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Transportation Arrangement:

An AADT Analysis, Emissions Study and the impact of COVID-19 on the Calgary-Edmonton corridor

Source: National Geographic Expeditions

https://www.nationalgeographic.com/expeditions/trip-types/train/

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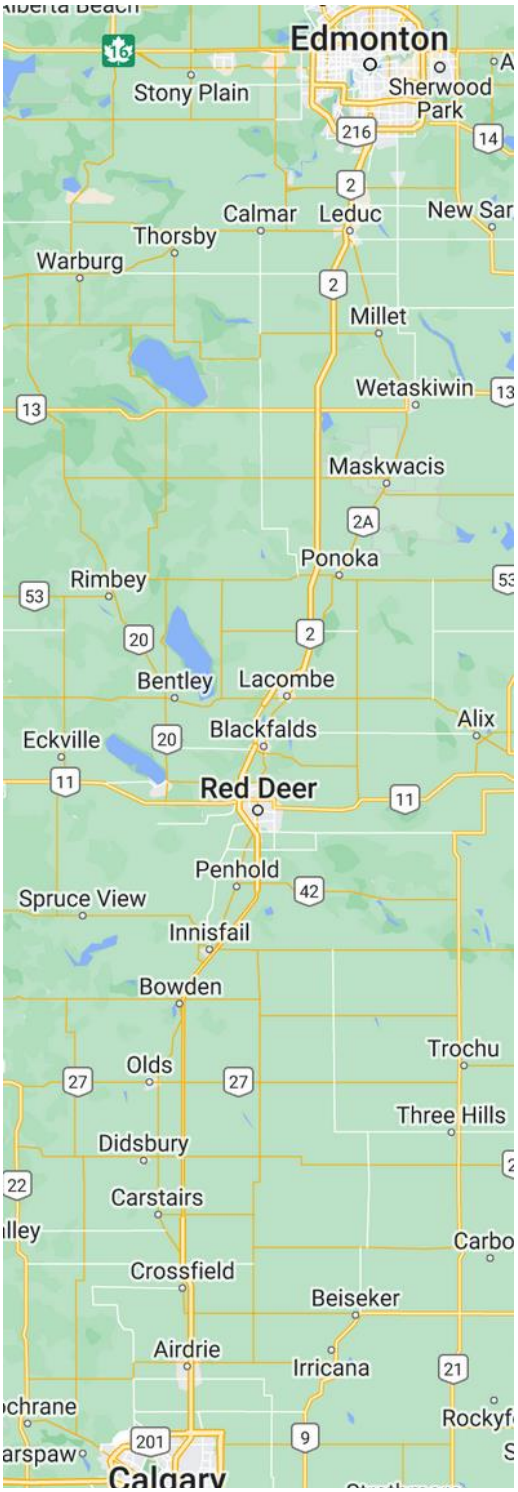


Figure 1: Highway 2 & 2A in Calgary-Edmonton Corridor

Abstract

The "Rail for All" project from Integrated Travel Research and Development (ITRD) looks to save on the cost to maintain highways and bringing economic benefit to Calgary-Edmonton corridor. This research will focus on conducting an Annual Average Daily Traffic (AADT) analysis for Highway 2 and 2A using datasets from Alberta from 2019 – 2023. The analysis will include

- traffic volume and patterns on Highway 2 and 2A
- the accumulation of greenhouse gas (GHG) emissions on Highway 2 and 2A
- the impact on the traffic volume and GHG emissions of the COVID-19 explosion on Highway 2 and 2A

The collection of data will provide recommendations to reduce GHG emissions, decrease the cost of maintaining the highway network, prioritize a railway right of way through Aldersyde, Calgary, Foothills County, and Edmonton, and arrange transportation for fluid traffic flow will be developed.

Introduction

This research considers all transportation modes within the Calgary-Edmonton corridor, including airports, railways, buses, and highways. Highways 2 and 2A were analyzed to improve transportation efficiency in Alberta. Calgary is Alberta's financial center. Edmonton's is Alberta's government hub. The Calgary-Edmonton corridor links numerous rural and indigenous communities, businesses, and services. The Calgary-Edmonton corridor runs through the Red Deer with Edmonton to the north and Calgary to the south.

Highway 2 is a major corridor within the National Highway System of Canada. It starts in southern Alberta at Fort Macleod, then heads north through Calgary, Red Deer, Edmonton, Donnelly to

Grimshaw in the North. In winter, accidents commonly occur because of rapid and unpredictable weather conditions between Calgary and Edmonton. Between Fort Macleod and Edmonton, Highway 2 is a 4 lane freeway, and improvements are ongoing to eliminate the at-grade crossings. [i]

Compared to Highway 2, Highway 2A starts from the town of High River, passing through Aldersyde and Okotoks. Highway 2A was the original highway between Calgary and Edmonton prior to the construction of Highway 2. It is now a secondary route to commute from Calgary to Edmonton. Although the traffic on Highway 2A is lighter than Highway 2, Highway 2A still significantly influences traffic volume. [ii]

In December 2019, Coronavirus disease 2019 (COVID-19) started to spread in China, resulting in a severe global impact on the human community. The symptoms of COVID-19 are breathing difficulties and loss of taste and smell. According to the National Library of Medicine report, 44% of the people who get infected with COVID-19 but remain asymptomatic through the infection. [iii] In the face of COVID-19, the Canadian government proposed entry restrictions to lock down the rapid spread of the pandemic. The lock down policy affected transportation options during COVID-19 in Canada, concerning infection-related factors rather than traditional factors, increasing the number of personal vehicles used. [iv]

Passenger rail development along the Calgary-Edmonton corridor is the main purpose of this project. ITRD is dedicated to building railways to benefit the economy in Alberta and develop an improved and integrated freight and passenger railway system. The system will increase the demand for trains by saving time to travel between cities. Improved customer service will lead to the achievement of reaching ITRD's sustainability goal to reduce GHG emissions from passenger vehicles (PV) and the costs to maintain and expand highway infrastructure.

In order to achieve the goal successfully and bring economic value to the Calgary-Edmonton corridor, the following steps will be reviewed. First, traffic volume data based on AADT analysis from the government of Alberta will be used to analyze the GHG emissions on Highways 2 and 2A from 2019 to 2023. Second, the traffic impact on Highways 2 and 2A during the COVID-19 lock-down is considered to identify transportation selections by residents and visitors in Alberta and to examine the effects of the lock-down in GHG emissions. Lastly, the railway infrastructure north from Aldersyde, through Calgary, Foothills County, and into Edmonton will be arranged using SOLIDWORKS to visualize the transportation system in these cities.

Methodology

This project uses datasets of Weighted Annual Average Daily Traffic (WAADT) from the Government of Alberta's [v] traffic counts and collects AADT data to analyze GHG emissions

and traffic patterns on Highway 2 and 2A between 2019-2023. The Highway 2 calculation for Highway 2 begins at the Memorial Drive interchange in Calgary (10000007), passing through Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, Red Deer, Lochinvar, Leduc, reaching the Ellerslie Interchange in Southern Edmonton (70000577).

The Highway 2A calculation separates into five highway sections:

- 2 & 2A & 72 SE OF CROSSFIELD (75230) to 2A & 587 BOWDEN (70000528)
- 2A & 590 AT INNISFAIL (82310) to 19 ST & TAYLOR DR, RED DEER (70000960)
- 2A & 11A AT RED DEER (87340) to 2A & MILTON RD (70000004) in Lacombe
- 2 & 2A SW OF MORNINGSIDE (92360) to 2A & 611 N OF MASKAWACIS approaching Wetaskiwin (99380)
- 2A & 13 N OF WETASKIWIN NJ (100390) to 2A & TWP RD 492, S OF LEDUC (90420)

Crossfield is at the beginning of the data analysis section. To the north is Carstairs, Olds, and the section ends in Bowden. The second dataset passes through Innisfail, Penhold, and Red Deer. The third dataset passes through Labuma, Blackfalds, and Lacombe. The fourth dataset starts from Morningside, passing through Ponoka, Maskwacis, and ends in Navarre. The final dataset passes through Wetaskiwin, Millet, and Leduc.

From the GHG emissions dataset from 2019 to 2022, we used the data from the Government of Alberta to represent the total GHG emissions from each type of transportation.[vi] From the dataset on Highway 2 and 2A from 2019 to 2023, the GHG emissions data will use previous AADT datasets along Highway 2 and 2A and apply a formula from TRB's Cooperative Research Programs website: [vii]

$$\Delta\, emissions = AADT * Vehicle\ Percentage * Segment\ Length * EF$$

The $\Delta\, emissions$ is summed across vehicle types and time periods. For the emission factor (EF), we use the formula from the United States Environmental Protection Agency (EPA) to calculate tailpipe emissions based on:

$CO_2\ emissions\ from\ a\ gallon\ of\ gasoline$: 8887 $grams\ CO_2/gallon$, and $CO_2\ emissions\ from\ a\ gallon\ of\ diesel$: 10180 $grams\ CO_2/gallon$.

Since the average vehicle on the road today has a fuel economy of about 22.2 miles per gallon (MPG). The formula can calculate the average vehicle when driving one mile has tailpipe $CO_2\ emissions$:

$$CO_2\ emissions\ per\ mile = \frac{CO_2\ per\ gallon}{MPG} = \frac{8887}{22.2} = 400\ grams$$

After the calculation, the average gasoline vehicle when driving one mile has tailpipe $CO_2\ emissions$ 400 grams per gasoline vehicle-mile, and 459 grams per diesel vehicle-mile. Since the tailpipe 1 gram per mile equal to 0.001 T of $CO_2\ emissions$ per mile. As a result, the personal vehicle (PV) and recreational vehicle (RV) will use 0.4 as an emission factor. On the other hand, the single unit truck (SUT), Bus, and the tractor trailer unit (TTC) will use 0.459 as the emission factor.

The AADT datasets will start from the Memorial Avenue Interchange in the center of Calgary and end at the Ellerslie Road interchange on the south side of Edmonton. Since AADT is different from Calgary to Edmonton and Edmonton to Calgary, we calculated two routes from both directions. Based on the intersection data on the traffic data mapping website, Highway 2 & Memorial Drive in Calgary (10000007) will be the start point and endpoint in Calgary, and the Highway 2 & 216 S Interchange will be Edmonton's start and endpoint (20000013).

After receiving the WAADT datasets of traffic counts and GHG emissions, we analyzed the impact of COVID-19 between 2019-2020, checked the difference between traffic counts and GHG emissions, and visualized traffic patterns before and after the pandemic explosion.

SOLIDWORKS was used to analyze the railway infrastructure in the Calgary-Edmonton corridor, including factors of topography, forest, population, and transportation demands, looking for possibilities to connect each town and city for better connection and convenience.

Results

Traffic Counts

Highway 2

WAADT Traffic Counts

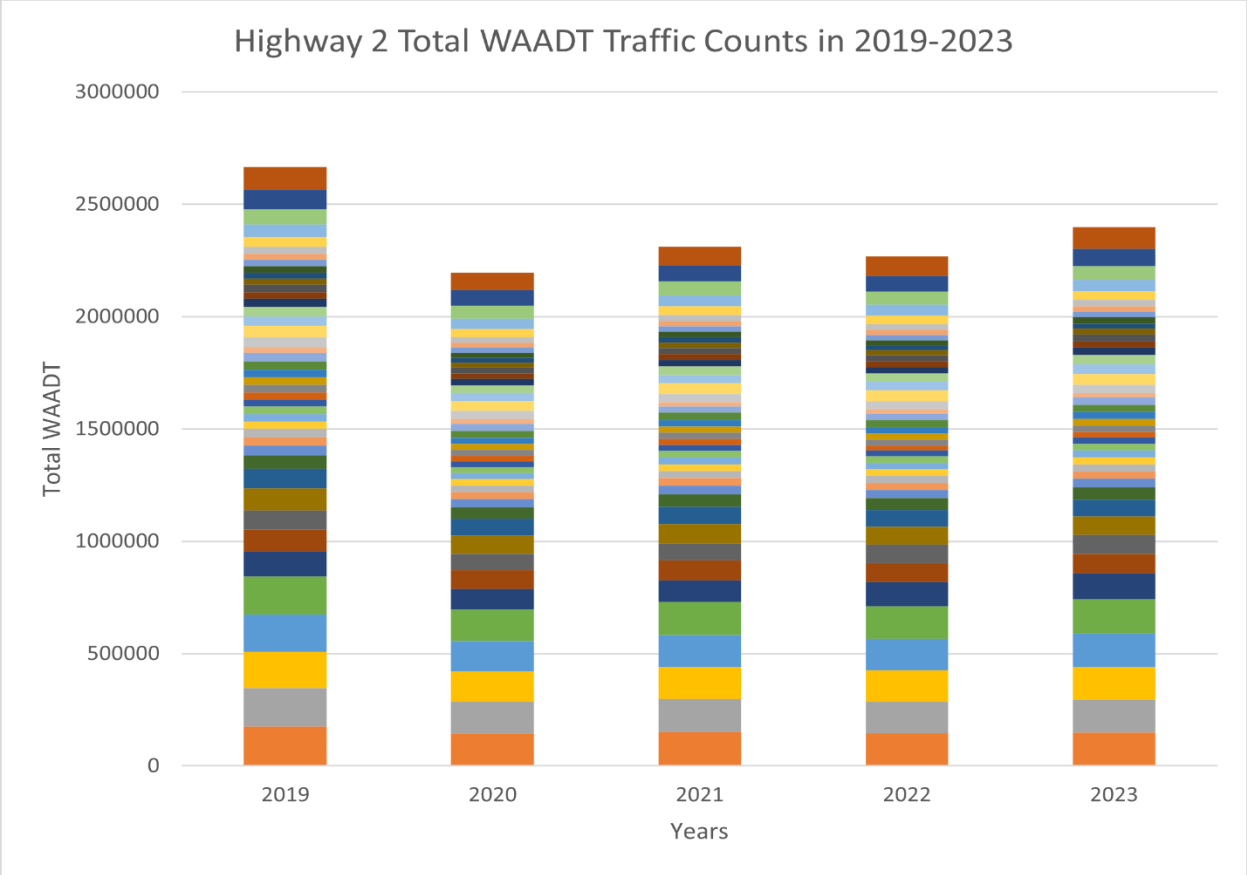


Figure 2: Highway 2 Total WAADT Traffic Counts in 2019-2023

The traffic counts in Figure 2 show the total WAADT from 2 & MEMORIAL DR IN CALGARY (10000007) [viii] to 2 & ELLERSLIE R (70000577) in Edmonton from 2019 to 2023. Each color line represents the intersection on Highway 2 from Calgary to Edmonton. Intersection 2 & MEMORIAL DR IN CALGARY (10000007) to 2 & BEDDINGTON TR IN CALGARY (10000002) has the highest traffic counts, approximately 147912 vehicles in 2023. After passing through the Calgary International Airport, the number of vehicles started to drop after reaching 2 & AIRPORT TR IN CALGARY (10000022) intersection, with approximately 116790 vehicles in 2023. Between 2 & AIRPORT TR IN CALGARY (10000022) and 2 & YANKEE VALLEY BLVD (154820) in Airdrie, the traffic counts have approximately 82033 vehicles in 2023. From the sections between Airdrie and Innisfail, the vehicle number is approximately 32632 in 2023. From Innisfail to Gasoline Alley, the vehicle number is approximately 29827 in 2023. From Gasoline Alley to The Highway 11 Interchange, the vehicle number is approximately 35250 in

2023. The vehicle number from The Highway 11 Interchange to Leduc is approximately 29877 in 2023. From Leduc to Edmonton, the vehicle number is approximately 64490 in 2023. The red sections in Figure 3 are the following locations: Calgary, Calgary International Airport, Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, The Highway 11 Interchange, Lochinvar, Leduc, Edmonton, showing that the transportation arrangement should focus on Between Calgary and Airdrie, Gasoline Alley and Lochinvar, Leduc and Edmonton sections.

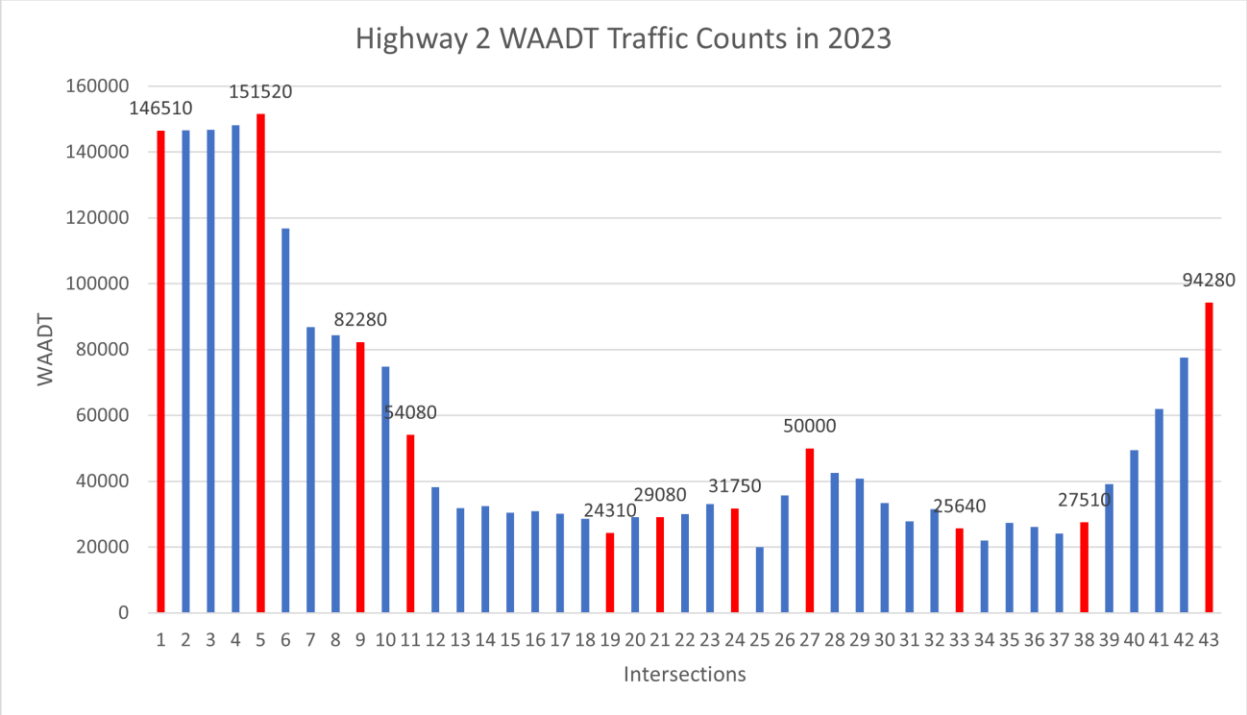


Figure 3: Highway 2 WAADT Traffic Counts in 2023

Intersection 1: Calgary; Intersection 5: Calgary International Airport; Intersection 9: Balzac

Intersection 11: Airdrie; Intersection 19: Bowden; Intersection 21: Innisfail

Intersection 24: Gasoline Alley; Intersection 27: The Highway 11 Interchange; Intersection 33: Lochinvar

Intersection 38: Leduc; Intersection 43: Edmonton

Impact of COVID-19 to the traffic counts

Figure 4 and Figure 5 show the total WAADT and traffic count percentage on Highway 2 from 2019 to 2023. The difference between 2019 and 2020 has dropped significantly since the COVID-19 explosion; approximately 469399 vehicles (3.97%) disappeared within a year. After vaccines are invented, the number of vehicles will be approximately 229307 from 2020 to 2023,

increasing 116121 (0.98%) between 2020 and 2021, slightly decreasing 43089 (0.36%) between 2021 and 2022, and increasing 128561 (1.09%) between 2022 and 2023.

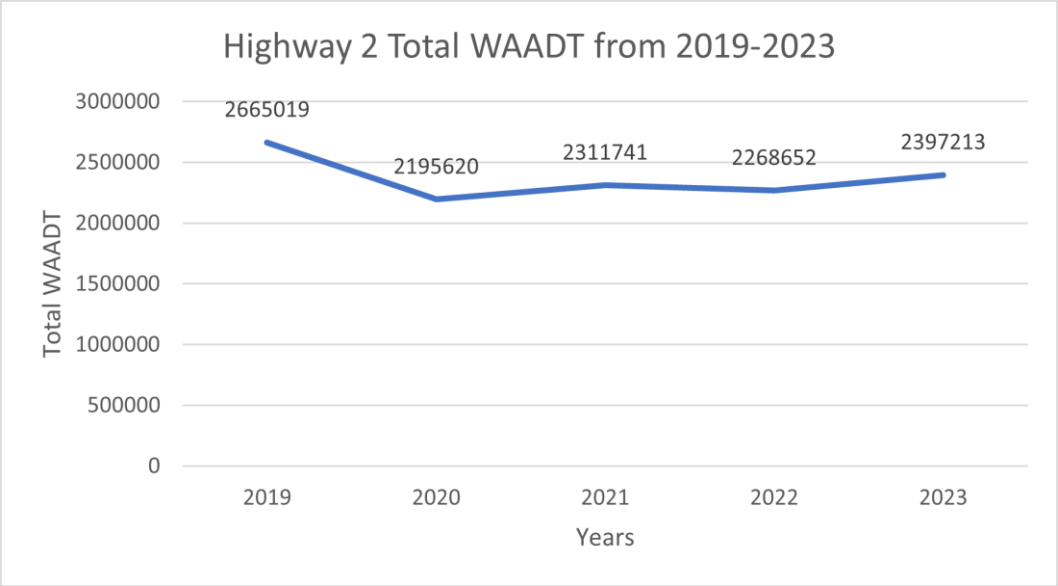


Figure 4: Highway 2 Total WAADT Vehicle Counts in 2019-2023

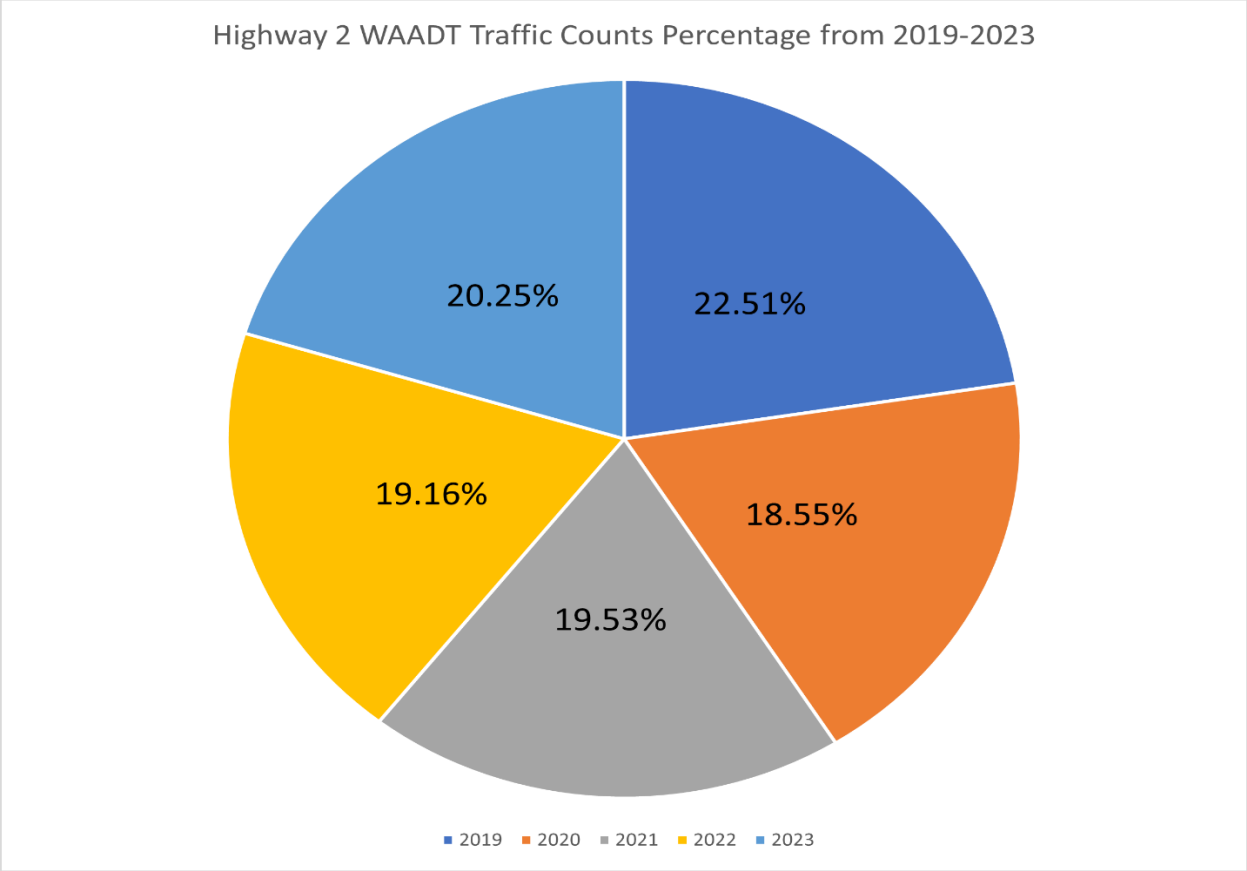


Figure 5: Highway 2 WAADT Total Traffic Counts Percentage in 2019-2023

Vehicle Types

From the dataset of vehicle types on the Government of Alberta in Figure 6, there are five types of vehicles occupied on Highway 2: Personal Vehicles (PV), Single Unit Truck (SUT), Tractor Trailer Unit (TTC), Bus, and Recreational Vehicle (RV). We calculated the average percentage for each type of vehicle, showing that PV occupied almost 85.92% of the highway, then TTC (9.91%), SUT (2.63%), RV (1.33%), and last was the BUS (0.19%).

