuel Consumption (L/hr)	Annual Hours (hrs/yr)	Net Power (hp)	$EF_{equipment\ type}$ (g CO_2e/L fuel)
CEDARAPIDS Mobile Aggregate Crushing system (MACS)	1	60	6350	600	2711
Aggregate Haul					
CAT 740 Articulated Truck	1	45	5253.75	453	2712
CAT D8T Track-Type Tractor Dozer	1	30	5253.75	310 (FP)	2712
CAT 385C L Hydraulic Excavator	1	49	5253.75	513 (NFP)	2713
GMC Sierra 3500 4x4 Service Truck	1	12	5253.75	360	2713
GMC Sierra 2500 4x4 Quad Cab	5	12	5253.75	360	2713
CAT 16M Motor Grader	1	30	5253.75	297	2712
CAT CS-433E Vibratory Soil Compactor	1	11	5253.75	100 (Gross)	2703
Freightliner M2 2010 Water Truck	1	30	5253.75	450	2714
Abutment/Pier/Box Culvert Extraction					
CAT 330 Hydraulic Excavator	1	45	170	270 (NFP)	2712
CAT D8T Track-Type Tractor Dozer	1	30	170	310 (FP)	2712
CAT 365 Backhoe	1	10	170	87	2697
GMC Sierra 3500 4x4 Service Truck	1	12	170	360	2713
GMC Sierra 2500 4x4 Quad Cab	3	12	170	360	2713
Piling					
GMC Sierra 3500 4x4 Service Truck	1	12	200	360	2713
GMC Sierra 2500 4x4 Quad Cab	1	12	200	360	2713
PILECO Diesel Hammer D19-42	1	35	200	25	2703
Freightliner Classic Truck with low bed trailer	1	35	500	560	2714
Concrete Production					
GMC Sierra 3500 4x4 Service Truck	1	12	650	360	2713
GMC Sierra 2500 4x4 Quad Cab	1	12	650	360	2713
Preem Advantage 101 (Portable Batch Plant)	1	60	100	600	2709
Concrete Pumper Truck	1	20	550	200	2708
Concrete Steel Reinforcement					
Freightliner Classic Truck with low bed trailer	1	35	600	560	2714
Girder Supply and Installation					
GMC Sierra 3500 4x4 Service Truck	1	12	200	360	2713
GMC Sierra 2500 4x4 Quad Cab	1	12	200	360	2713
Freightliner Classic Truck with low bed trailer	1	35	250	560	2714
Linkbelt 138 HSL Lattice Boom Crawler Crane	1	40	200	400	2712

3.2.4 GHG Emissions of Air Travel

It was assumed that air travel to and from Berens River and Bloodvein during the construction period would remain the same as the Baseline scenario between the period 2010 and 2012 (i.e., during the first three years of construction). In the final (fourth) year of construction and first year of ASR operation, it was assumed that air traffic would decline by 80% from the Baseline. From year two of the ASR operating, it was assumed that air traffic to these communities would become near negligible. This large decline in air travel is a potential scenario since the cheaper mode of road transportation would be favoured for both goods and people. The methodology used in estimating the annual GHG emissions due to air travel described in **Section 3.1.3** was applied with the above assumption.

3.2.5 GHG Emissions of Ferry Crossing

As with the air travel, it was assumed that ferry traffic between Islandview/Pine Dock and Bloodvein during the first three years of construction would remain the same as the Baseline scenario between 2010 and 2012. The final year, year four, of construction, ferry/barge traffic and service would decline by one-third of the Baseline scenario. In the first year of the ASR operating, the ferry/barge traffic and service would decline further by two-thirds of the Baseline scenario. Thereafter it was assumed that the ferry/barge services would cease to operate. The methodology used in estimating the annual GHG emissions due to ferry crossing described in **Section 3.1.4** was applied with the above assumptions.

3.2.6 GHG Emissions of Vehicular Travel on PTH 8 and PR 234

It was assumed that travel using the ferry/barge service would continue during the four years of construction and the first year of ASR operation to allow for commuting between Bloodvein / Berens River and communities along PTH 8 and PR 234. A number of assumptions were made when estimating the GHG emissions due to continued travel between Bloodvein / Berens River and PTH 8 over this period:

- Travel by air would be limited due to its cost; and

- The decline in traffic volumes associated with commuting via the ferry/barge and by air would be comparable to the decline in ferry/barge trips and air movements estimated above.

The methodology used in estimating the annual GHG emissions due to vehicular travel between Winnipeg and Islandview/Pine Dock described in **Section 3.1.5** was followed with the above assumptions.

3.2.7 GHG Emissions of Vehicular Travel Between Winnipeg and Berens River

The annual GHG emission due to vehicular traffic from Winnipeg to Manigotagan via PR 304, and from Manigotagan to Berens River on the ASR was estimated by:

Annual GHG Emissions of Transportation Between Winnipeg and Berens River (tonnes CO_2e/yr*) =* $\sum_{vehicle\ category}$ *{Vehicle Category Number of Trips (Trips/yr) × Trip Duration (hr/Trip) × Fuel Use (L/hr) ×* $EF_{vehicle\ category}$ *(g* CO_2e/L*) ×* 10^{-6} *(tonnes/g)}*

The annual averaged daily traffic (AADT) volume on the ASR was assumed to be 172 for the first 10 years of operation (note that the design of the ASR allows for an AADT of 300, PR 304 to Berens River All-Season Road Environmental Impact Assessment). This AADT was estimated from the total ice road volumes (approximate AADT of 130) and vehicular traffic volumes during the non-winter season (approximate AADT of 13 from the combined traffic due to ferry and airport usage) and assuming an increase of 20% based on ease of travel afforded by the ASR.

Under the Baseline scenario, the percentage of cars and pickup trucks versus heavy trucks travelling to and from Islandview/Pine Dock and Winnipeg was approximately 93% to 7%, respectively. This split in the vehicle categories was assumed to be valid for the traffic between Winnipeg and the new ASR.

The road surface between Winnipeg and Manigotagan is asphalt and the surface of the ASR is gravel. For the gravel surfaced ASR, the fuel economy was assumed to deteriorate by approximately 16% (US EPA, 2006). The distance between Winnipeg and Manigotagan was estimated to be approximately 200 km. The posted speed limit on PR 304 was 90 km/h with an estimated minimum travel speed of 60 km/h resulting in the trip duration of approximately 3.3 hours. The total distance of the ASR was approximately 155 km with a posted maximum speed of 80 km/h and a minimum speed of 60 km/h. This results in an estimated travel time on the ASR of approximately 2.6 hours.

The $EF_{vehicle\ category}$ was 2498 g CO_2e/L for cars and pickup trucks assuming conservatively the emission factor for light duty gasoline trucks; and 2691 g CO_2e/L for heavy trucks assuming heavy duty diesel vehicle emission factor (Environment Canada, 2009).

3.2.8 GHG Sequestration due to Reforestation of the Disturbed Land

In order to mitigation the environmental impacts and GHG emissions associated with the ASR, it is proposed that approximately 106 ha of land cleared along the ASR route will undergo reforestation. Indigenous forest species will be used for the reforestation. The carbon sequestered by the reforestation will occur over a multi-decadal time period. However for the purposes of this assessment, it was assumed that the carbon sequestered over the time period to establish a mature forest (assumed to be 90 years for this assessment) can be distributed linearly over time. The estimated annual carbon sequestration rate was estimated to be 13.2 tonnes CO_2e/yr.

4. GHG Emissions Estimate

Tables **4.1** and **4.2** summarises the GHG emissions under the Baseline scenario and the Project scenario. The Baseline scenario resulted in a total of approximately 136,201 tonnes CO_2e being emitted from 2010 to 2023 inclusive. The Project scenario was estimated to emit a total of approximately 162,720 tonnes CO_2e over the same time period which is roughly 19% more than the Baseline emissions. The net change in GHG emissions due to the Project was therefore estimated to be approximately +27 kilo-tonnes (kt) CO_2e over the time period 2010 to 2023. The majority of the GHG emission is due to the construction of the ASR (approximately 33% of the total) and the increased traffic between Winnipeg and Berens River (approximately 63% of total).