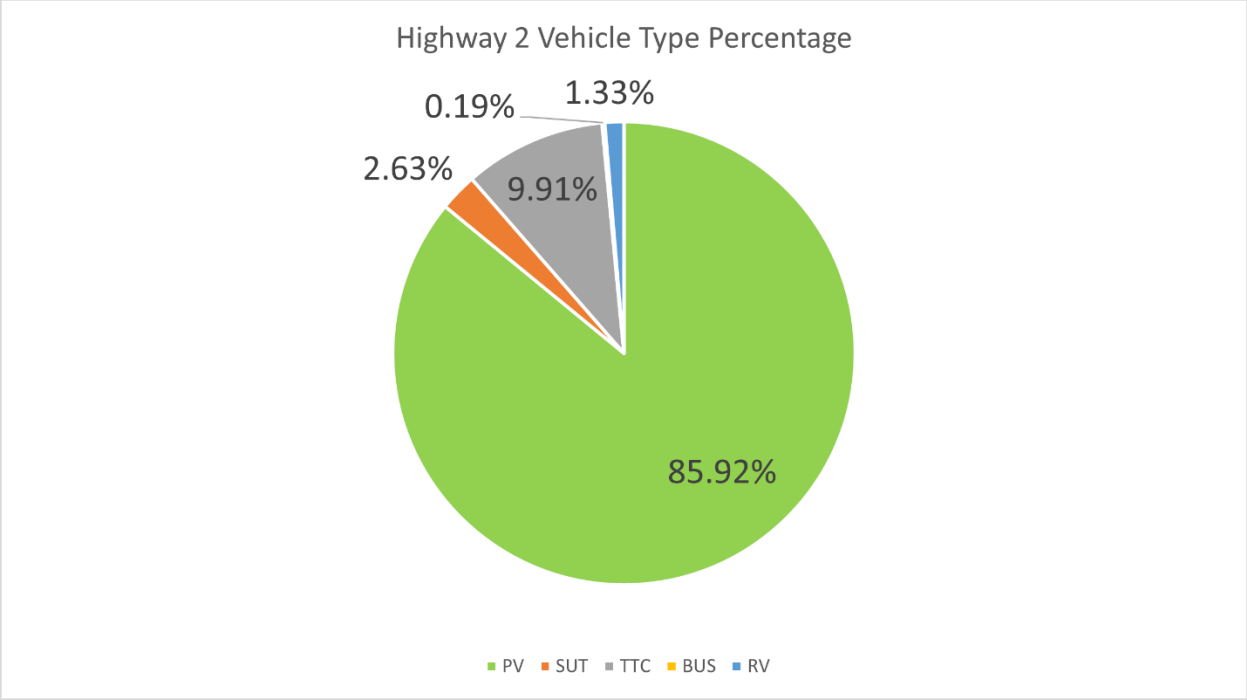


Figure 6: Highway 2 Vehicle Types Percentage

Highway 2A

WAADT Traffic Counts

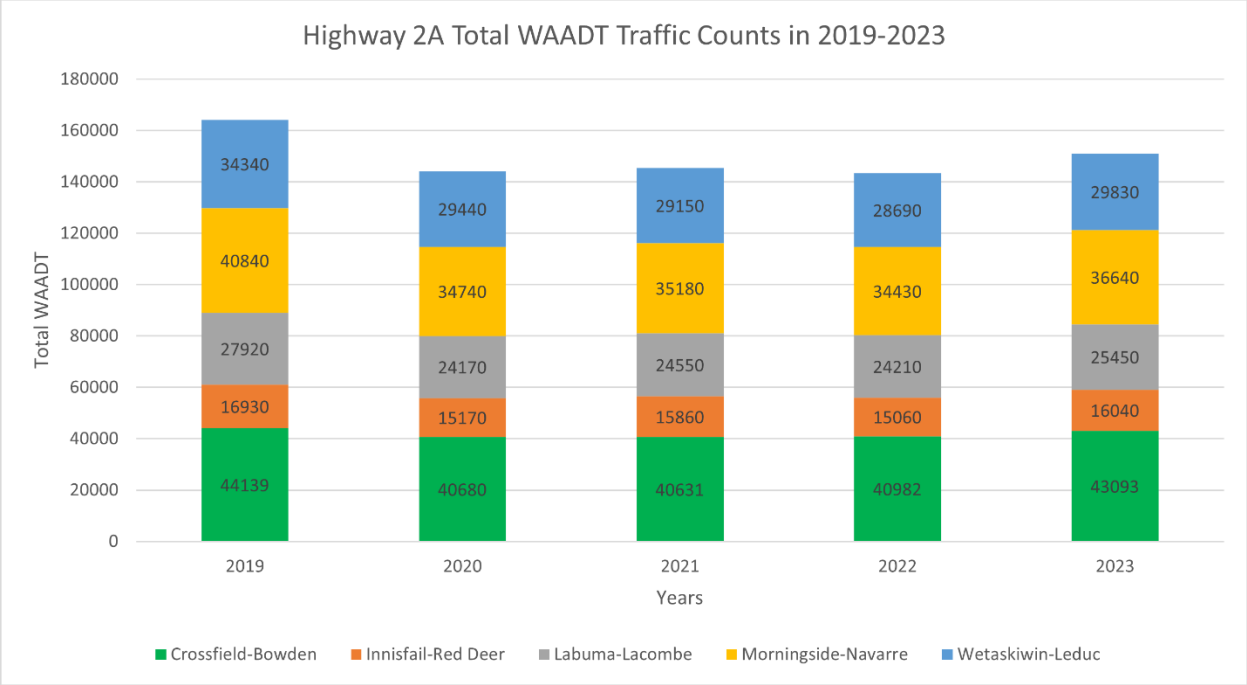


Figure 7: Highway 2A WAADT Traffic Counts in 2019-2023

The traffic counts in Figure 7 show the total WAADT from Crossfield to Leduc from 2019 to 2023. Each color line represents the intersection on Highway 2A from Crossfield to Leduc. Intersection Crossfield to Bowden has the highest traffic counts, with approximately 43093 vehicles in 2023. After passing through the Bowden, the number of vehicles started to drop in the intersection of Innisfail to Red Deer, with approximately 16040 vehicles in 2023. After crossing through Red Deer, the number of vehicles at the intersection of Labuma to Lacombe started to increase, with approximately 25450 vehicles in 2023. From the sections between Morningside and Navarre, the vehicle number is approximately 36640 in 2023. From Wetaskiwin to Leduc, the vehicle number is approximately 29830 in 2023. The dataset in Figure 7 shows that the transportation arrangement should focus on Crossfield-Bowden first, then Morningside-Navarre, Wetaskiwin-Leduc, and Labuma-Lacombe, and the last one will be the Innisfail-Red Deer intersection.

Impact of COVID-19 to the traffic counts

From the dataset in Figure 8 & Figure 9, the traffic counts significantly dropped between 2019 and 2020, approximately decreasing 19969 vehicles (2.67%) in 2020. Traffic counts have slightly risen between 2020 and 2021, approximately 1171 vehicles (0.16%) in 2021. Between 2021 and 2022, traffic counts dropped slightly, approximately decreasing 1999 vehicles (0.27%) in 2022. Between 2022 and 2023, traffic counts have increased, with an approximate increase of 1171 vehicles (0.16%) in 2021.

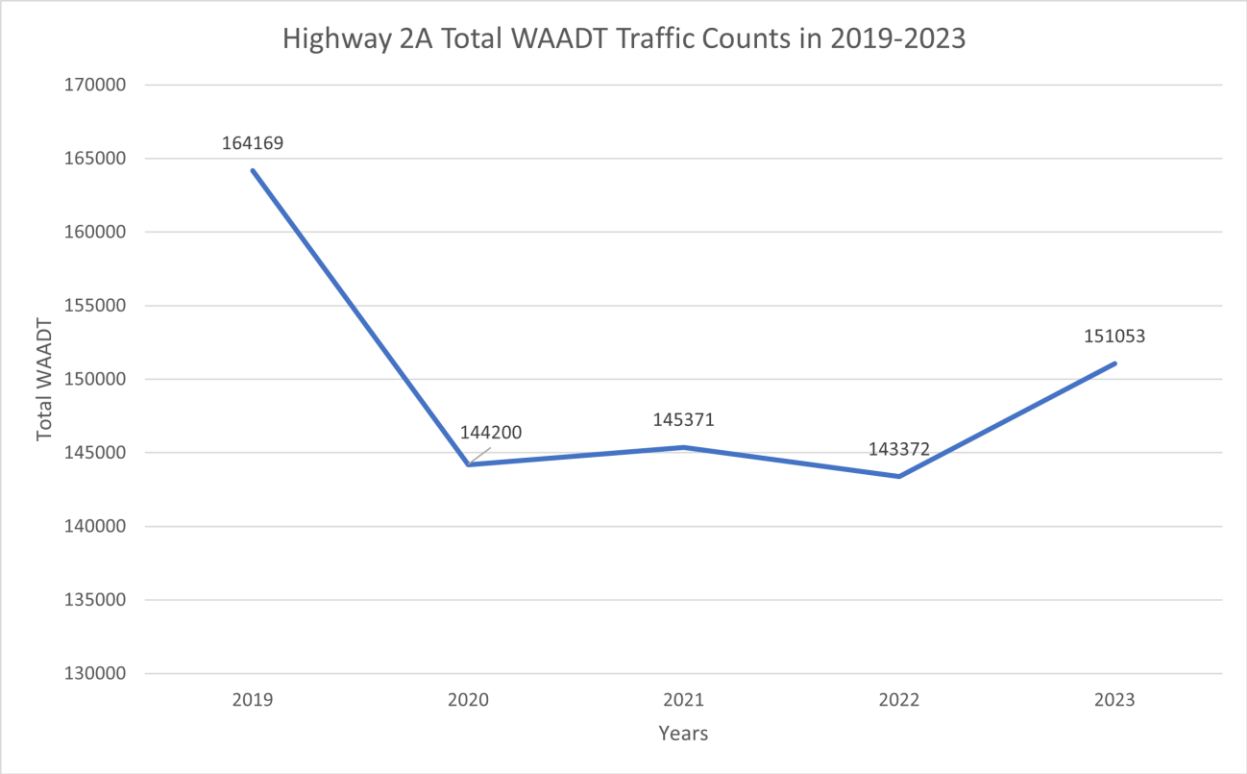


Figure 8: Highway 2A Total WAADT Traffic Counts in 2019-2023

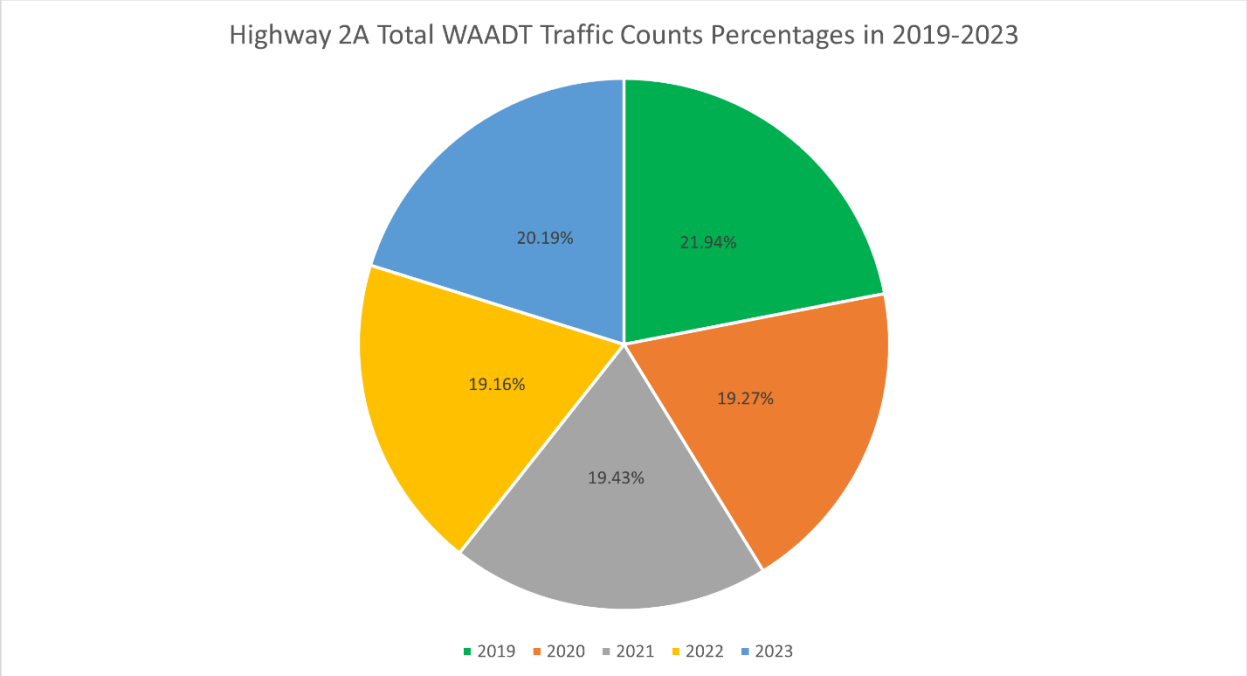
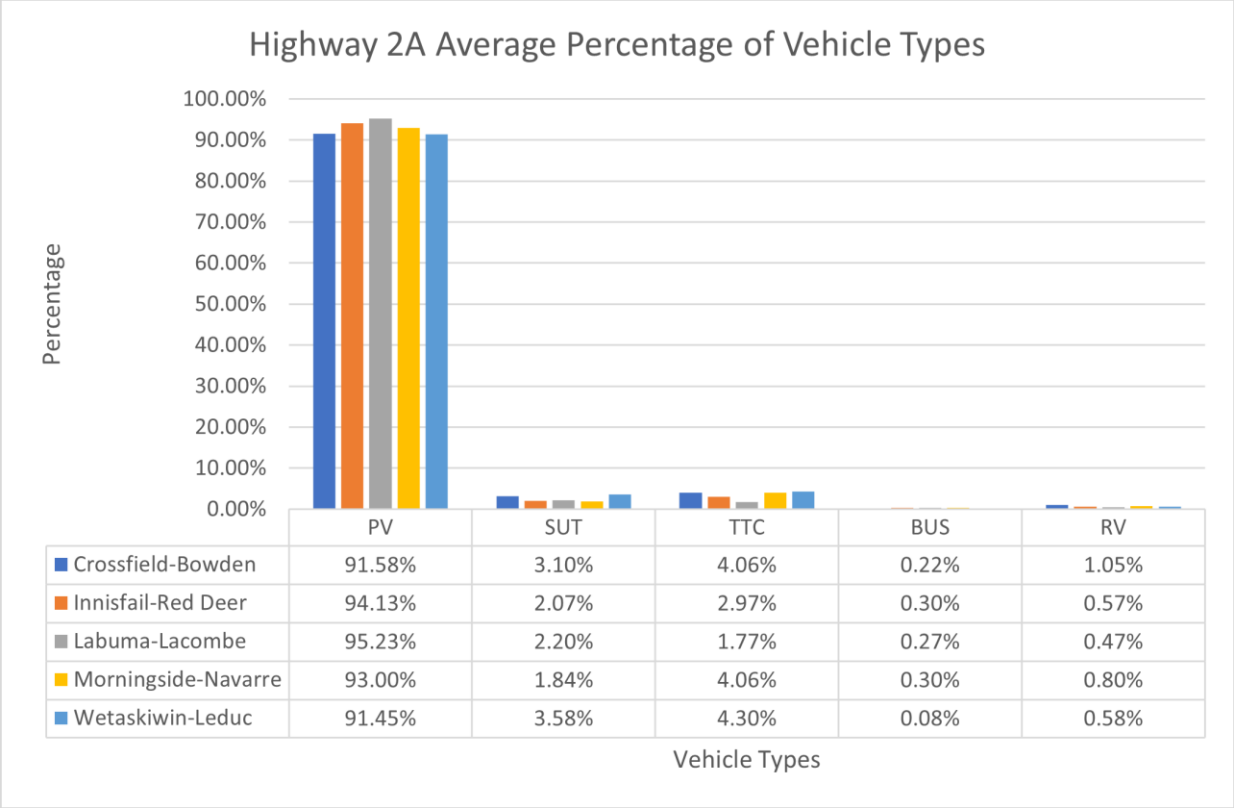


Figure 9: Highway 2A Total WAADT Traffic Counts Percentages in 2019-2023

Vehicle Types

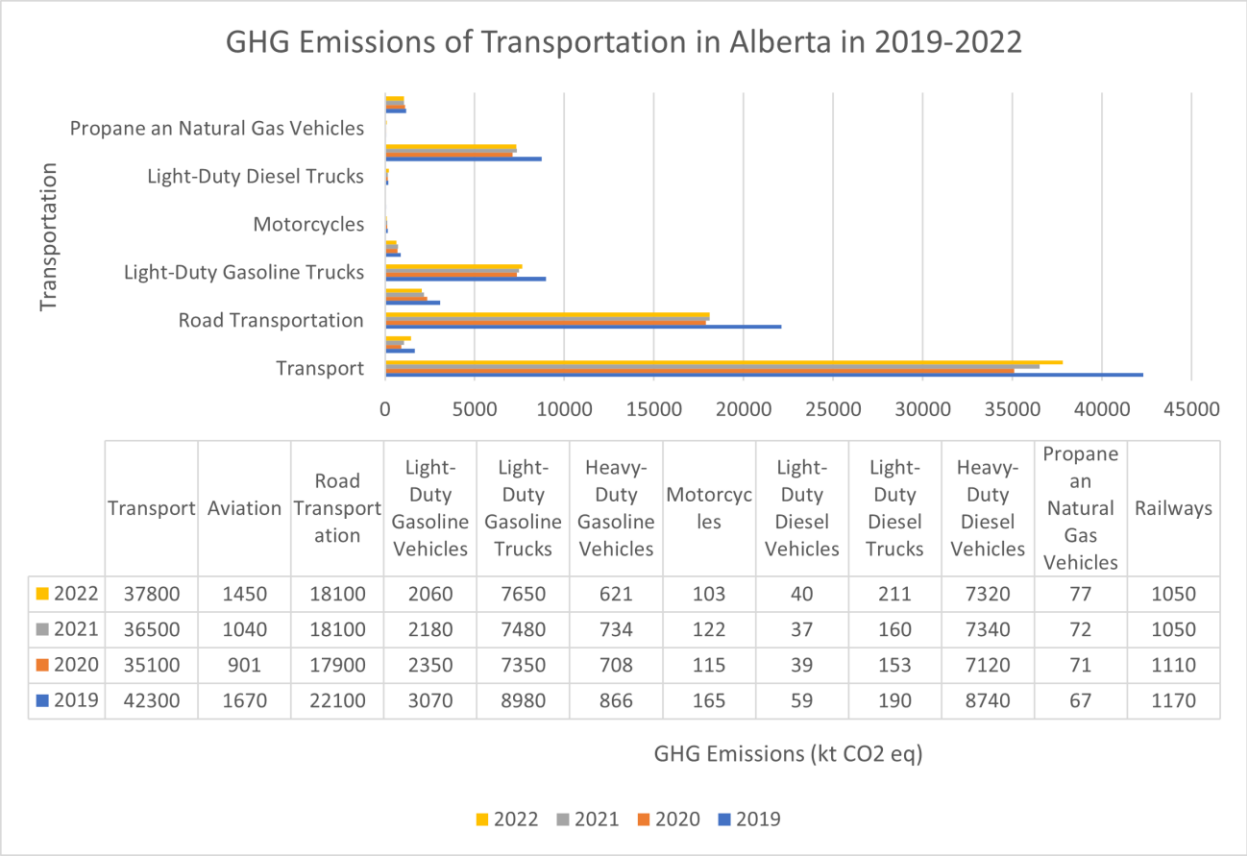


	PV	SUT	TTC	BUS	RV
Crossfield-Bowden	91.58%	3.10%	4.06%	0.22%	1.05%
Innisfail-Red Deer	94.13%	2.07%	2.97%	0.30%	0.57%
Labuma-Lacombe	95.23%	2.20%	1.77%	0.27%	0.47%
Morningside-Navarre	93.00%	1.84%	4.06%	0.30%	0.80%
Wetaskiwin-Leduc	91.45%	3.58%	4.30%	0.08%	0.58%

Figure 10: Highway 2A Vehicle Types Percentage

The dataset in Figure 10 shows that the main vehicle type is PV in the Calgary-Edmonton corridor on Highway 2A. Within these five intersections, the average amount of PV is 93.08%, SUT is 2.56%, TTC is 3.43%, BUS is 0.23%, and RV is 0.69%. For the PV, PV dominated the intersection of Labuma-Lacombe with 95.23%, 94.13% in the intersection of Innisfail-Red Deer, 93.00% in the intersection of Morningside-Navarre, 91.58% in the intersection of Crossfield-Bowden, and 91.45% in the intersection of Wetaskiwin-Leduc. On the contrary, the Bus has the lowest ratio of vehicle types in all five intersections. 0.30% in the intersection of Innisfail-Red Deer, 0.30% in the intersection of Morningside-Navarre, 0.27% in the intersection of Labuma-Lacombe, 0.22% in the intersection of Crossfield-Bowden and 0.08% in the intersection of Wetaskiwin-Leduc. The traffic counts in the Wetaskiwin-Leduc intersection were the third from the result in Figure 9. However, the ratio of the Bus was the lowest within these five intersections.