During the construction period, the average annual GHG emission for road construction related activities was estimated to be approximately 13 kt CO_2e per year. Under the Baseline scenario, the annual GHG emission due to the construction of the seasonal road was estimated to be approximately 0.16 t CO_2e per year over the corresponding time period. Therefore the construction of the ASR is anticipated to increase the GHG emissions over the Baseline scenario by nearly +13 kt CO_2e per year. This annual increase in GHG emissions would increase the provincial GHG emissions of construction activities by approximately 13 % based on the 2008 estimates of 0.098 Mt CO_2e. This increase is temporary so that once construction of the ASR has been completed it would result in the reduction of the Province's construction-based GHG emissions.

With the ASR in place, the average annual GHG emission due to road transportation was estimated to be approximately 10 kt CO_2e, in comparison to the average annual GHG emission over the same time period under the Baseline scenario of approximately 9 kt CO_2e due to road, ferry/barge and air travel resulting in a net annual increase in GHG emissions of approximately 1 kt CO_2e. The GHG emissions due only to the road transportation with the ASR in place was therefore estimated to be less than 0.2% of the Province's total GHG emissions of 5.13 Mt CO_2e due to road transportation in 2008.

Table 4.1 Baseline Scenario GHG Emissions from 2010 to 2023

PERIOD CORRESPONDING TO PROJECT SCENARIO	GHG EMMISIONS (Tonnes CO_2e)										TOTAL PER YEAR (Tonnes CO_2e)
	Seasonal Rd Construction	Seasonal Rd Maintenance	Vehicular Use Highway 8	Vehicular Use PR 234	Vehicular Use Seasonal Road	Ferry Operation	Air Travel	Land Clearing	Forest Carbon Sequestration	Wetland Net GHG Emissions	
Construction											
2010	83	74	296	214	7,805	73	1,054	0	-45	668	10,223
2011	83	74	275	199	7,805	73	977	0	-45	668	10,109
2012	83	74	253	183	7,805	73	905	0	-45	668	9,999
2013	83	74	231	167	7,805	73	838	0	-45	668	9,894
Operation											
2014	83	74	209	151	7,805	73	776	0	-45	668	9,794
2015	83	74	209	151	7,805	73	719	0	-45	668	9,737
2016	83	74	209	151	7,805	73	667	0	-45	668	9,685
2017	83	74	209	151	7,805	73	620	0	-45	668	9,638
2018	83	74	209	151	7,805	73	577	0	-45	668	9,596
2019	83	74	209	151	7,805	73	540	0	-45	668	9,559
2020	83	74	209	151	7,805	73	508	0	-45	668	9,527
2021	83	74	209	151	7,805	73	481	0	-45	668	9,500
2022	83	74	209	151	7,805	73	459	0	-45	668	9,478
2023	83	74	209	151	7,805	73	442	0	-45	668	9,461
Total per Mode	1,158	1,033	3,148	2,274	109,273	1,028	9,562	0	-630	9,356	
Overall Total (tonnes CO_2e)											**136,201**

Table 4.2 Project Scenario GHG Emissions from 2010 to 2023

PERIOD	GHG EMMISIONS (Tonnes CO_2e)										TOTAL PER YEAR (Tonnes CO_2e)
	ASR Road Construction	Vehicular Use ASR	Vehicular Use Winnipeg Connect.	Vehicular Use PTH 8 + PR 234	Ferry Operation	Air Travel	Land Clearing	Forest Biomass Decomposition	Forest Carbon Sequestration	Wetland Net GHG Emissions	
Construction											
2010	11,685	0	0	0	0	0	1,361	637	0	488	14,170
2011	11,685	0	0	0	0	0	1,361	0	0	488	13,533
2012	11,685	0	0	0	0	0	1,361	0	0	488	13,533
2013	11,685	0	0	120	49	838	1,361	0	0	488	14,541
Operation											
2014	0	5,921	4,274	69	24	155	0	0	-13	488	10,918
2015	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2016	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2017	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2018	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2019	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2020	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2021	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2022	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
2023	0	5,921	4,274	0	0	0	0	0	-13	488	10,670
Total per Mode	46,739	59,213	42,735	189	74	993	5,443	0	-132	6,830	
Overall Total (tonnes CO_2e)											**162,720**

5. Recommendations for Mitigation and Monitoring

GHG emissions due to the construction and operational phases of the Project can be partially mitigated through the adoption of best management practices and GHG offsets. The following sections explore some of the potential options for the reduction of GHG emissions due to the Project.

5.1 Construction Phase

During the construction of the ASR, construction best management practices should be followed in order to abate GHG emissions (US EPA, 2009). These include, but are not limited to:

- Maintenance and upkeep of all construction equipment in order to meet performance standards set by the manufacturers of the equipment. This will result in efficient use of fuel when the equipment is in operation. Poorly maintained equipment will result in the inefficient use of fuel and the associated increase in GHG emissions.
- Properly size the equipment for the task. Over-sizing or under-sizing the equipment results in excess fuel being consumed and burned.
- Replacing or rebuilding old equipment with more fuel efficient new equipment. The fuel economy, emission rates, and maintenance costs will then be brought up to the current standard resulting in overall lower GHG emissions.
- Driver / operator training for the correct / optimal operation of equipment under different operating conditions. Fuel savings and hence reductions in GHG emissions can be realised through driver / operator training in order to correctly position, operate, and optimise the equipment under different operating conditions. The US EPA (2009) estimated that a typical excavator can save approximately 3 – 8 % in fuel use per year with correct operator training.
- Anti-idling policy for all mobile equipment. Idling of equipment when not in use will result in unnecessary fuel being burned and GHG emissions. Anti-idling policies typically limit the maximum idling time to between 3 and 5 minutes. This policy is especially effective in mitigating GHG emissions during the non-winter months. The installation of fuel-efficient auxiliary power for comfort heating and cooling for equipment operators can also be used in order to abate GHG emissions.

- Busing of construction crew to the construction site will reduce the use of private or individual vehicles thereby reducing GHG emissions.
- Alternatives to diesel generators. Use of dual fuel (natural gas / propane and diesel) generators can significantly reduce GHG emissions in comparison to diesel generators. The US EPA (2009) estimated an approximate 30 % reduction in emissions for a large 500 kW generator.
- Materials selection, procurement and shipping should be optimised in order to minimise the environmental impact of such activities. It is noted that the aggregate and potentially other materials for the construction of the ASR is accessed from nearby site(s). This will therefore help to abate the GHG emissions associated with transportation. Where appropriate, wood from the harvested forest cover should be used in the construction phase.

5.2 Operation Phase

GHG emissions during the operation of the ARS can be partially mitigated or offset through the following:

- Paving the ASR. The proposed ASR is a gravel surfaced roadway. As noted in the assessment, gravel roads reduce the fuel economy of vehicles thereby increasing the fuel consumption rate by approximately 19 % in comparison to an asphalt road (US EPA, 2006). Paving the ASR with asphalt can therefore reduce the annual GHG emissions due to travel on the ASR by approximately 19 % per year. It should be noted that paving with asphalt will increase the construction based emissions but this added emission can be offset by the reduced annual emissions on the ASR. Note that for paving to occur, a threshold volume on the ASR needs to be met and/or exceeded.
- Intercity Transit. Private bus transit between Winnipeg and Bloodvein / Berens River may potentially become economical. Such commuting has the potential to reduce the number of vehicles using the ASR by approximately 40.
- Carbon offsets through afforestation / reforestation. The GHG emissions due to the Project has included a carbon offset due to reforestation of approximately 106 ha of disturbed land along the ROW of the ASR.
- It is recommended that the wetland areas within the ROW remain as wetlands in order to maintain their carbon sequestration potential.