GHG Emissions in Alberta in 2019-2022



	Transport	Aviation	Road Transportation	Light-Duty Gasoline Vehicles	Light-Duty Gasoline Trucks	Heavy-Duty Gasoline Vehicles	Motorcycles	Light-Duty Diesel Vehicles	Light-Duty Diesel Trucks	Heavy-Duty Diesel Vehicles	Propane an Natural Gas Vehicles	Railways
2022	37800	1450	18100	2060	7650	621	103	40	211	7320	77	1050
2021	36500	1040	18100	2180	7480	734	122	37	160	7340	72	1050
2020	35100	901	17900	2350	7350	708	115	39	153	7120	71	1110
2019	42300	1670	22100	3070	8980	866	165	59	190	8740	67	1170

Figure 11: GHG Emissions of Transportation in Alberta in 2019-2022

The dataset in Figure 11 shows the primary emissions caused by light-duty gasoline trucks and heavy-duty diesel vehicles on road transportation. In 2022, light-duty gasoline trucks and heavy-duty diesel vehicles produced $7650\ and\ 7320\ kt\ CO_2\ eq$ GHG emissions on road transportation, almost 39.6% of GHG emissions in total transport, respectively. The GHG emissions from 2019 to 2022 on transportation significantly fell in 2020, approximately decreasing 7200 (17%) vehicles in 2020. After the vaccine for COVID-19 was invented, the GHG emissions from transportation gradually increased from 2020 to 2022, with approximately 1400 (4%) vehicles in 2021 and 1300 vehicles (3.6%) in 2022. Although light-duty gasoline vehicles, aviation, and railways did not conduct as much GHG emissions as light-duty gasoline vehicles and heavy-duty diesel vehicles, the amount of GHG emissions was still considerable in 2022, with approximately 2060 GHG emissions from light-duty gasoline vehicles, $1450\ kt\ CO_2\ eq$ GHG emissions from aviation, and 1050 GHG emissions from railways.

Highway 2

GHG emissions on Highway 2 from Calgary to Edmonton (South to North)

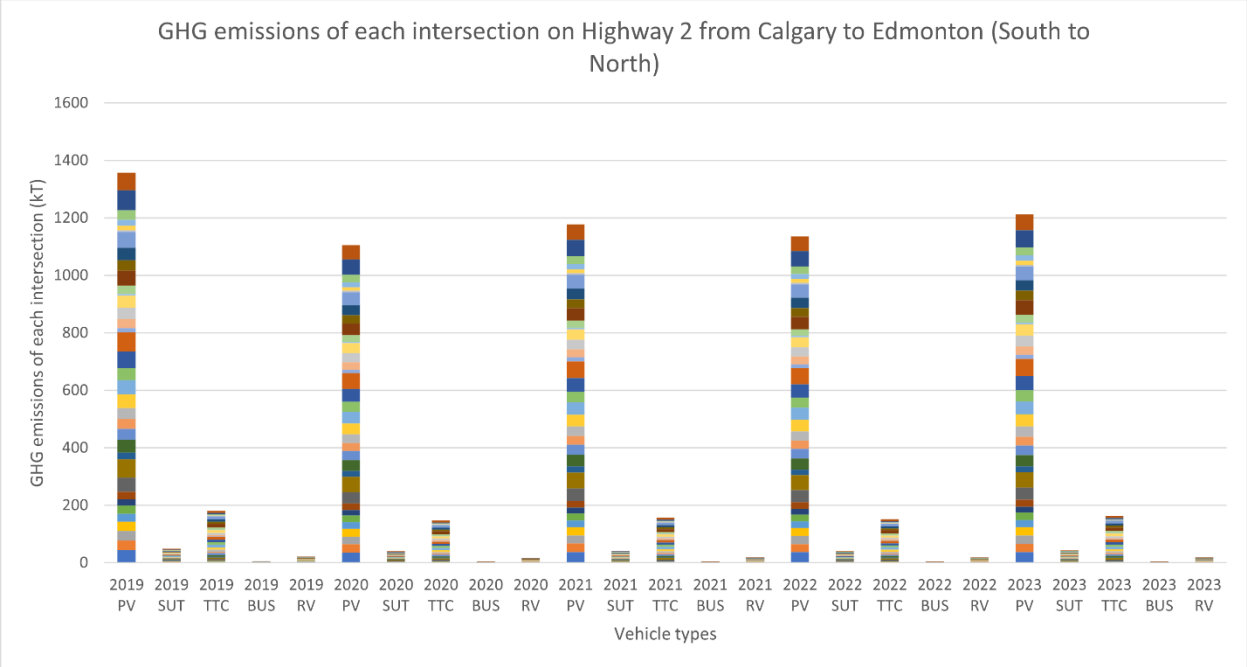


Figure 12: GHG emissions of each intersection on Highway 2 from Calgary to Edmonton (South to North)

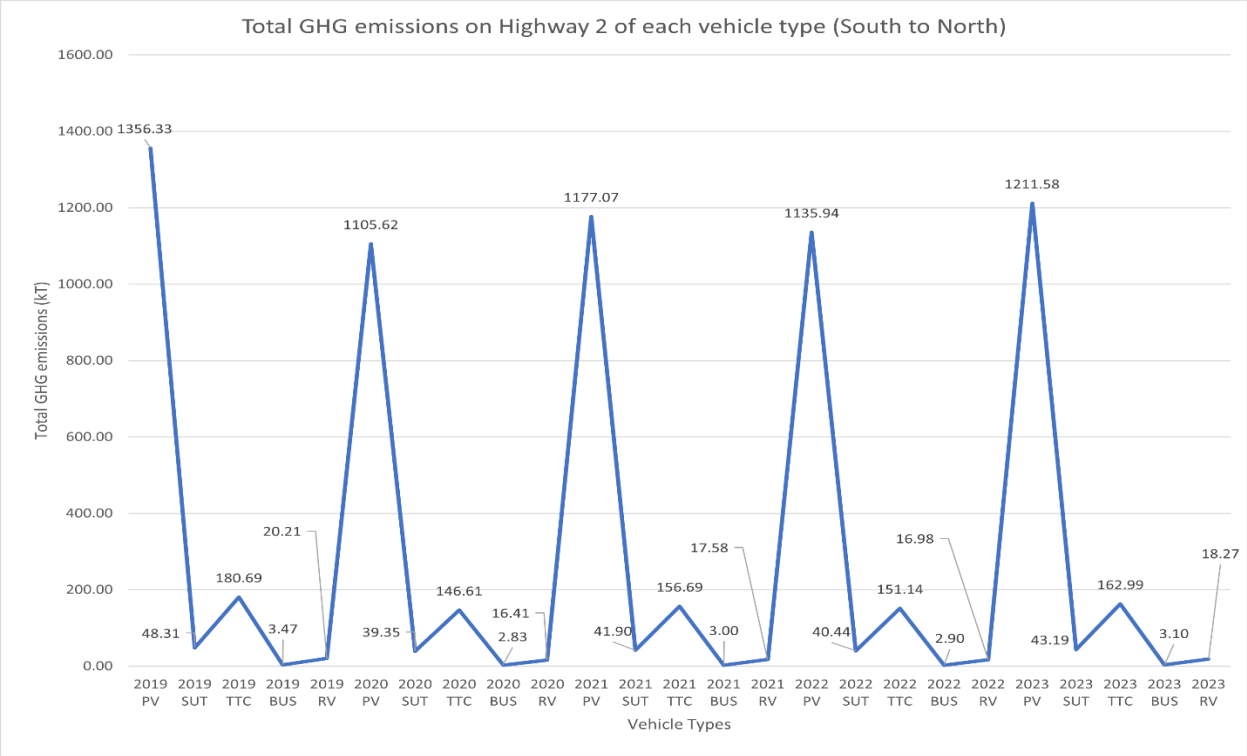


Figure 13: Total GHG emissions on Highway 2 of each vehicle type (South to North)

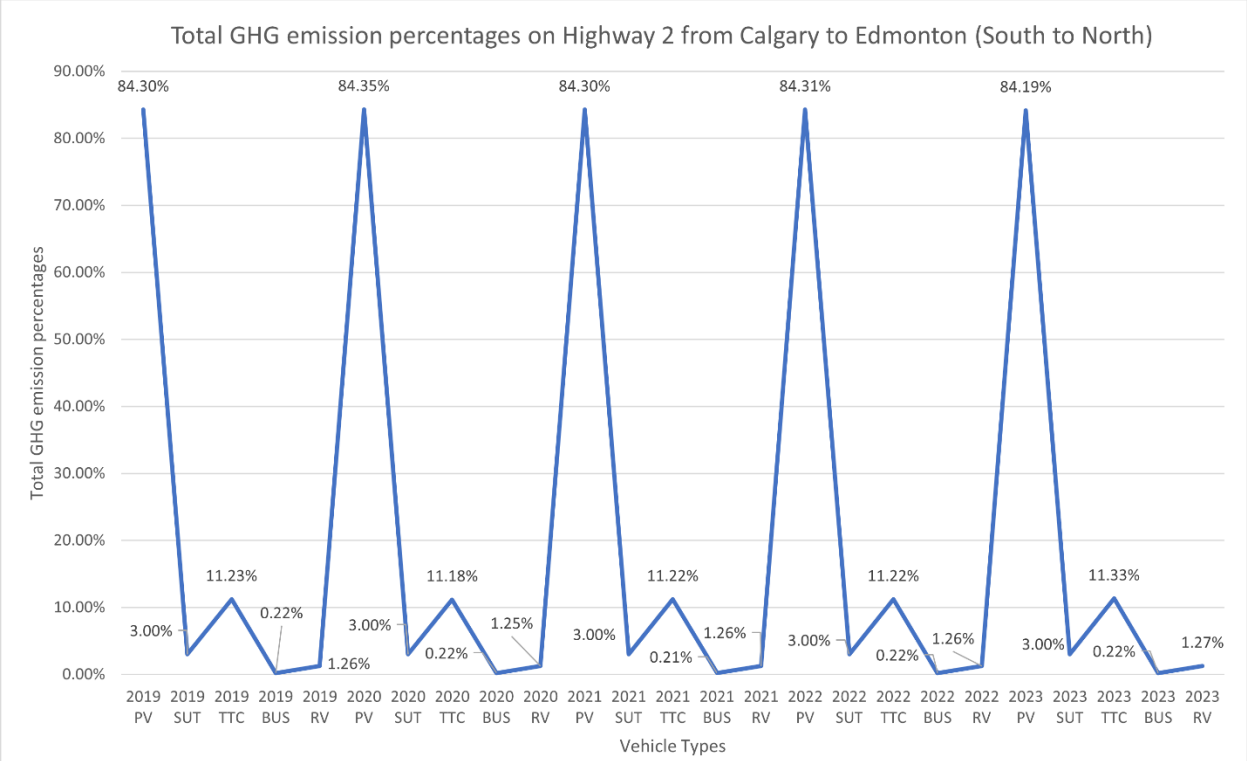


Figure 14: Total GHG emission percentages on Highway 2 from Calgary to Edmonton (South to North)

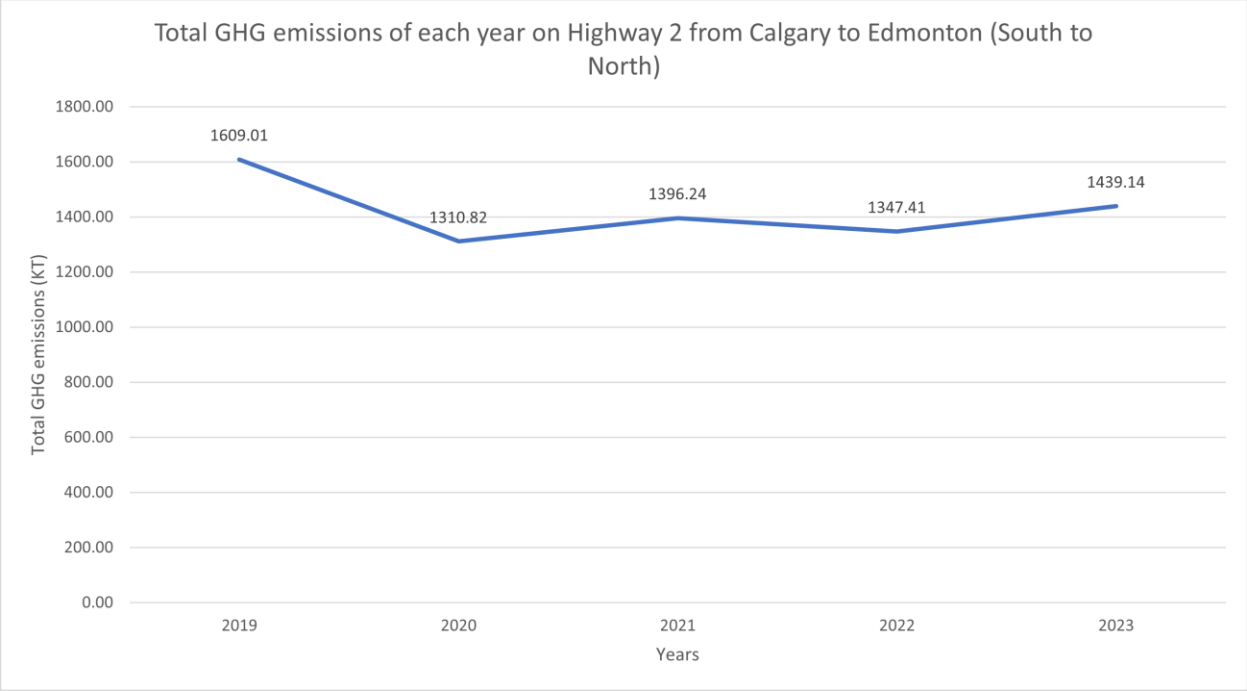


Figure 15: Total GHG emissions of each year on Highway 2 from Calgary to Edmonton (South to North)

Based on the GHG emission formula calculation, the GHG emissions on Highway 2 from South to North are mainly PV vehicles. With 85.6% of PV, 2.7% of SUT, 10.3% of TTC, 0.2% of BUS, and 1.3% of RV from Calgary to Edmonton. From Figure 12, each color means different intersection from Calgary to Edmonton. Start point in the center of Calgary, going through Calgary International Airport, Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, West Park Extension, The Highway 11 Interchange, The Highway 12 Interchange, The Highway 39 intersection, Leduc, and endpoint in Edmonton. From Figure 15, the total GHG emissions between 2019 to 2023 are 1603.01, 1310.82, 1396.24, 1347.41, and 1439.14 kT.

From the dataset of AADT traffic load on Highway 2 from Calgary to Edmonton (South to North), starting from the center of Calgary, the traffic counts decreased the most after crossing through Calgary International Airport, from 72500 dropped to 46040 vehicles in 2023. From Calgary International Airport to Balzac, the vehicle counts dropped from 46040 to 37360 in 2023. From Balzac to Airdrie, the vehicle counts dropped from 37360 to 27050 in 2023. From Bowden to Innisfail, the vehicle counts dropped from 27050 to 15840 in 2023. From Bowden to Innisfail, the vehicle counts dropped from 15840 to 14980 in 2023. From Innisfail to Gasoline Alley, the vehicle counts increased from 14980 to 17490 in 2023. From Gasoline Alley to West Park Extension, the vehicle counts rose from 17490 to 25160 in 2023. From West Park Extension to The Highway 11 Interchange, the vehicle counts dropped from 25160 to 19040 in 2023. From The Highway 11 Interchange to The Highway 12 Interchange, the vehicle counts

dropped from 19040 to 11960 in 2023. From The Highway 12 Interchange to The Highway 39 intersection, the vehicle counts increased from 11960 to 19570 in 2023. From The Highway 39 intersection to Leduc, the vehicle counts increased from 19570 to 24780 in 2023. From Leduc to Edmonton, the vehicle counts increased from 24780 to 39720 in 2023. The highest traffic load is between Calgary and Calgary International Airport. From 2019 to 2023, the AADT traffic counts are approximately 75047, 62219, 65174, 63665, and 66366 vehicles yearly. On the contrary, the lowest traffic load is between The Highway 11 Interchange and The Highway 12 Interchange. From 2019 to 2023, the AADT traffic counts are approximately 15626, 12610, 13497, 13087, and 14558 vehicles yearly.

Highway 2 from South to North (C-E)

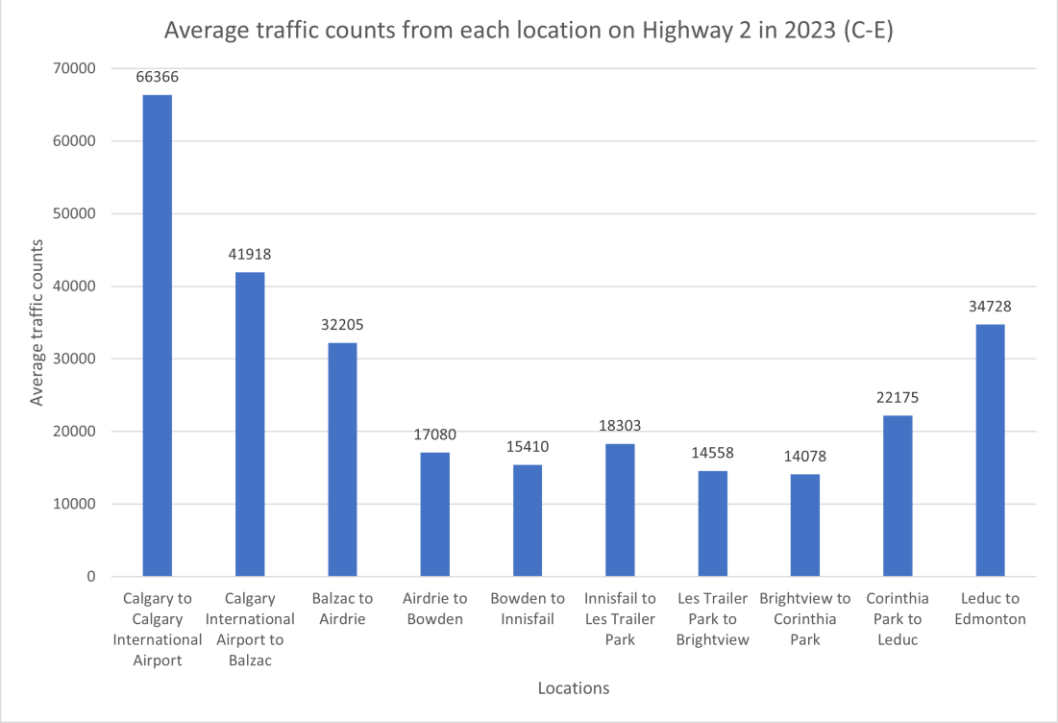


Figure 16: Average traffic counts from each location on Highway 2 in 2023 (C-E)

Calgary to Calgary International Airport

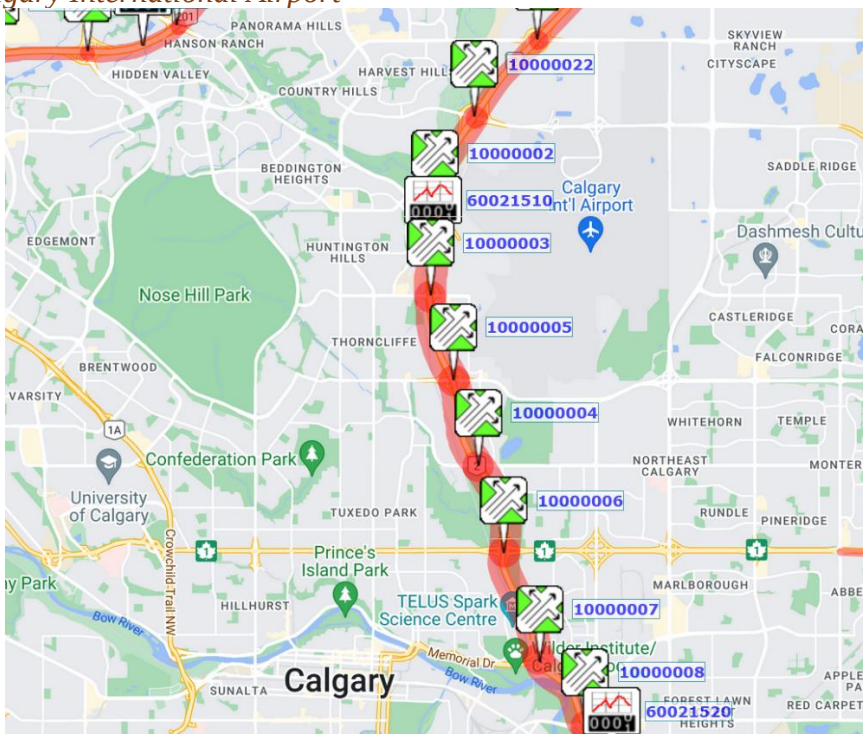


Figure 17: Intersections from Calgary to Calgary International Airport

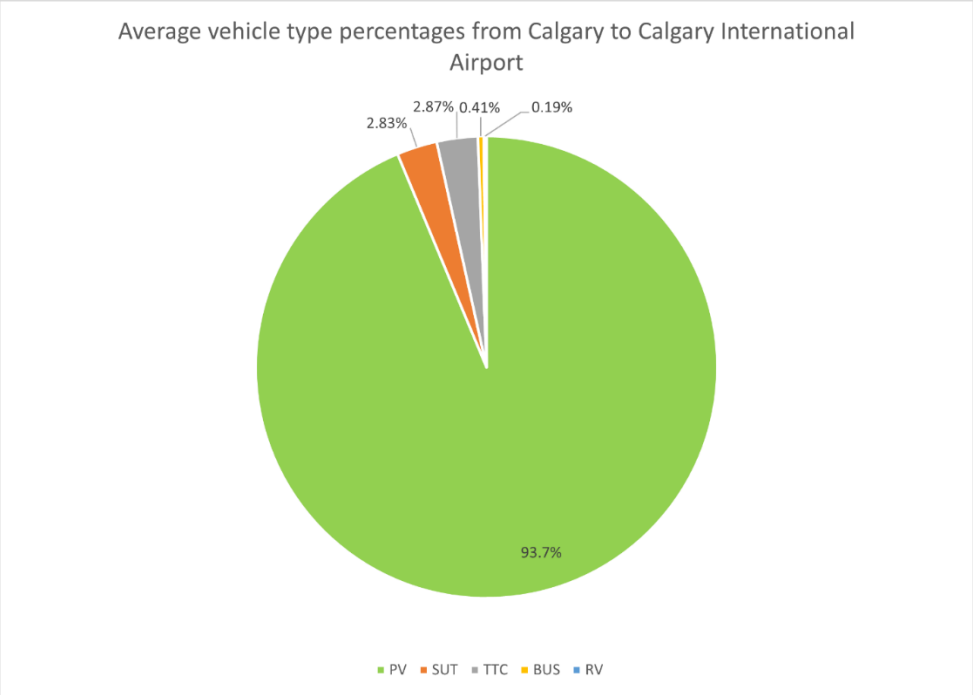


Figure 18: Average vehicle type percentages from the center of Calgary to Calgary International Airport

The first one is Calgary (#10000007) to Calgary International Airport (#10000022), shown in Figure 17. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Calgary to Calgary International Airport are shown in Figure 18.

PV dominated the traffic type on Highway 2 from the center of Calgary to Calgary International Airport, with 93.7% of all vehicle types. ***For public transportation, the BUS only occupied 0.41% of all vehicle types***. For other types of vehicles, SUT occupied 2.83%, TTC was 2.87%, and RV was 0.19%.

For the GHG emissions shown in Figure 19, PV occupied 195.01 kT, then SUT had 6.83 kT, TTC had 6.72 kT, BUS had 1.0 kT, and RV had 0.38 kT. In 2023, PV was 16.1%, SUT was 15.82%, TTC was 4.12%, BUS was 32.25%, and RV was 2.09%.

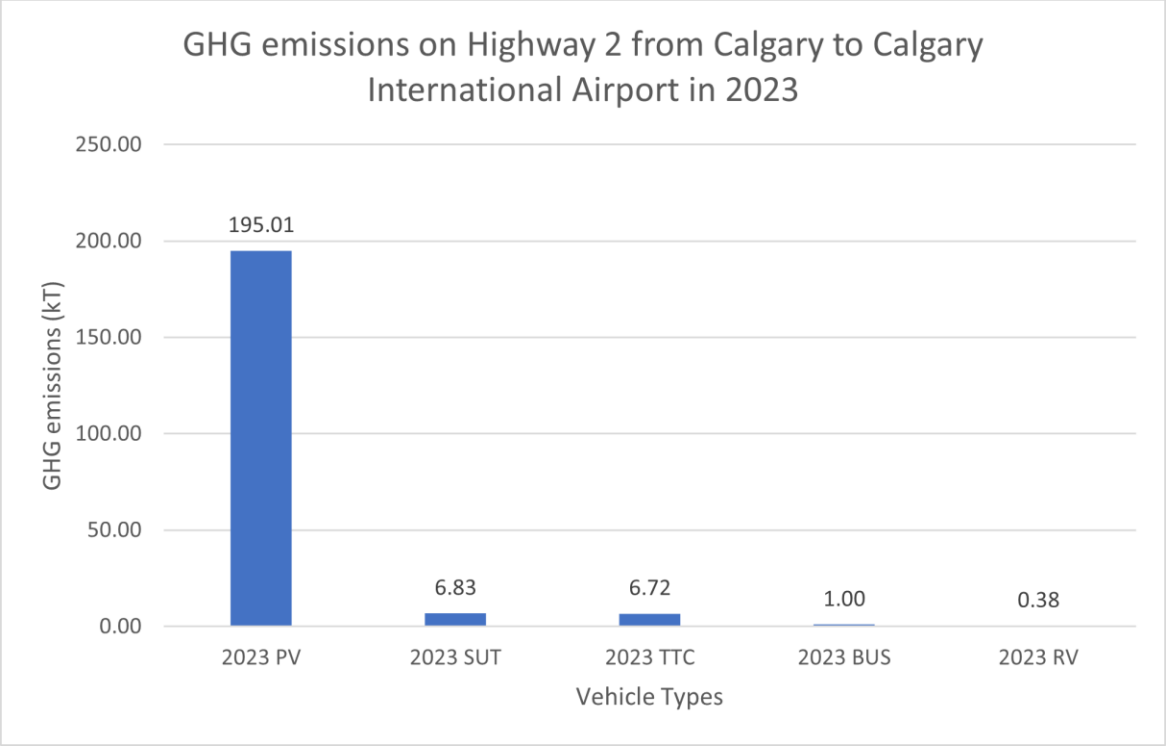


Figure 19: GHG emissions on Highway 2 from Calgary to Calgary International Airport in 2023

Calgary International Airport to Balzac

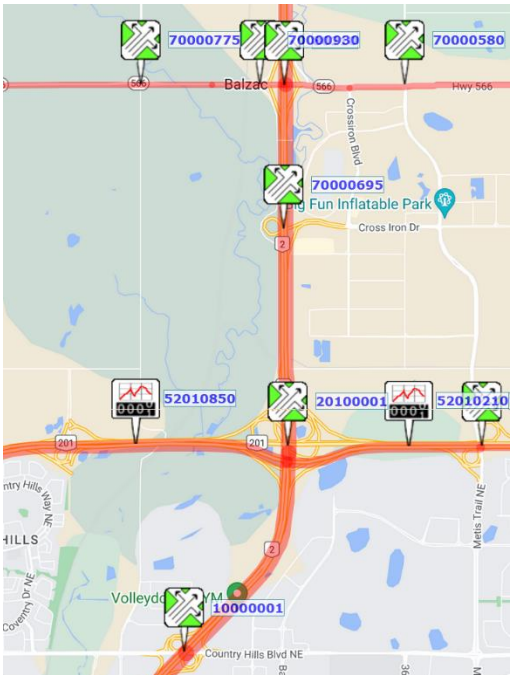


Figure 20: Intersections from Calgary International Airport to Balzac

The second intersection is Calgary International Airport (#10000022) to Balzac (#80210), shown in Figure 20. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Calgary International Airport to Balzac are shown in Figure 21.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 91.1% of the total vehicle types. For public transportation, the BUS only occupied 0.18% of all vehicle types. For other types of vehicles, SUT occupied 2.7%, TTC was 5.48%, and RV was 0.55%.

For the GHG emissions shown in Figure 22, PV occupied 141.77 kT, then SUT had 4.79 kT, TTC had 10.66 kT, BUS had 0.27 kT, and RV had 0.9 kT. In 2023, PV was 11.7%, SUT was 11.08%, TTC was 6.54%, BUS was 8.57%, and RV was 4.91%.

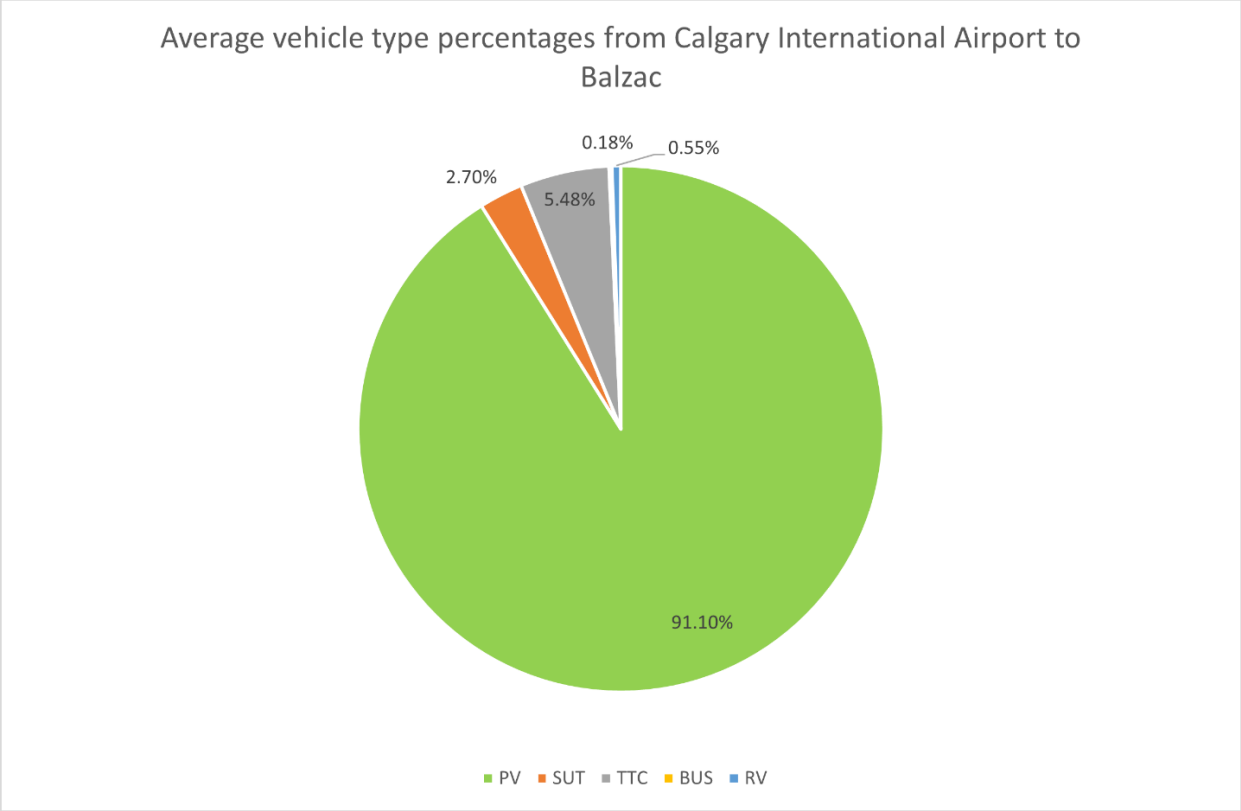


Figure 21: Average vehicle type percentages from Calgary International Airport to Balzac

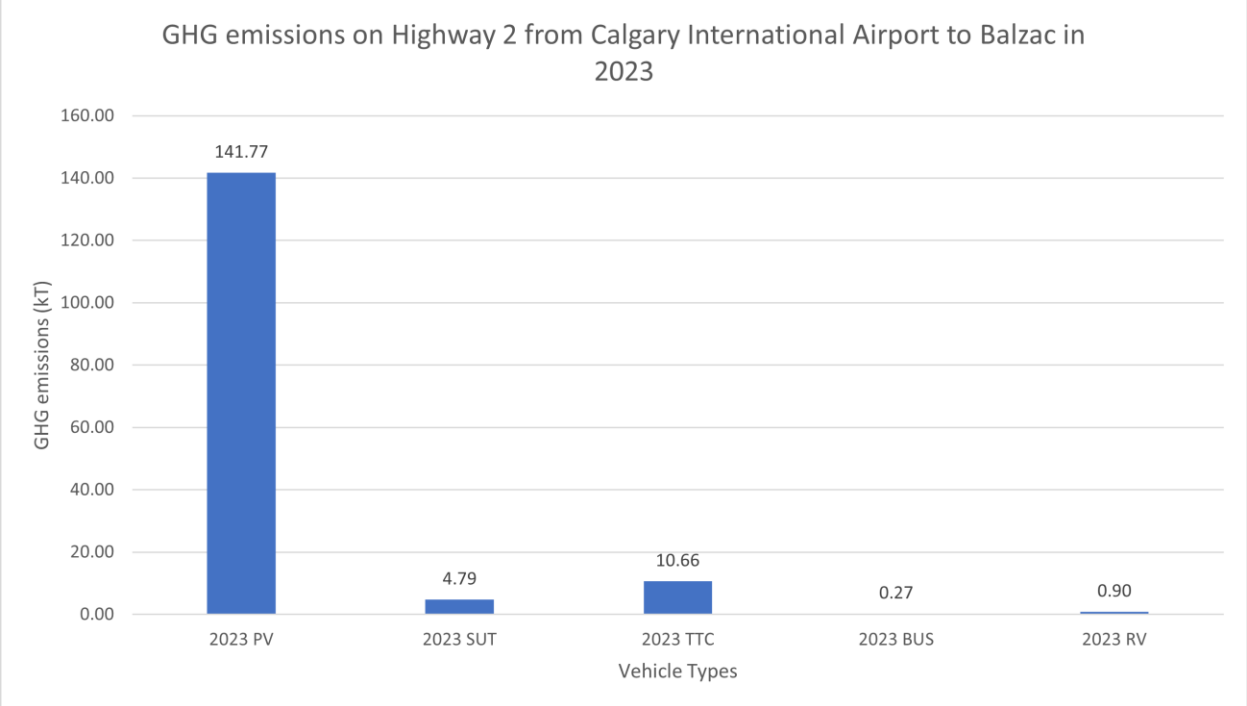


Figure 22: GHG emissions on Highway 2 from Calgary International Airport to Balzac in 2023

Balzac to Airdrie

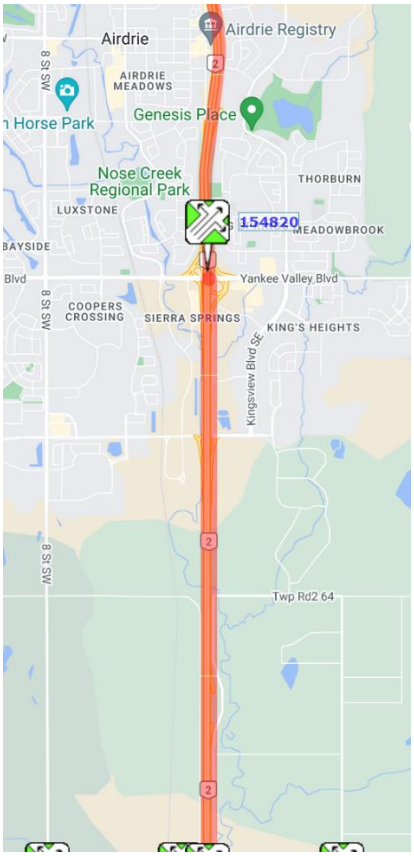


Figure 23: Intersections from Balzac to Airdrie

The third intersection is Balzac (#80210) to Airdrie (#154820), shown in Figure 23. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Balzac to Airdrie are shown in Figure 24.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 88.8% of the total vehicle types. For public transportation, the BUS only occupied 0.1% of all vehicle types. For other types of vehicles, SUT occupied 2.5%, TTC was 7.8%, and RV was 0.8%.

For the GHG emissions shown in Figure 25, PV occupied 73.45 kT, then SUT had 2.31 kT, TTC had 6.92 kT, BUS had 0.09 kT, and RV had 0.58 kT. In 2023, PV was 6.06%, SUT was 5.36%, TTC was 4.24%, BUS was 3.04%, and RV was 3.18%.

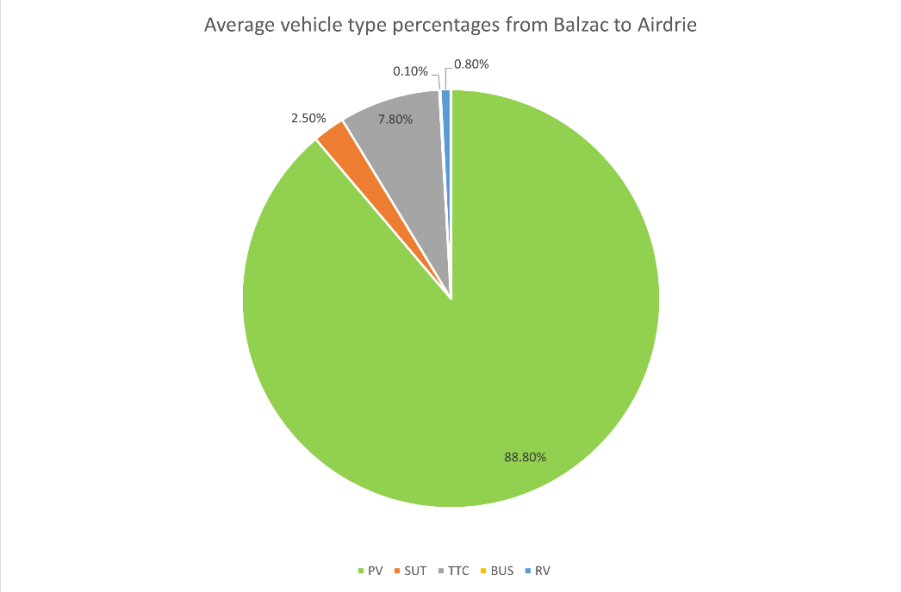


Figure 24: Average vehicle type percentages from Balzac to Airdrie

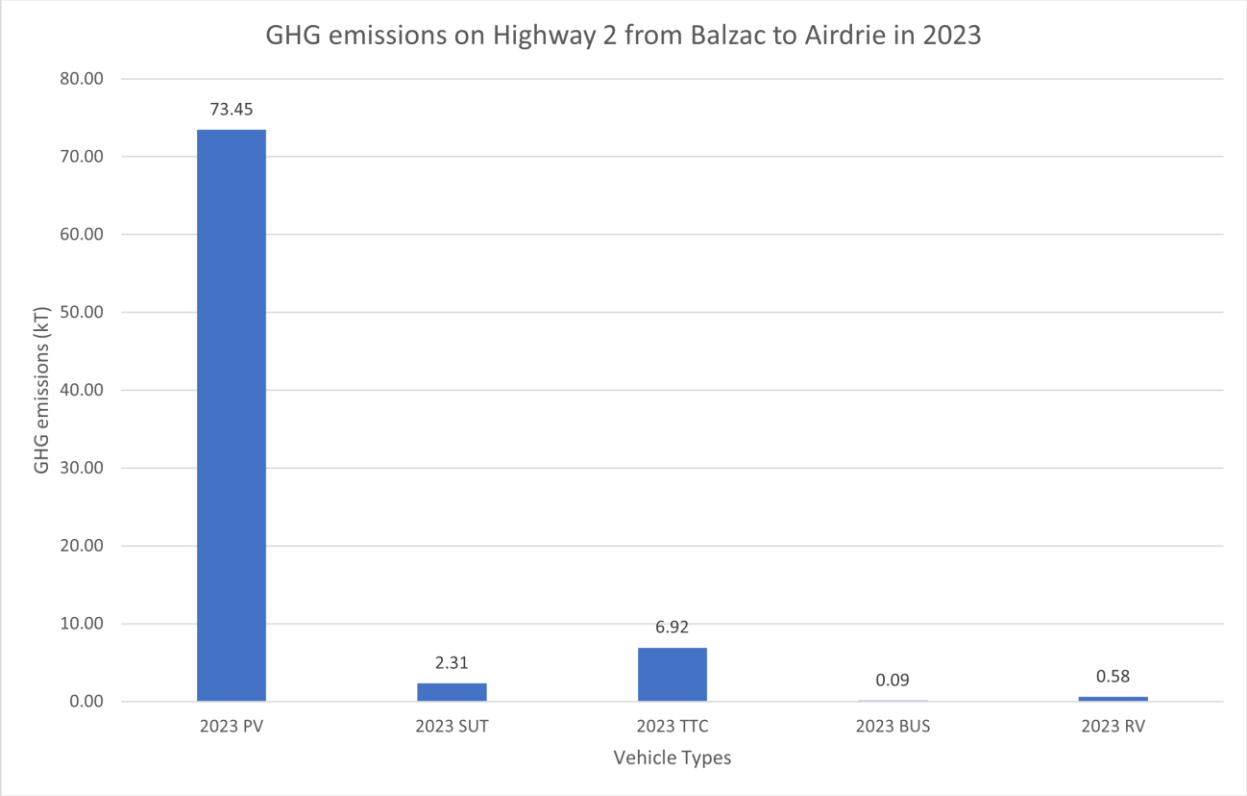


Figure 25: GHG emissions on Highway 2 from Balzac to Airdrie in 2023

Airdrie to Bowden

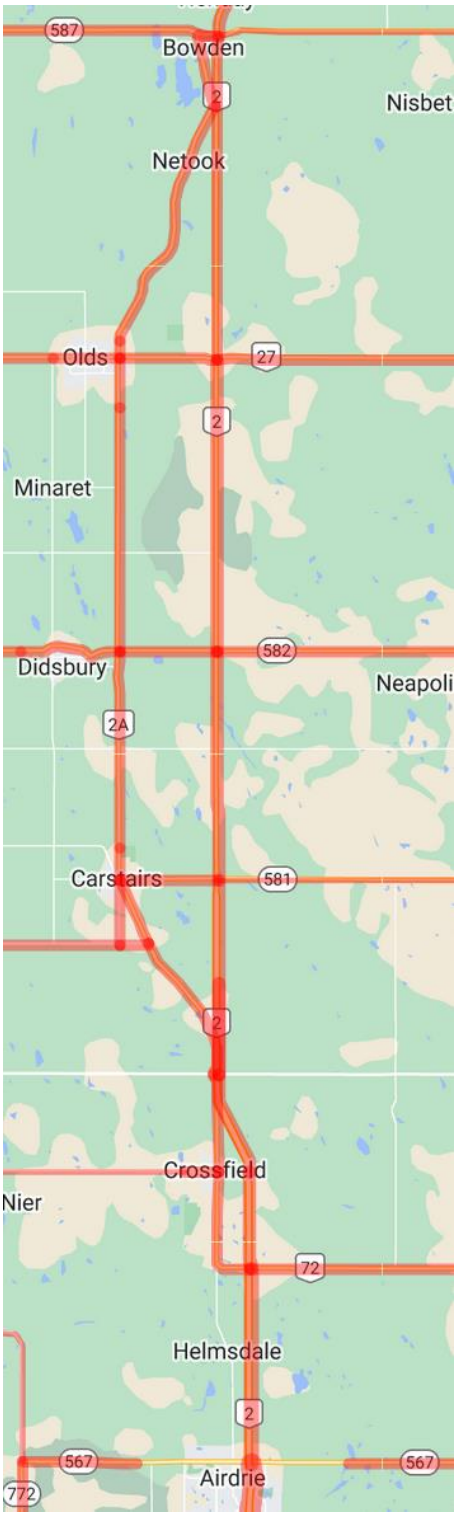


Figure 26: Intersections from Airdrie to Bowden

The fourth intersection north of Calgary along Highway 2 is Airdrie (#154820) to Bowden (#79290), shown in Figure 26. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Airdrie to Bowden are shown in Figure 27.

PV dominated the traffic type on Highway 2 from Airdrie to Bowden, with 83.53% of the total vehicle types. For public transportation, intercity bus travel only occupied 0.13% of all vehicle types. For other types of vehicles, SUT occupied 2.58%, TTC 11.79%, and RV 1.99%.

GHG emissions shown in Figure 28, PV occupied 284.27 kT, then SUT had 10.16 kT, TTC had 47.43 kT, BUS had 0.51 kT, and RV had 6.97 kT. In 2023, PV was 23.46%, SUT was 23.52%, TTC was 29.1%, BUS was 16.45%, and RV was 38.16%.

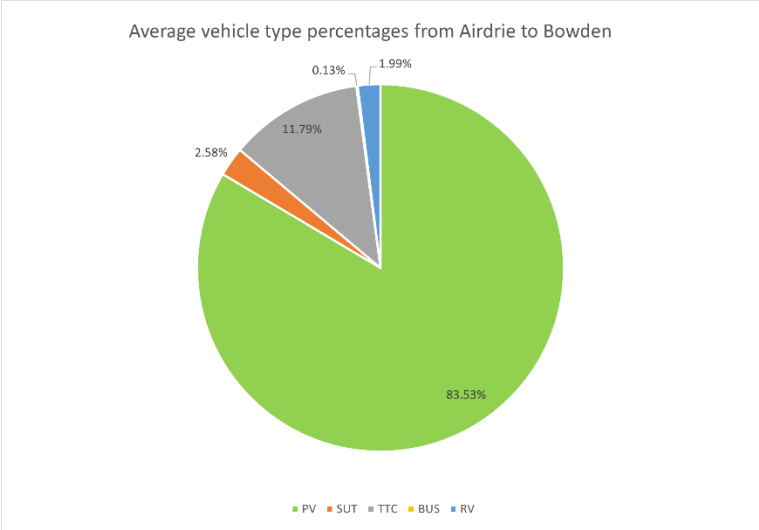


Figure 27: Average vehicle type percentages from Airdrie to Bowden

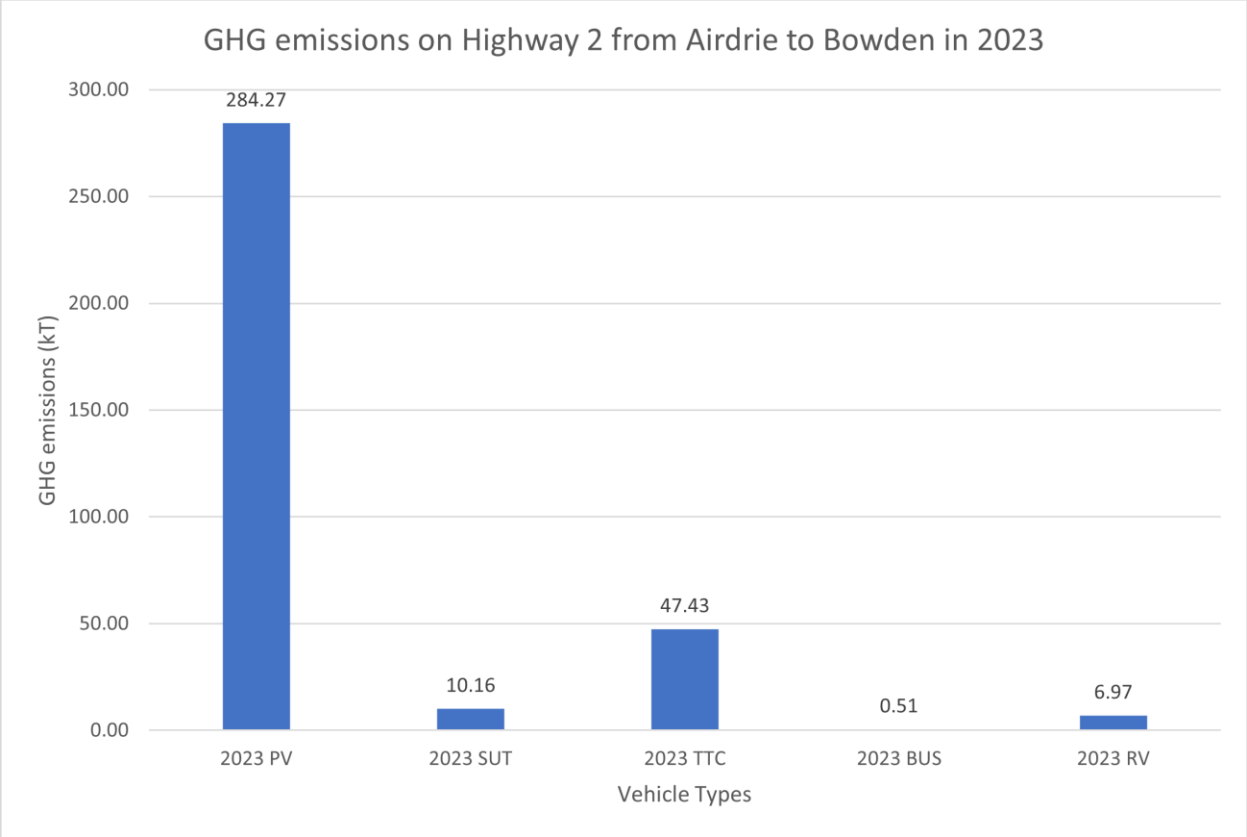


Figure 28: GHG emissions on Highway 2 from Airdrie to Bowden in 2023

Bowden to Innisfail

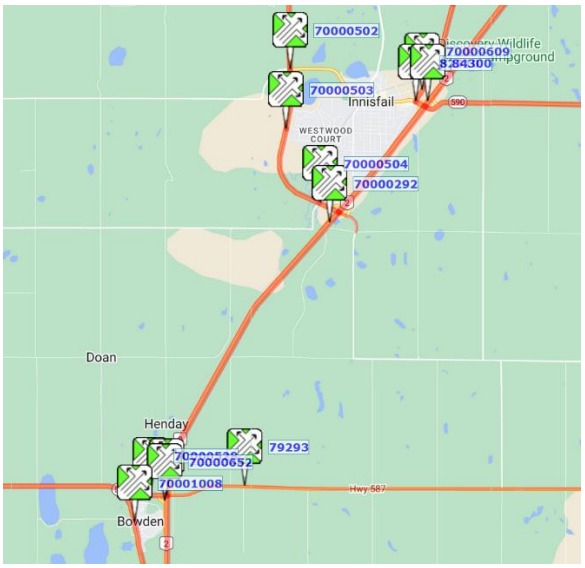


Figure 29: Intersections from Bowden to Innisfail

The Bowden (#79290) to Innisfail (#84300) intersection, is shown in Figure 29. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Bowden to Innisfail are shown in Figure 30.