5.3 Monitoring

In order to improve upon the accuracy of this GHG assessment and to determine the effect of potential mitigation plans and offsets, it is recommended that monitoring of the Project with respect to GHG emissions inventory calculations and verification be conducted. This procedure includes:

- Development of Best Management Practices for the construction and operational phase of the Project as outlined above.
- A policy / program to collect fuel consumption and equipment use data during the construction phase in order to recalculate the GHG inventory of this phase and determine the effectiveness of mitigation measures as outline the Best Management Practices.
- This program to collect data pertaining to the construction phase should be extended to include data on air, ferry and vehicle travel volumes and statistics once the ASR is open to the public (i.e., during the operation phase of the Project). This will allow for the recalculation of the GHG inventory of the operation phase of the Project and evaluate potential abatement measures as outlined above.
- The reassessment of the GHG emissions inventory will assist in evaluating the potential for carbon offsets, if considered necessary, as well as the potential to participate in any future Provincial, regional (e.g., Western Climate Initiative), and national carbon cap and trade system.

6. Conclusions and Limitations

The GHG assessment estimated the total direct and indirect GHG emissions due to the Project and compared this estimate with the GHG emissions (direct and indirect) under the business as usual Baseline scenario (i.e., without the Project). The assessment was conducted over the time period 2010 to 2023 inclusive which includes up to four (4) years of construction and 10 years of operation of the ASR.

The Baseline scenario resulted in a total of approximately 136 kt CO_2e being emitted from 2010 to 2023 inclusive. The Project scenario was estimated to emit a total of approximately 163 kt CO_2e over the same time period which is roughly 19% more than the Baseline emissions. The net change in GHG emissions due to the Project was therefore estimated to be approximately +27 kilo-tonnes (kt) CO_2e over the time period 2010 to 2023. The significant portions of the GHG emission are due to the construction of the ASR (approximately 33% of the total). The construction of the ASR was estimated to increase the Province's construction based GHG emissions by approximately 13 % based on the 2008 estimates of 0.098 Mt CO_2e. This increase is temporary so that once construction of the ASR has been completed it would result in the reduction of the Province's construction-based GHG emissions. Another increase is the estimated vehicular traffic between Winnipeg and Berens River (**Table 4.2**). However the anticipated improvements in future vehicular technology that result in emissions reductions have not been included in this assessment. The GHG emissions due to the road transportation with the ASR in place was estimated to be less than 0.2% of the Province's total GHG emissions of 5.13 Mt CO_2e due to road transportation in 2008.

Recommendations on the potential GHG emissions abatement and / or offsets during the construction and operational phases of the Project were suggested. In particular, construction best management practices would help to reduce the GHG emissions associated with this phase of the Project. For the operational phase of the project, maintenance of the wetland areas surrounding the ASR, increased reforestation of decommissioned winter road alignment and eventual paving of the ASR may potentially reduce the GHG emissions during this phase of the Project. Recommendations on developing mitigation plans and policies, monitoring and data collection, and verification were provided. This will help to verify the initial estimates of the GHG emissions associated with the Project provided in this report and assist in positioning the Province to participate in future provincial, regional and federal carbon trading mechanisms.

It should be noted that the assessment was limited by the assumptions made in the study methodology as a result of a lack of appropriate data. These assumptions included those made in the calculations of the biogenic sources and sinks, calculations related to the construction of the seasonal (winter and ice) road, seasonal road traffic volumes, and the changes in air and vehicular traffic volumes as a result of the operation of the ASR. The study also did not consider the changes in travel patterns, potential development along the PR 304 and other routes from Winnipeg, and potential development within Bloodvein and Berens River as a result of the increased ease in commuting on the resulting GHG emissions due to the Project.

7. Closure

This GHG assessment report has been prepared based on the information provided and/or approved by the East Side Road Authority. This report is intended to provide a reasonable review of available information within an agreed work scope, schedule and budget. This report was prepared by Dillon for the sole benefit of the East Side Road Authority as supporting documentation for the EA Approvals process. The material in the report reflects Dillon's judgment in context of the information available to Dillon at the time of this report preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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