PV dominated the traffic type on Highway 2 from Bowden to Innisfail, with 82.75% of the total vehicle types. For public transportation, the BUS only occupied 0.2% of all vehicle types. For other types of vehicles, SUT occupied 2.85%, TTC 12.6%, and RV 1.6%.

For the GHG emissions shown in Figure 31, PV occupied 87.25 kT, then SUT had 3.45 kT, TTC had 15.06 kT, BUS had 0.24 kT, and RV had 1.66 kT. In 2023, PV was 7.2%, SUT was 7.99%, TTC was 9.24%, BUS was 7.79%, and RV was 9.09%.

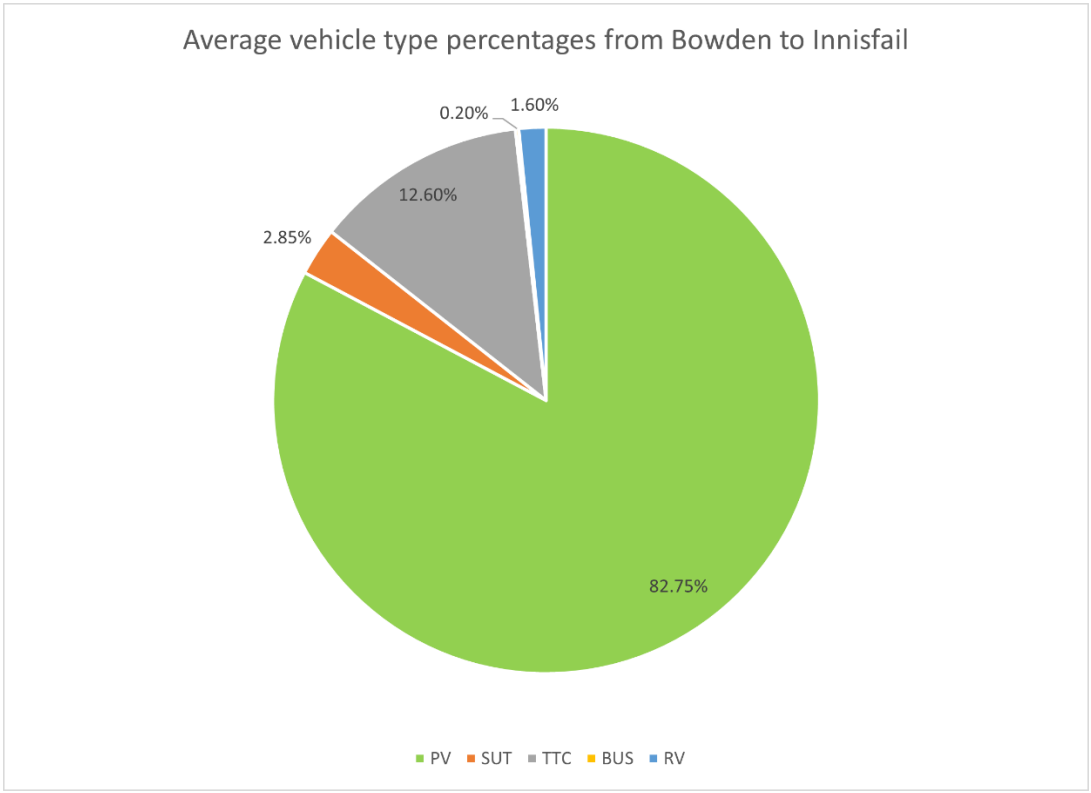


Figure 30: Average vehicle type percentages from Bowden to Innisfail

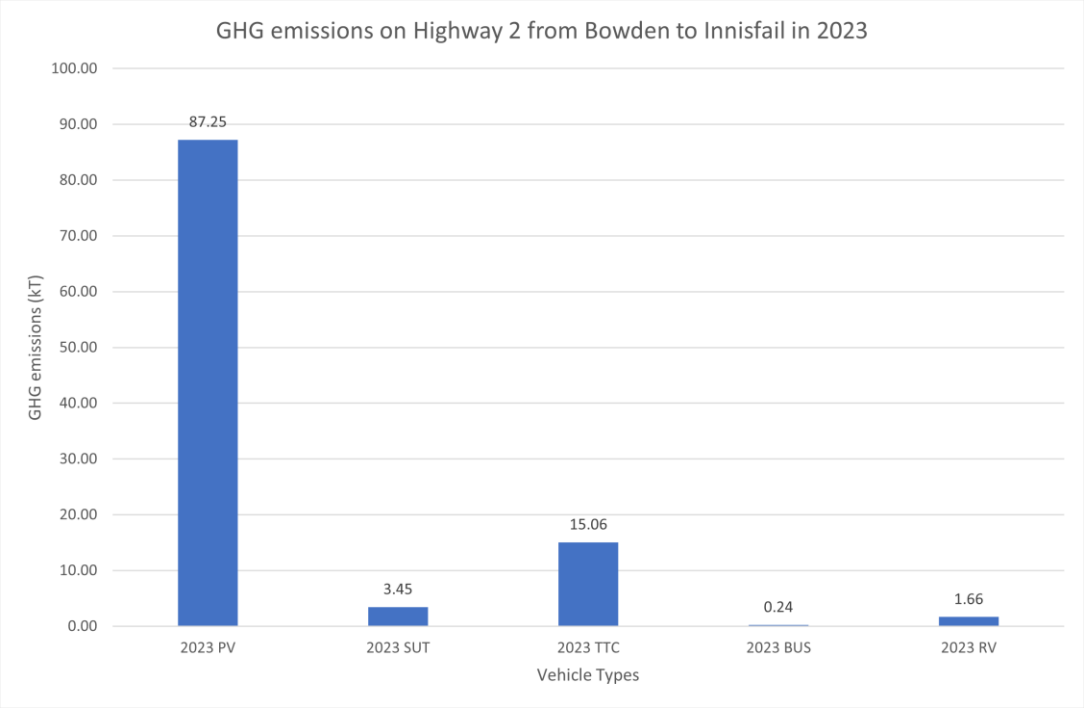


Figure 31: GHG emissions on Highway 2 from Bowden to Innisfail in 2023

Innisfail to The Highway 11 Interchange

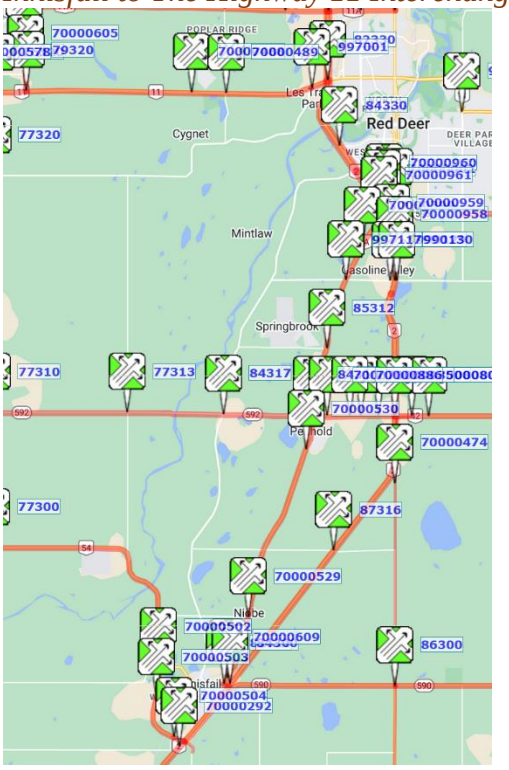


Figure 32: Intersections from Innisfail to Les Trailer Park

Travelling north from Innisfail (#84300) to the Highway 11 interchange is a major crossroad. Highway 11 heads west to Rocky Mountain House and East into Red Deer (#82330), shown in Figure 32. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Innisfail to The Highway 11 Interchange are shown in Figure 33.

PV dominated the traffic type on Highway 2 from Innisfail to The Highway 11 Interchange, with 84.29% of the total vehicle types. For public transportation, the BUS only occupied 0.11% of all vehicle types. For other types of vehicles, SUT occupied 2.87%, TTC 11.11%, and RV 1.61%.

For the GHG emissions shown in Figure 34, PV occupied 123.29 kT, then SUT had 4.85 kT, TTC had 18.2 kT, BUS had 0.23 kT, and RV had 2.2 kT. In 2023, PV was 10.18%, SUT was 11.23%, TTC was 11.17%, BUS was 7.56%, and RV was 12.04%.

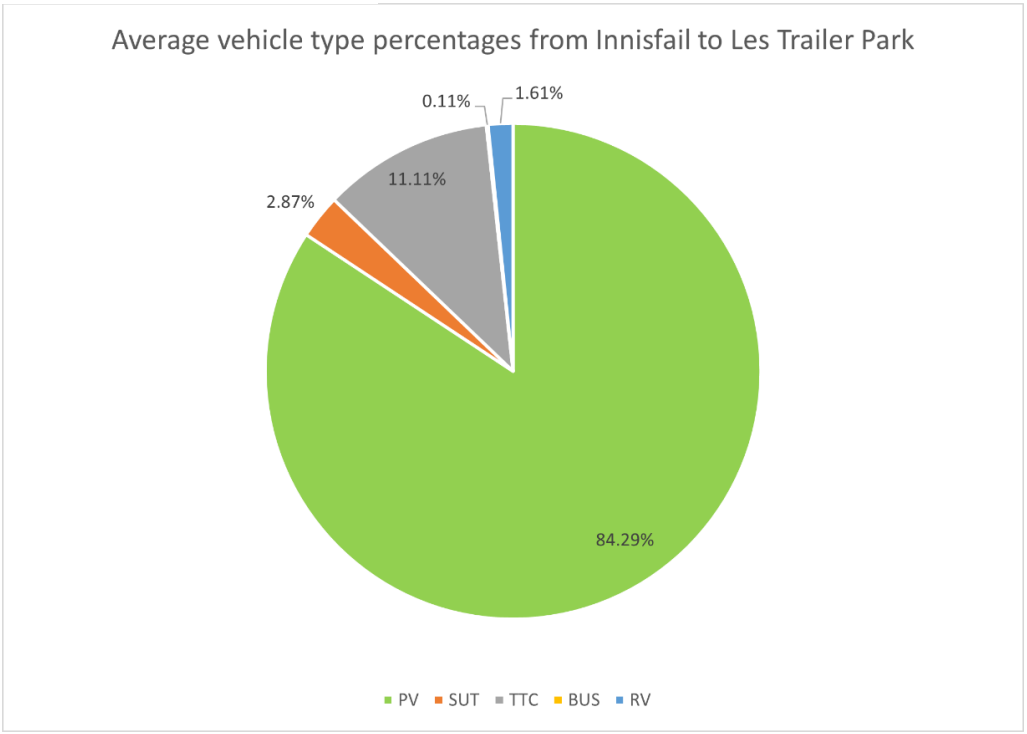


Figure 33: Average vehicle type percentages from Innisfail to The Highway 11 Interchange

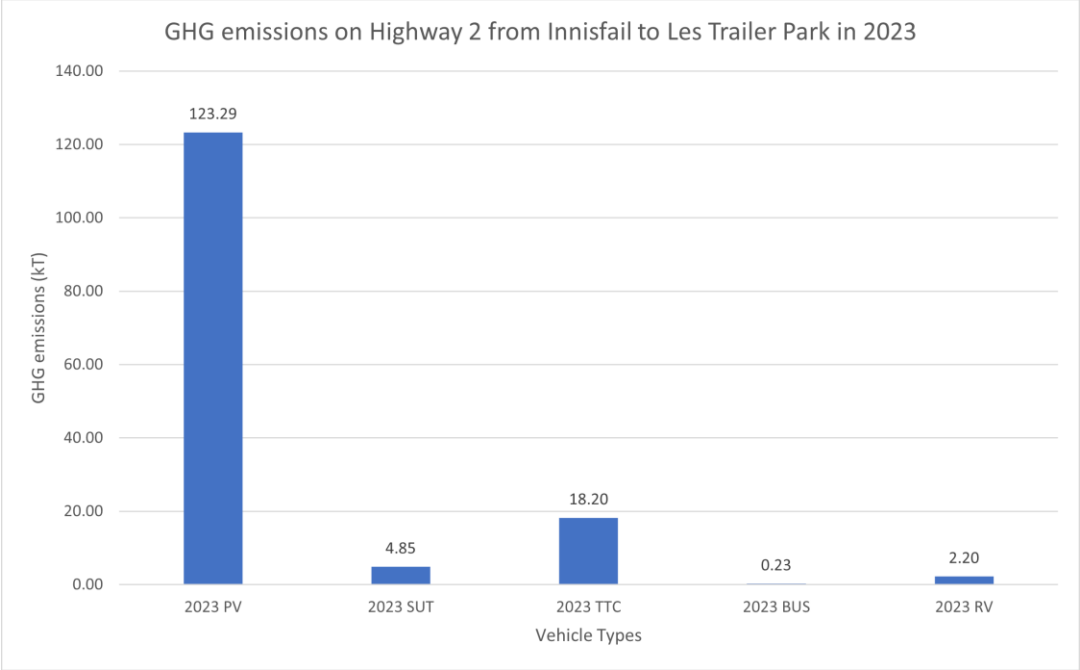


Figure 34: GHG emissions on Highway 2 from Innisfail to The Highway 11 Interchange in 2023

The Highway 11 Interchange to The Highway 12 Interchange

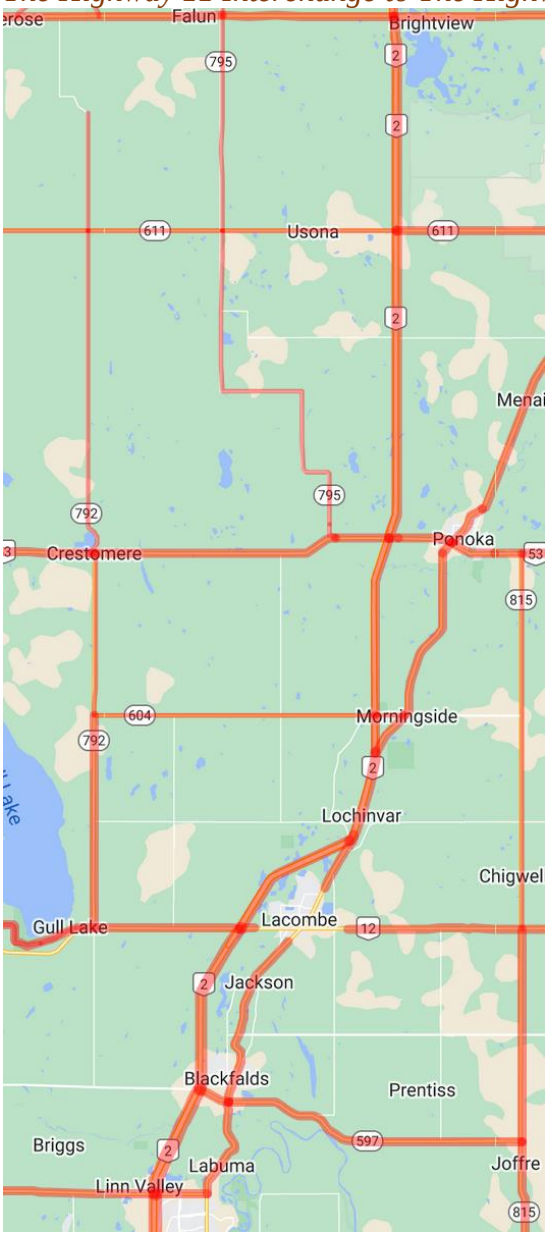


Figure 35: Intersections from Les Trailer Park to The Highway 12 Interchange

The seventh intersection from Calgary is from Highway 11 (#82330) to The Highway 12 Interchange (#94390), shown in Figure 35. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from the Highway 11 interchange to the Highway 12 Interchange are shown in Figure 36.

PV dominated the traffic type on Highway 2 from The Highway 11 Interchange to The Highway 12 Interchange, with 80.59% of the total vehicle types. For public transportation, the BUS only occupied 0.16% of all vehicle types. For other types of vehicles, SUT occupied 2.72%, TTC 14.88%, and RV 1.65%.

For the GHG emissions shown in Figure 37, PV occupied 274.08 kT, then SUT had 10.51 kT, TTC had 56.88 kT, BUS had 0.62 kT, and RV had 5.76 kT. In 2023, PV was 22.62%, SUT was 24.33%, TTC was 34.9%, BUS was 19.96%, and RV was 31.54%.

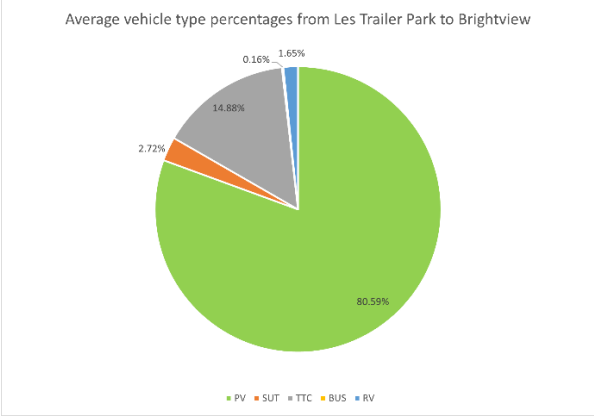


Figure 36: Average vehicle type percentages from the Highway 11 interchange to the Highway 12 Interchange

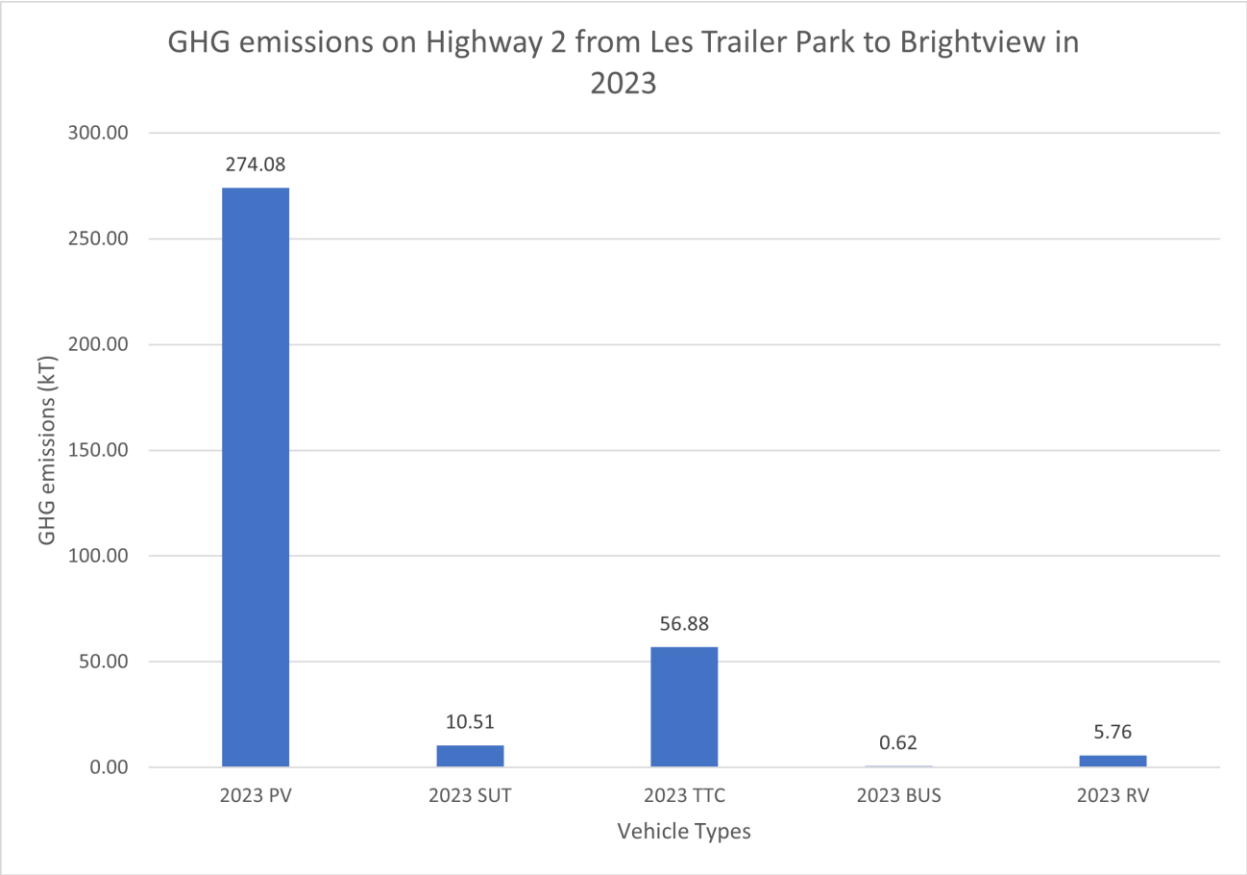


Figure 37: GHG emissions along Highway 2 from the Highway 11 interchange to the Highway 12 Interchange in 2023

The Highway 12 Interchange to the Highway 39 intersection

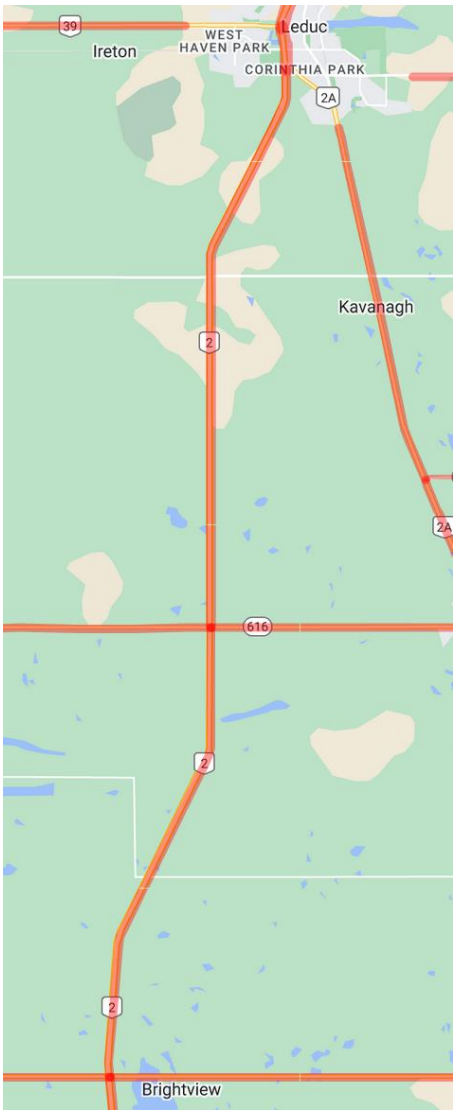


Figure 38: Intersections from the Highway 12 Interchange to the Highway 39 intersection

The eighth interchange is the Highway 12 Interchange (#94390) to The Highway 39 intersection (#87450), shown in Figure 38. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from the Highway 12 Interchange to the Highway 39 intersection are shown in Figure 39.

PV dominated the traffic type on Highway 2 from the Highway 12 Interchange to the Highway 39 intersection, with 82.5% of the total vehicle types. For public transportation, the BUS only occupied 0.14% of all vehicle types. For other types of vehicles, SUT occupied 2.46%, TTC 13.44%, and RV 1.46%.

For the GHG emissions shown in Figure 40, PV occupied 90.21 kT, then SUT had 3.13 kT, TTC had 17.61 kT, BUS had 0.19 kT, and RV had 1.64 kT. In 2023, PV was 7.45%, SUT was 7.24%, TTC was 10.8%, BUS was 6.23%, and RV was 9.0%.

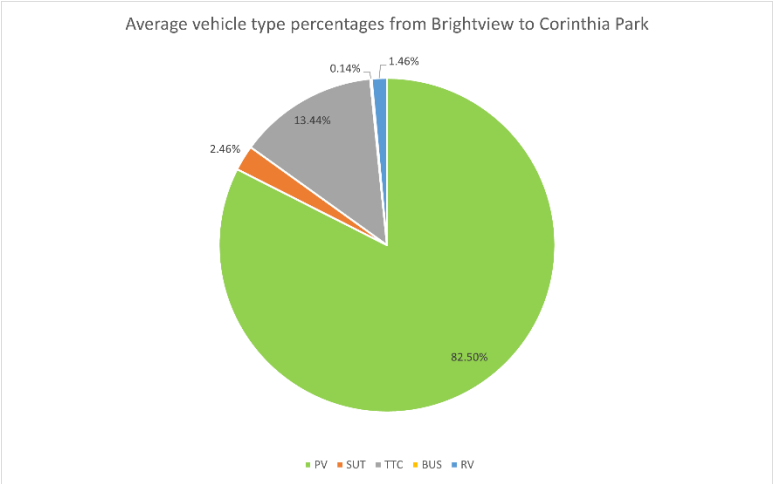


Figure 39: Average vehicle type percentages from the Highway 12 Interchange to the Highway 39 intersection

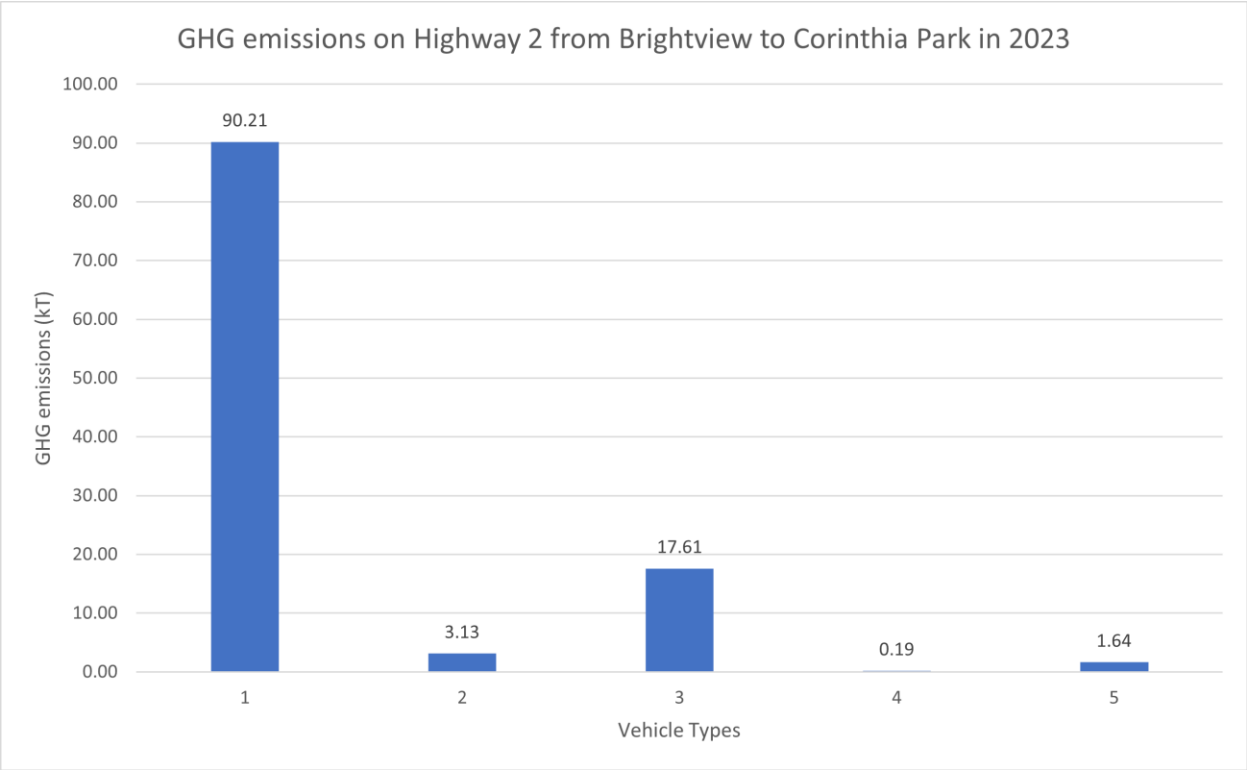


Figure 40: GHG emissions on Highway 2 from the Highway 12 Interchange to the Highway 39 intersection in 2023

The Highway 39 intersection to Leduc

The ninth one is the Highway 39 intersection (#87450) to Leduc (#88450), shown in Figure 41. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from The Highway 39 intersection to Leduc are shown in Figure 42.

PV dominated the traffic type on Highway 2 from The Highway 39 intersection to Leduc, with 87.5% of the total vehicle types. For public transportation, the BUS only occupied 0.1% of all vehicle types. For other types of vehicles, SUT occupied 2.3%, TTC was 9.15%, and RV was 0.95%.

For the GHG emissions shown in Figure 43, PV occupied 19.26 kT, then SUT had 0.58 kT, TTC had 2.17 kT, BUS had 0.03 kT, and RV had 0.19 kT. In 2023, PV was 1.59%, SUT was 1.34%, TTC was 1.33%, BUS was 0.81%, and RV was 1.07%.

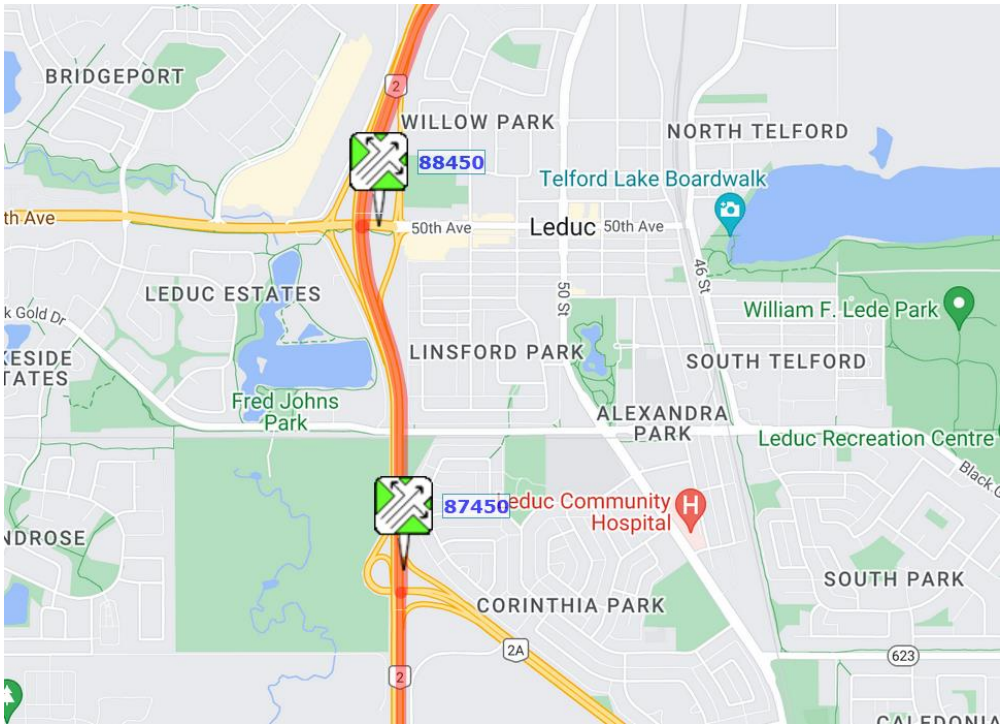


Figure 41: Interchanges from the Highway 39 intersection to Leduc

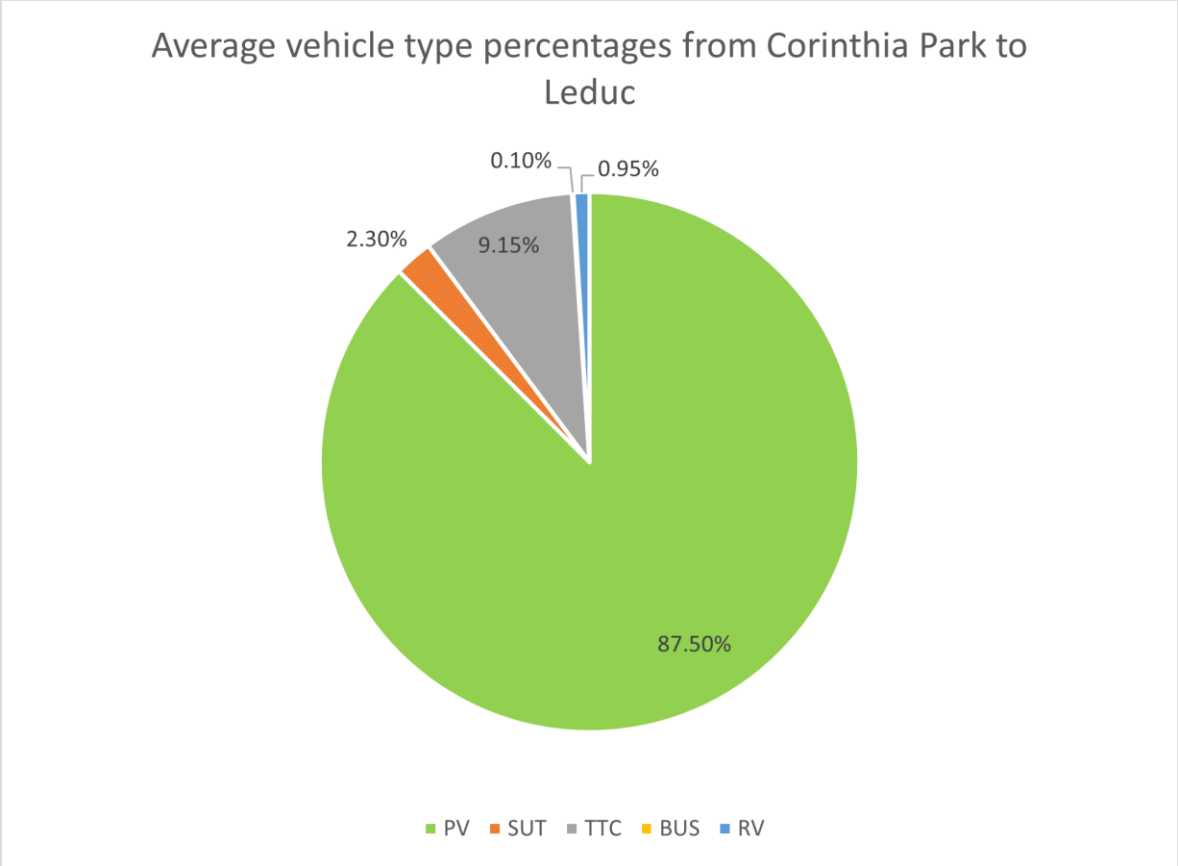


Figure 42: Average vehicle type percentages from the Highway 39 intersection to Leduc

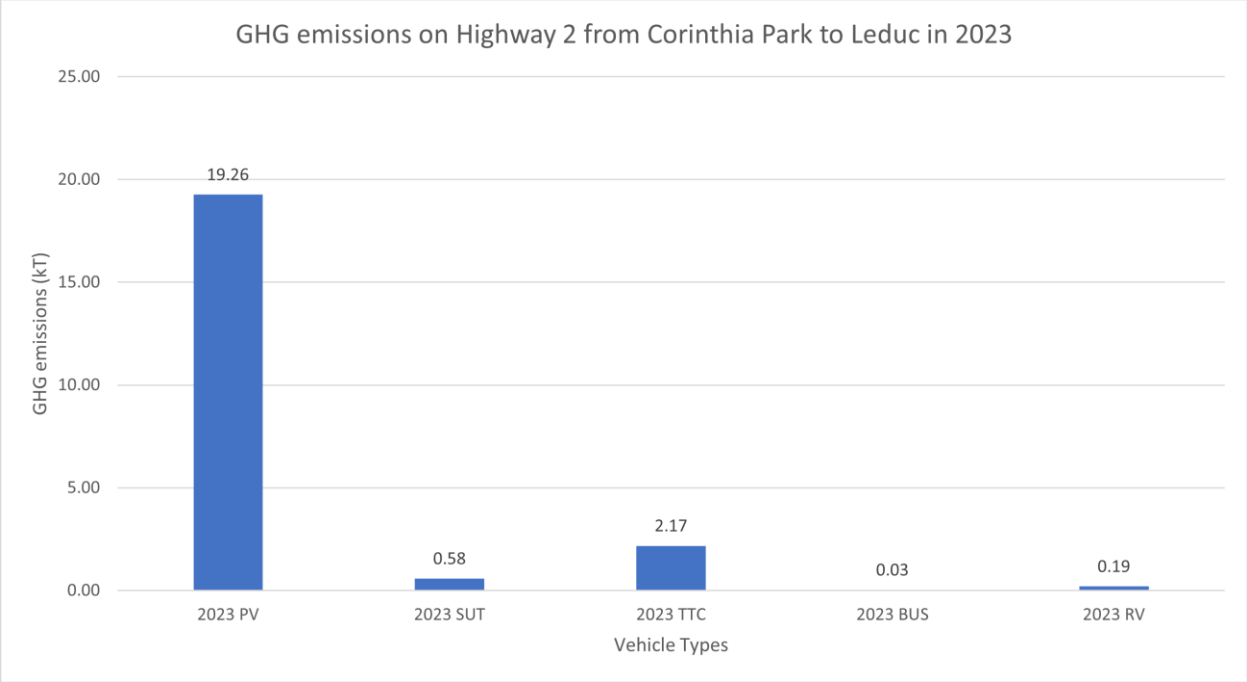


Figure 43: GHG emissions on Highway 2 from the Highway 39 intersection to Leduc in 2023

Leduc to Edmonton

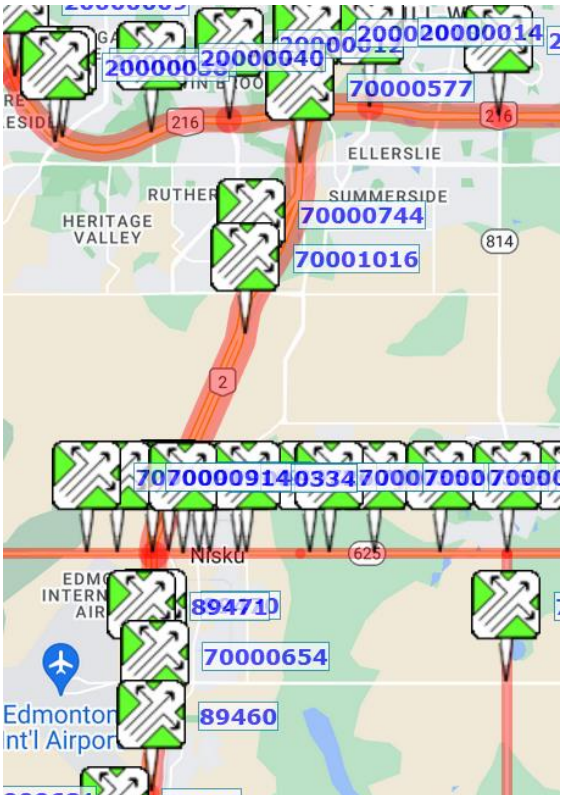


Figure 44: Intersections from Leduc to Edmonton

The final interchange, Leduc (#88450) to Edmonton (#20000013), is shown in Figure 44. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Leduc to Edmonton are shown in Figure 45.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 89.76% of the total vehicle types. For public transportation, the BUS only occupied 0.16% of all vehicle types. For other types of vehicles, SUT occupied 2.39%, TTC was 6.9%, and RV was 0.79%.

For the GHG emissions shown in Figure 46, PV occupied 174.41 kT, then SUT had 5.59 kT, TTC had 15.76 kT, BUS had 0.4 kT, and RV had 1.54 kT. In 2023, PV was 14.39%, SUT was 12.94%, TTC was 9.67%, BUS was 12.93%, and RV was 8.41%.

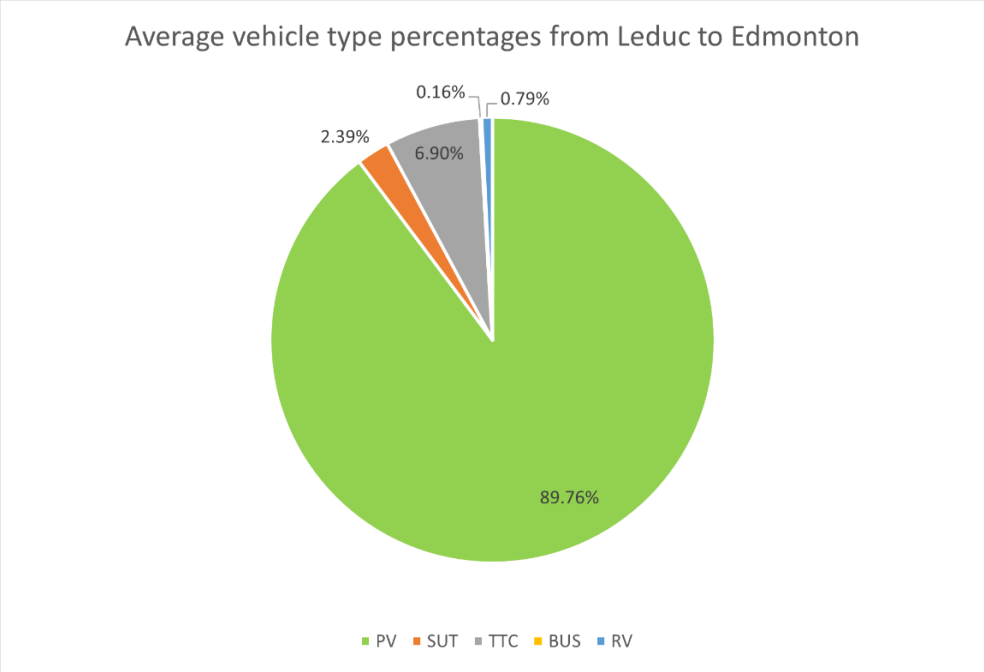


Figure 45: Average vehicle type percentages from Leduc to Edmonton

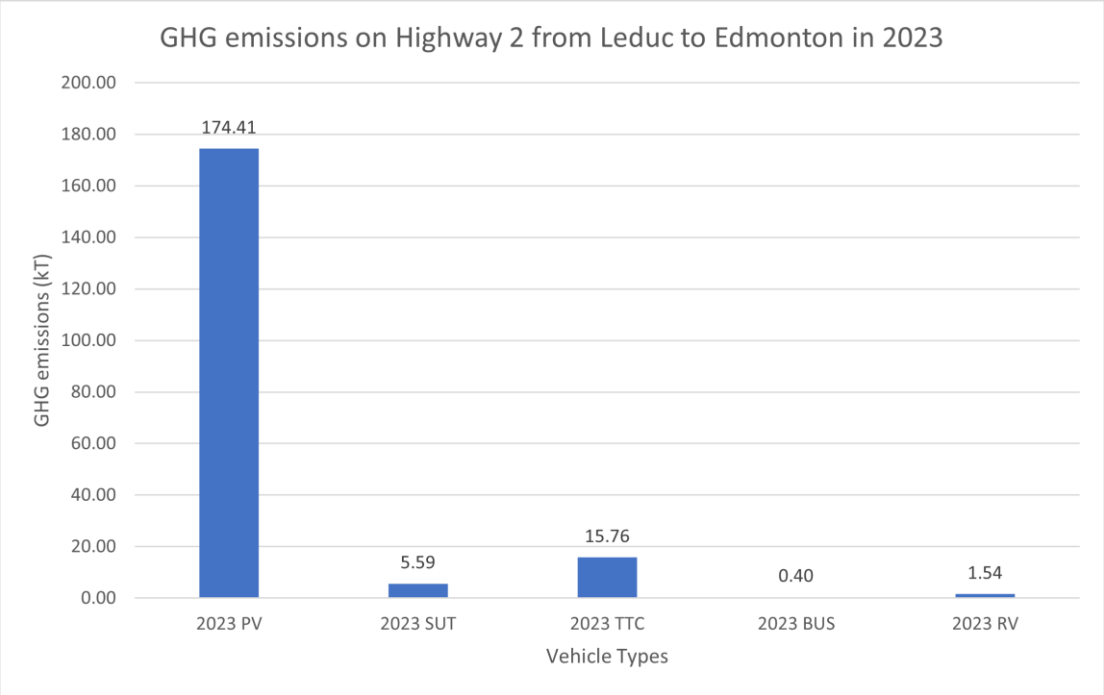


Figure 46: GHG emissions on Highway 2 from Leduc to Edmonton in 2023

Impact of COVID-19 to GHG emissions

From 2019 until 2020 the COVID-19 pandemic impacted GHG emissions which dropped 298.18 kT. Specifically, based on Figure 13 and Figure 14, in 2019 and 2020, PV created 1356.33 kT (84.30%) GHG emission, SUT created 48.31 kT (3.00%) GHG emission, TTC created 180.69 kT (11.23%) GHG emission, BUS created 3.47 kT (0.22%) GHG emission, and RV created 20.21 kT (1.26%) GHG emission. In 2020, PV created 1105.62 kT (84.35%) GHG emissions, SUT created 39.35 kT (3.00%) GHG emissions, TTC created 149.61 kT (11.18%) GHG emissions, BUS created 2.83 kT (0.22%) GHG emission, and RV created 16.41 kT (1.25%) GHG emission.

After the vaccine was invented in 2020, the GHG emission gradually increased and slightly decreased from 2020 to 2023. From 2020 to 2021, the GHG emission increased 85.41 kT. From 2021 to 2022, the GHG emission decreased 48.83 kT. From 2022 to 2023, the GHG emission increased 91.73 kT.

GHG emissions on Highway 2 from Edmonton to Calgary (North to South)

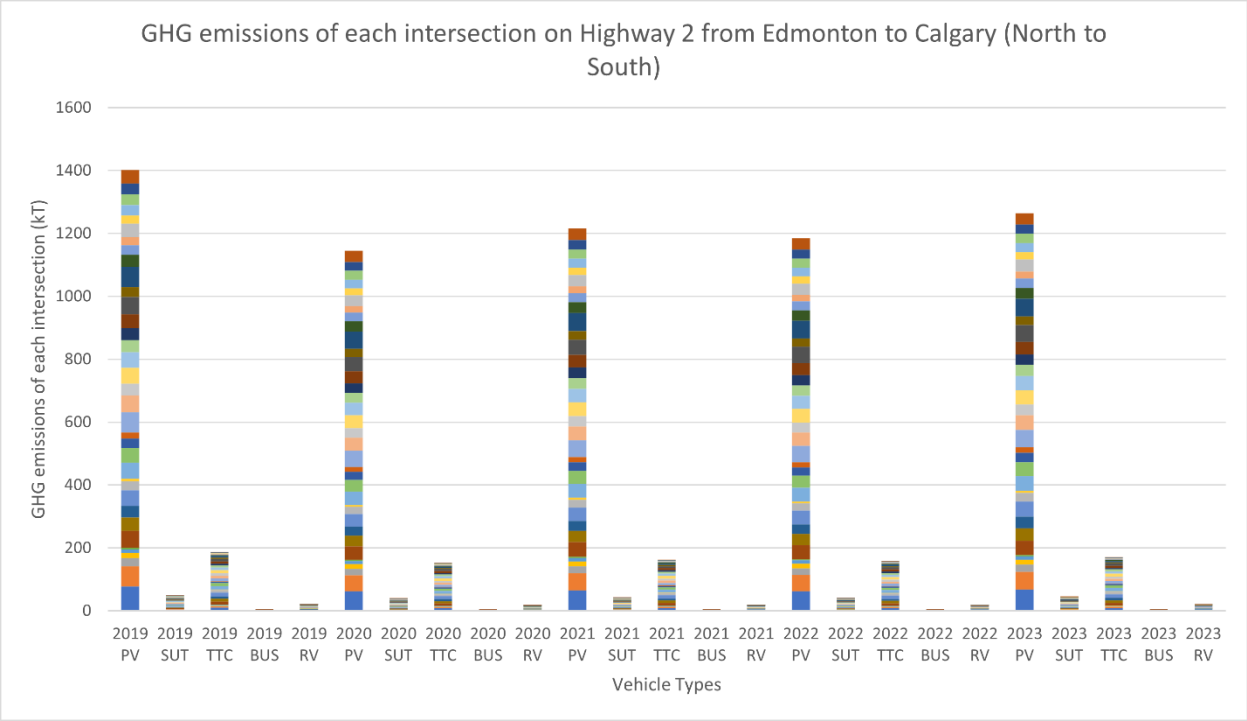


Figure 47: GHG emissions of each intersection onto Highway 2 from Edmonton to Calgary (North to South)

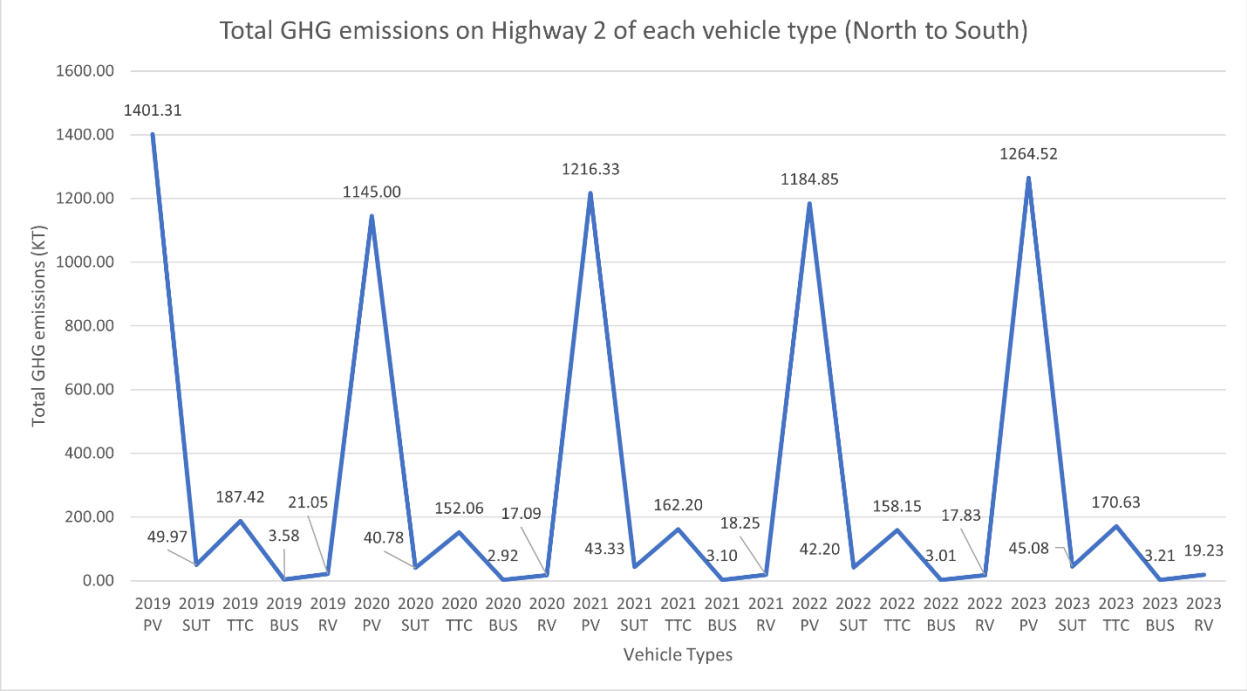


Figure 48: Total GHG emissions on Highway 2 of each vehicle type (North to South)

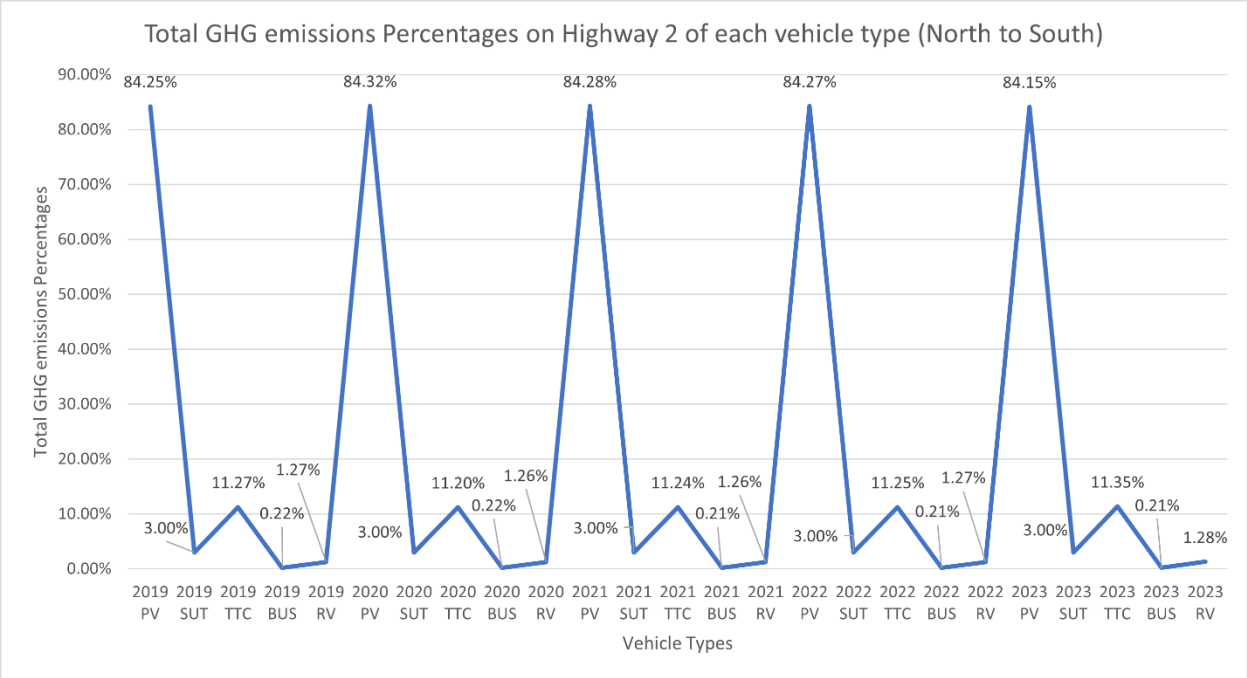


Figure 49: Total GHG emissions Percentages on Highway 2 of each vehicle type (North to South)

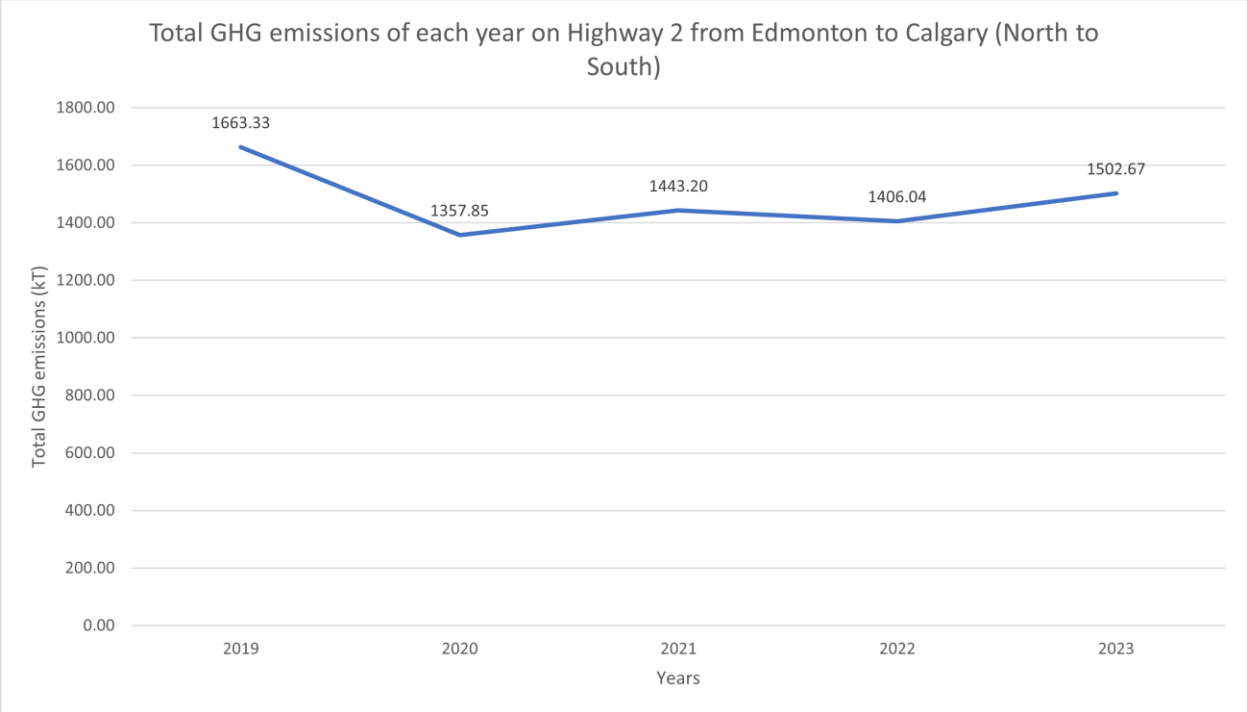


Figure 50: Total GHG emissions of each year on Highway 2 from Edmonton to Calgary (North to South)

Based on the GHG emission formula calculation, the GHG emissions on Highway 2 from North to South are mainly PV vehicles. With 85.6% of PV, 2.7% of SUT, 10.3% of TTC, 0.2% of BUS, and 1.3% of RV from Edmonton to Calgary. From Figure 47, each color differentiates interchanges between Edmonton and Calgary. Start point the South of Edmonton, going through Leduc, The Highway 39 intersection, the Highway 12 Interchange, The Highway 11 Interchange, West Park Extension, Gasoline Alley, Innisfail, Bowden, Airdrie, Balzac, Calgary International Airport, and endpoint in Calgary. From Figure 50, the total GHG emissions between 2019 to 2023 are 1663.33, 1357.85, 1443.20, 1406.04, and 1502.67 kT.

From the dataset of AADT traffic load on Highway 2 from Edmonton to Calgary (North to South), starting from the Edmonton to Leduc, the traffic counts gradually decreased, from 48610 dropped to 19560 vehicles in 2023. From Leduc to The Highway 39 intersection, the vehicle counts dropped from 19560 to 13200 in 2023. From The Highway 39 intersection to the Highway 12 Interchange, the vehicle counts dropped from 13200 to 12820 in 2023. From the Highway 12 Interchange to The Highway 11 Interchange, the vehicle counts increased from 12820 to 24130 in 2023. From The Highway 11 Interchange to West Park Extension, the vehicle counts dropped from 24130 to 20310 in 2023. From West Park Extension to Gasoline Alley, the vehicle counts dropped from 20310 to 17580 in 2023. From Gasoline Alley to Innisfail, the vehicle counts dropped from 17580 to 14150 in 2023. From Innisfail to Bowden, the vehicle counts dropped from 14150 to 14100 in 2023. From Bowden to Airdrie, the vehicle counts rose from 14100 to 37450 in 2023. From Airdrie to Balzac, the vehicle counts increased from 37450 to 39130 in 2023. From Balzac to Calgary International Airport, the vehicle counts increased from 39130 to 49720 in 2023. From Calgary International Airport to Calgary, the vehicle counts increased from 49720 to 71490 in 2023. The highest traffic load is between Calgary and Calgary International Airport. From 2019 to 2023, the AADT traffic counts are approximately 80086, 66167, 69274, 67616, and 69931 vehicles yearly. On the contrary, the lowest traffic load is between The Highway 11 Interchange and the Highway 12 Interchange. From 2019 to 2023, the AADT traffic counts are approximately 16849, 13688, 14641, 14281, and 16130 vehicles yearly.

Highway 2 from North to South (E-C)

The second route is from Edmonton to Calgary. Starting from the center of Edmonton, passing through Leduc, The Highway 39 intersection, the Highway 12 Interchange, the Highway 11 Interchange, Innisfail, Bowden, Airdrie, Balzac, Calgary International Airport, and arrived at Calgary. Based on the result from Figure 51, Calgary to Calgary International Airport took up most of the traffic load on Highway 2 from Edmonton to Calgary, with 69931 vehicles. The average traffic counts start from Edmonton to Leduc with 32578 vehicles, then plunged to 16380 vehicles, fluctuated approximately 15974 vehicles from Leduc to Bowden, then surged in Balzac from 19674 to 38290 vehicles, slightly increased from Balzac to Calgary International Airport, and finally surged from Calgary International Airport to Calgary, from 43243 to 69931 vehicles.

With the pattern from Edmonton to Calgary, the priority of reducing GHG emissions should follow the below sequence: Calgary International Airport to Calgary, Balzac to Calgary International Airport, Airdrie to Balzac, Edmonton to Leduc, Bowden to Airdrie, The Highway 11 Interchange to Innisfail, Leduc to The Highway 39 intersection, the Highway 12 Interchange to The Highway 11 Interchange, Innisfail to Bowden, and finally The Highway 39 intersection to the Highway 12 Interchange.

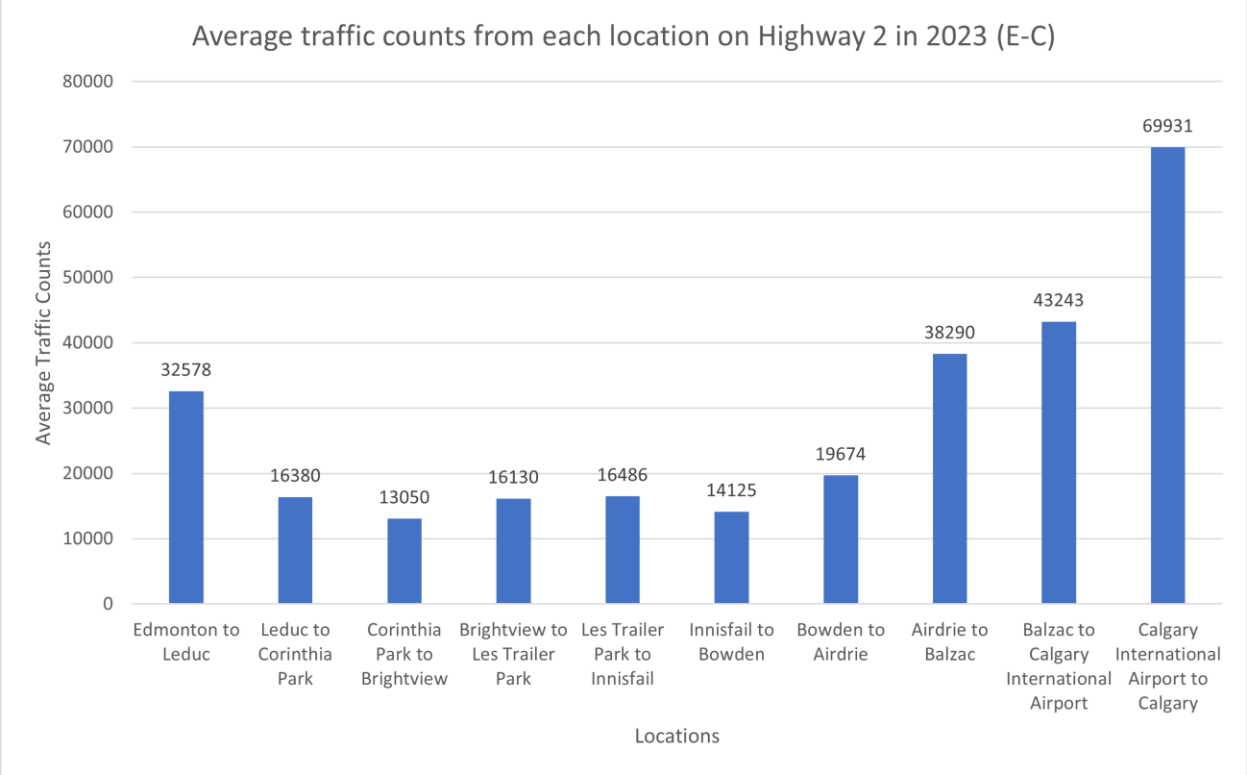


Figure 51: Average traffic counts from each location on Highway 2 in 2023 (E-C)

Edmonton to Leduc

The first dataset south of Edmonton (#20000013) to Leduc (#88450) along Highway 2 is shown in Figure 44. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Edmonton to Leduc are shown in Figure 52.

PV dominated the traffic type on Highway 2 from Edmonton to Leduc, with 89.76% of all vehicle types. For public transportation, the BUS only occupied 0.16% of all vehicle types. For other types of vehicles, SUT occupied 2.39%, TTC was 6.9%, and RV was 0.79%.

For the GHG emissions shown in Figure 53, PV occupied 173.4 kT, then SUT had 5.65 kT, TTC had 16.36 kT, BUS had 0.41 kT, and RV had 1.62 kT. In 2023, PV was 13.71%, SUT was 12.52%, TTC was 9.59%, BUS was 12.68%, and RV was 8.44%.

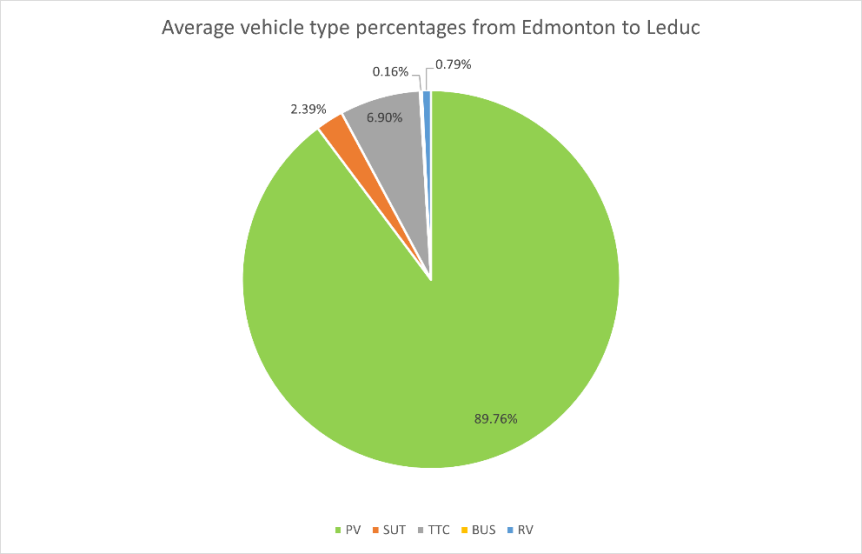


Figure 52: Average vehicle type percentages from Edmonton to Leduc

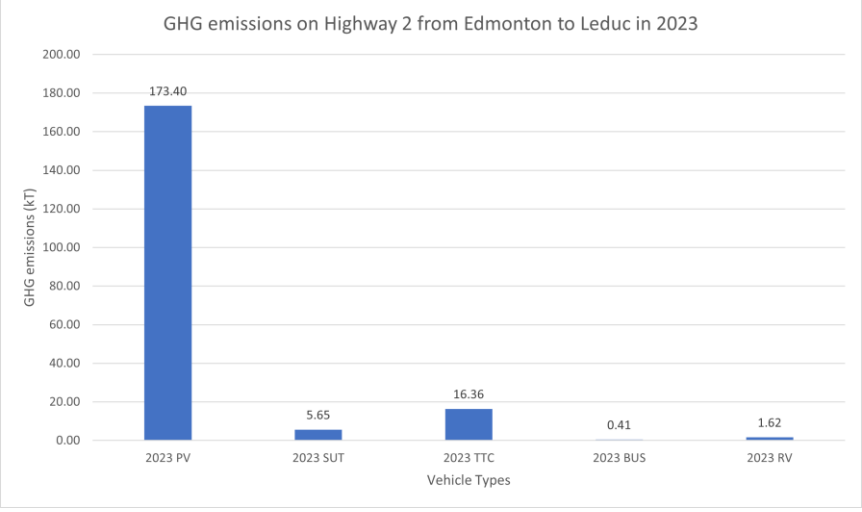


Figure 53: GHG emissions on Highway 2 from Edmonton to Leduc in 2023

Leduc to The Highway 39 intersection

The second traffic count section is between Leduc (#88450) to The Highway 39 interchange (#87450) as shown in Figure 41. The dataset of GHG emissions reflecting locations (E-C), and vehicle types from Leduc to The Highway 39 intersection are shown in Figure 54.

PV dominated the traffic along Highway 2 from Leduc to The Highway 39 intersection, with 87.5% of all vehicle types. For public transportation, the BUS only occupied 0.1% of all vehicle types. For other types of vehicles, SUT occupied 2.3%, TTC was 9.15%, and RV was 0.95%.

GHG emissions shown in Figure 55, confirm PV occupied 14.55 kT, then SUT had 0.44 kT, TTC had 1.62 kT, BUS had 0.02 kT, and RV had 0.15 kT. In 2023, PV was 1.15%, SUT was 0.97%, TTC was 0.95%, BUS was 0.59%, and RV was 0.76%.

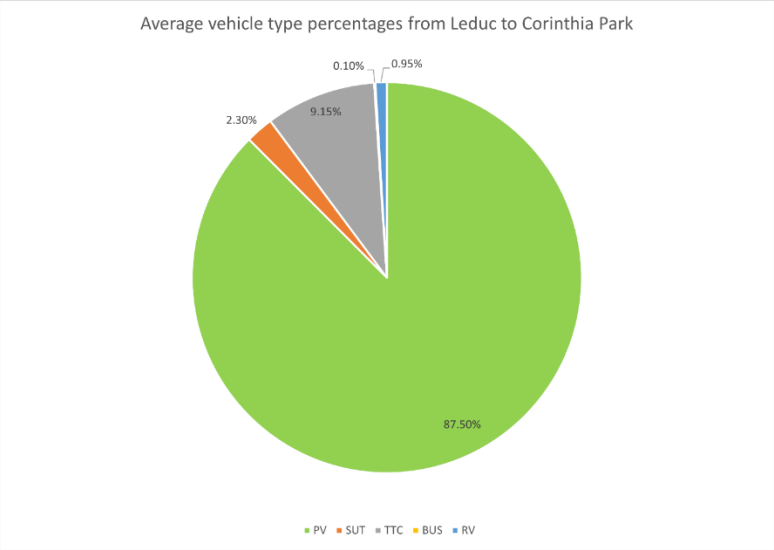


Figure 54: Average vehicle type percentages from Leduc to The Highway 39 intersection

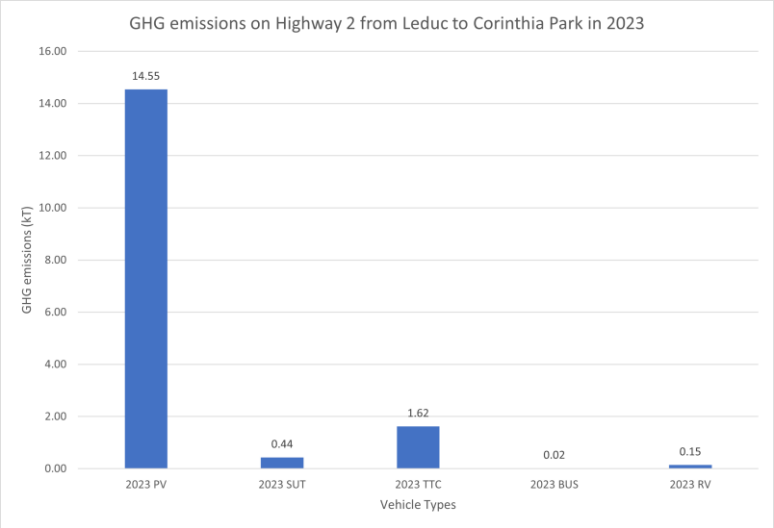


Figure 55: GHG emissions on Highway 2 from Leduc to The Highway 39 intersection in 2023

The Highway 39 intersection to the Highway 12 Interchange

The third graphic shows The Highway 39 intersection (#87450) to the Highway 12 Interchange (#94390) in Figure 38. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from The Highway 39 intersection to the Highway 12 Interchange are shown in Figure 56.

PV dominated the traffic type on Highway 2 from The Highway 39 intersection to the Highway 12 Interchange, with 82.5% of all vehicle types. For public transportation, the BUS only occupied 0.14% of all vehicle types. For other types of vehicles, SUT occupied 2.46%, TTC was 13.44%, and RV was 1.46%.

For the GHG emissions shown in Figure 57, PV occupied 89.01 kT, then SUT had 3.1 kT, TTC had 17.51 kT, BUS had 0.19 kT, and RV had 1.65 kT. In 2023, PV was 7.04%, SUT was 6.88%, TTC was 10.26%, BUS was 5.88%, and RV was 8.57%.

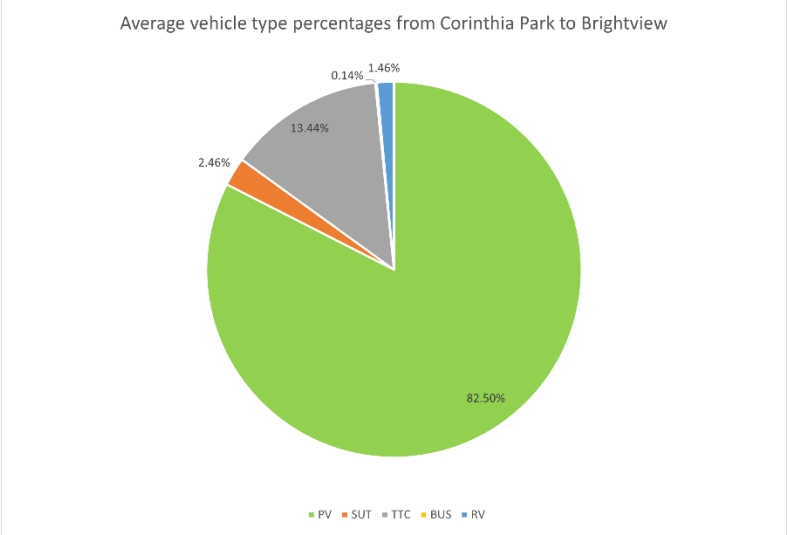


Figure 56: Average vehicle type percentages from The Highway 39 intersection to the Highway 12 Interchange

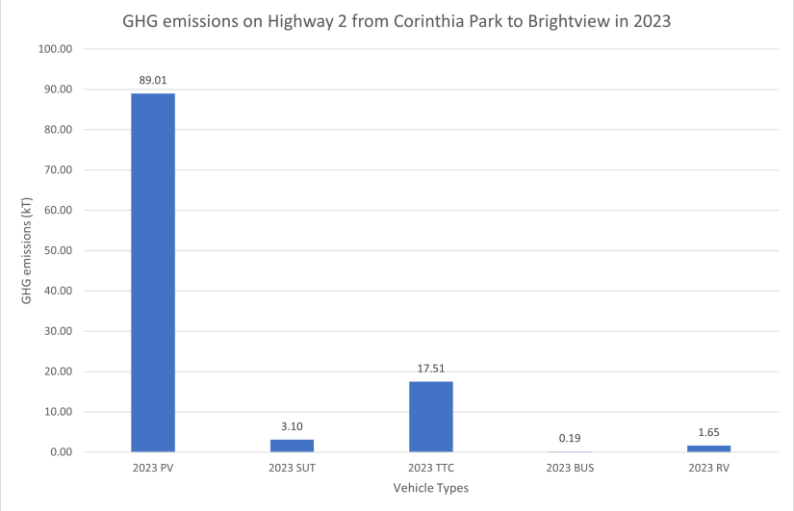


Figure 57: GHG emissions on Highway 2 from The Highway 39 intersection to the Highway 12 Interchange in 2023

The Highway 12 Interchange to the Highway 11 Interchange

The fourth traffic count section is from the Highway 12 Interchange (#94390) to the Highway 11 Interchange (#82330) shown in Figure 35. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from the Highway 12 Interchange to The Highway 11 Interchange are shown in Figure 58.

PV dominated the traffic type on Highway 2 from the Highway 12 Interchange to The Highway 11 Interchange, with 80.59% of all vehicle types. For public transportation, the BUS only occupied 0.16% of all vehicle types. For other types of vehicles, SUT occupied 2.72%, TTC was 14.88%, and RV was 1.65%.

For the GHG emissions shown in Figure 59, PV occupied 297.89 kT, then SUT had 11.43 kT, TTC had 61.38 kT, BUS had 0.67 kT, and RV had 6.23 kT. In 2023, PV was 23.56%, SUT was 25.35%, TTC was 35.97%, BUS was 20.92%, and RV was 32.38%.

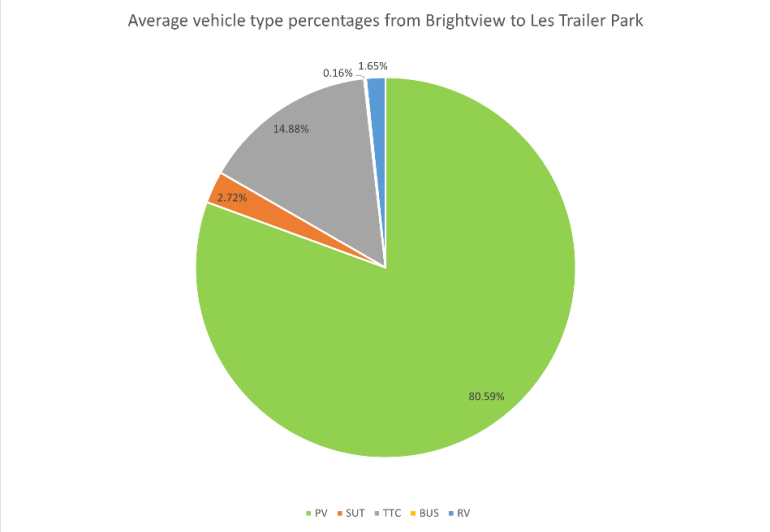


Figure 58: Average vehicle type percentages from the Highway 12 Interchange to The Highway 11 Interchange

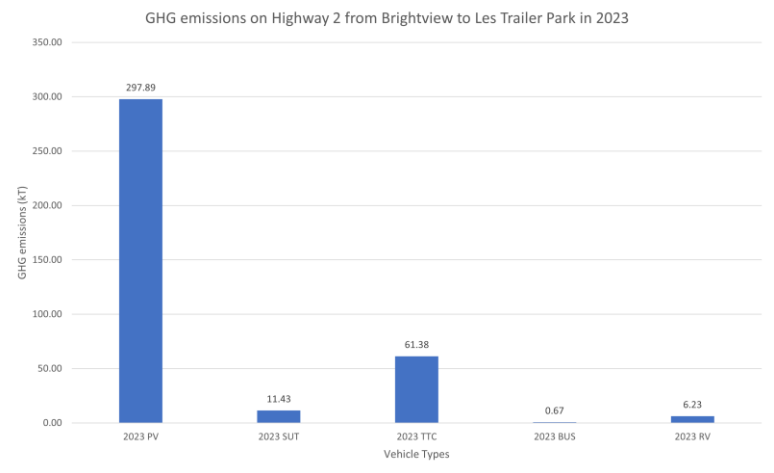


Figure 59: GHG emissions on Highway 2 from the Highway 12 Interchange to The Highway 11 Interchange in 2023

The Highway 11 Interchange to Innisfail

The fifth one is the Highway 11 Interchange (#82330) to Innisfail (#84300) shown in Figure 32. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from The Highway 11 Interchange to Innisfail are shown in Figure 60.

PV dominated the traffic type on Highway 2 from The Highway 11 Interchange to Innisfail, with 84.29% of all vehicle types. For public transportation, the BUS only occupied

0.11% of all vehicle types. For other types of vehicles, SUT occupied 2.87%, TTC was 11.11%, and RV was 1.61%.

For the GHG emissions shown in Figure 61, PV occupied 118.75 kT, then SUT had 4.67 kT, TTC had 17.4 kT, BUS had 0.22 kT, and RV had 2.11 kT. In 2023, PV was 9.39%, SUT was 10.36%, TTC was 10.2%, BUS was 6.99%, and RV was 10.99%.

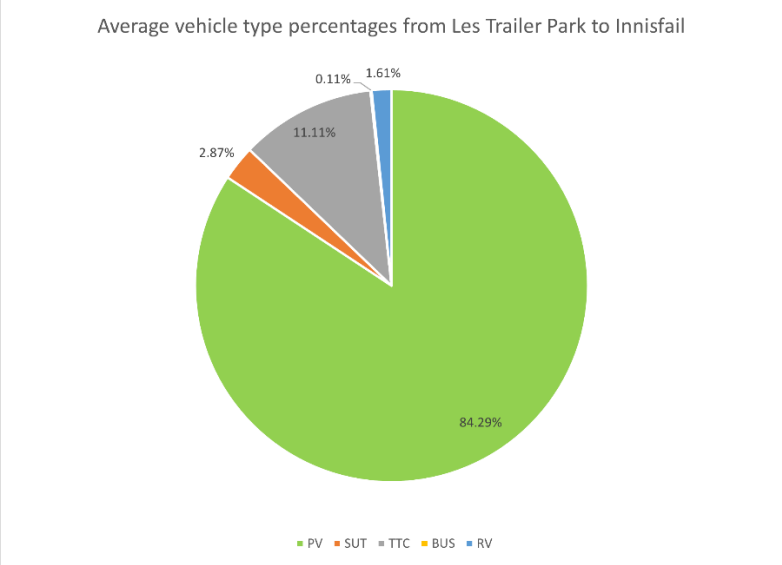


Figure 60: Average vehicle type percentages from the Highway 11 Interchange to Innisfail

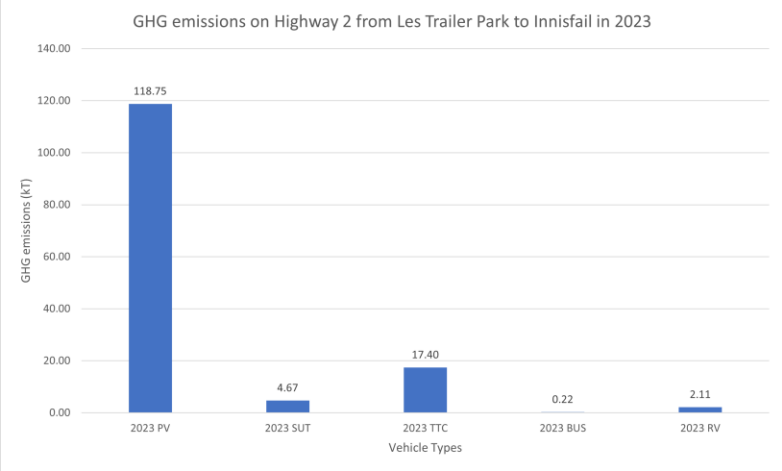


Figure 61: GHG emissions on Highway 2 from The Highway 11 Interchange to Innisfail in 2023

Innisfail to Bowden

The sixth one is from Innisfail (#84300) to Bowden (#79290) shown in Figure 29. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Innisfail to Bowden are shown in Figure 62.

PV dominated the traffic type on Highway 2 from Innisfail to Bowden, with 82.75% of all vehicle types. For public transportation, the BUS only occupied 0.2% of all vehicle types. For other types of vehicles, SUT occupied 2.85%, TTC was 12.6%, and RV was 1.6%.

For the GHG emissions shown in Figure 63, PV occupied 80.34 kT, then SUT had 3.18 kT, TTC had 13.82 kT, BUS had 0.22 kT, and RV had 1.52 kT. In 2023, PV was 6.35%, SUT was 7.04%, TTC was 8.1%, BUS was 6.92%, and RV was 7.92%.

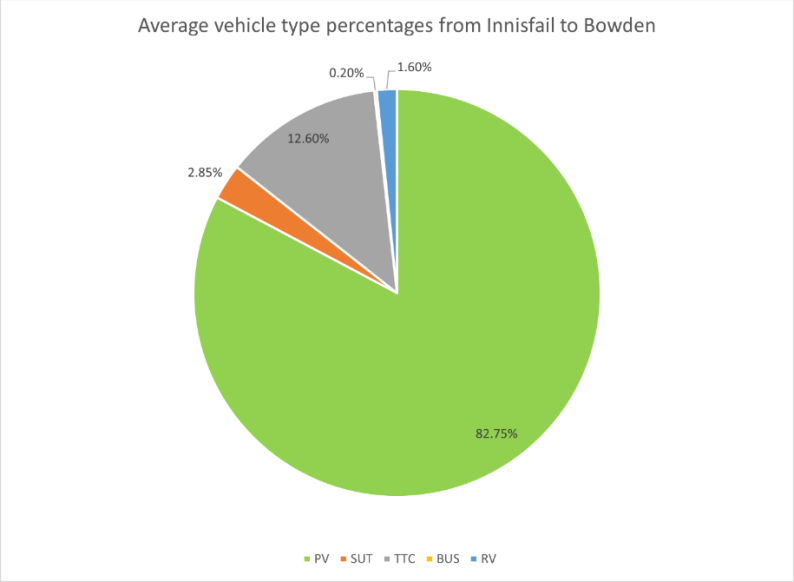


Figure 62: Average vehicle type percentages from Innisfail to Bowden

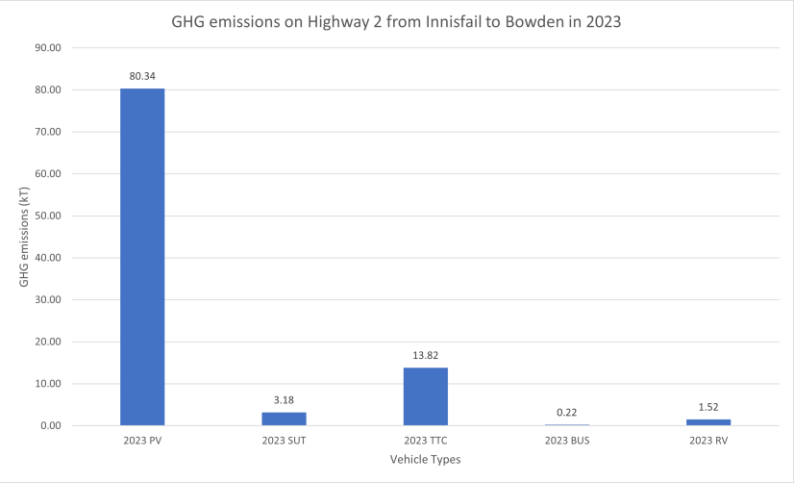


Figure 63: GHG emissions on Highway 2 from Innisfail to Bowden in 2023

Bowden to Airdrie

The seventh one is Bowden (#79290) to Airdrie (#154820) shown in Figure 26. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Bowden to Airdrie are shown in Figure 64.

PV dominated the traffic type on Highway 2 from Bowden to Airdrie, with 83.53% of all vehicle types. For public transportation, the BUS only occupied 0.13% of all vehicle types. For other types of vehicles, SUT occupied 2.58%, TTC was 11.79%, and RV was 1.99%.

For the GHG emissions shown in Figure 65, PV occupied 313.56 kT, then SUT had 11.12 kT, TTC had 51.44 kT, BUS had 0.54 kT, and RV had 7.55 kT. In 2023, PV was 24.8%, SUT was 24.67%, TTC was 30.15%, BUS was 16.97%, and RV was 39.26%.

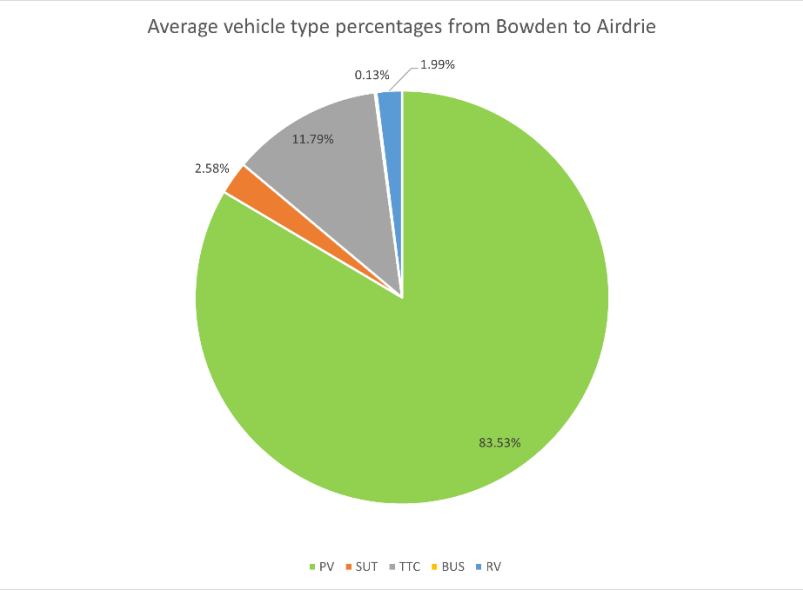


Figure 64: Average vehicle type percentages from Bowden to Airdrie

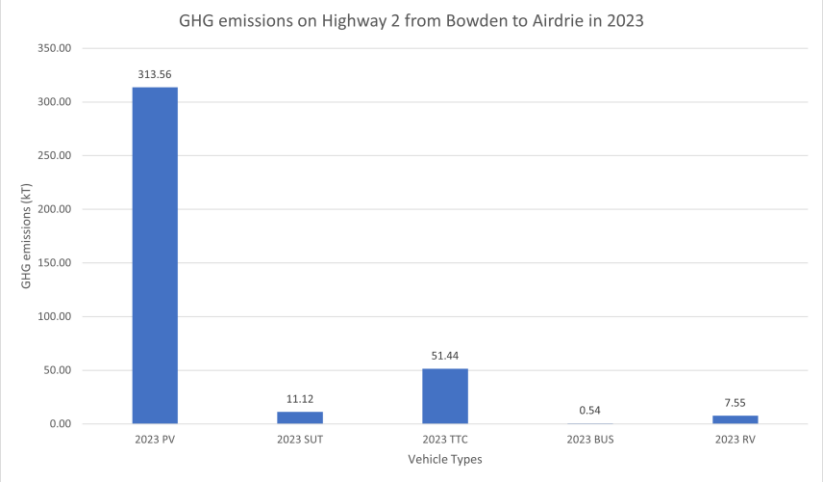


Figure 65: GHG emissions on Highway 2 from Bowden to Airdrie in 2023

Airdrie to Balzac

The eighth one is Airdrie (#154820) to Balzac (#80210) shown in Figure 23. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Airdrie to Balzac are shown in Figure 66.

PV dominated the traffic type on Highway 2 from Airdrie to Balzac, with 88.8% of all vehicle types. For public transportation, the BUS only occupied 0.1% of all vehicle types. For other types of vehicles, SUT occupied 2.5%, TTC was 7.8%, and RV was 0.8%.

For the GHG emissions shown in Figure 67, PV occupied 83.41 kT, then SUT had 2.64 kT, TTC had 7.99 kT, BUS had 0.11 kT, and RV had 0.68 kT. In 2023, PV was 6.6%, SUT was 5.86%, TTC was 4.68%, BUS was 3.34%, and RV was 3.55%.

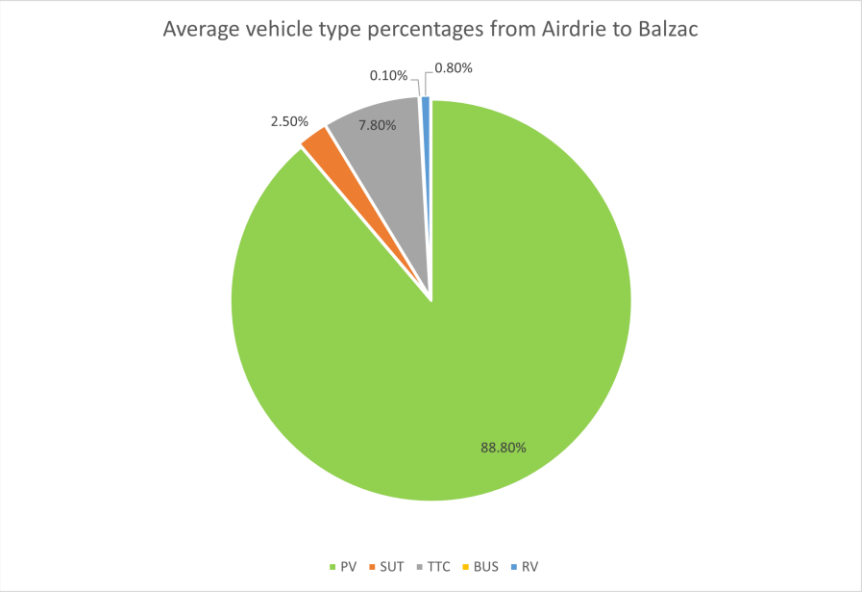


Figure 66: Average vehicle type percentages from Airdrie to Balzac

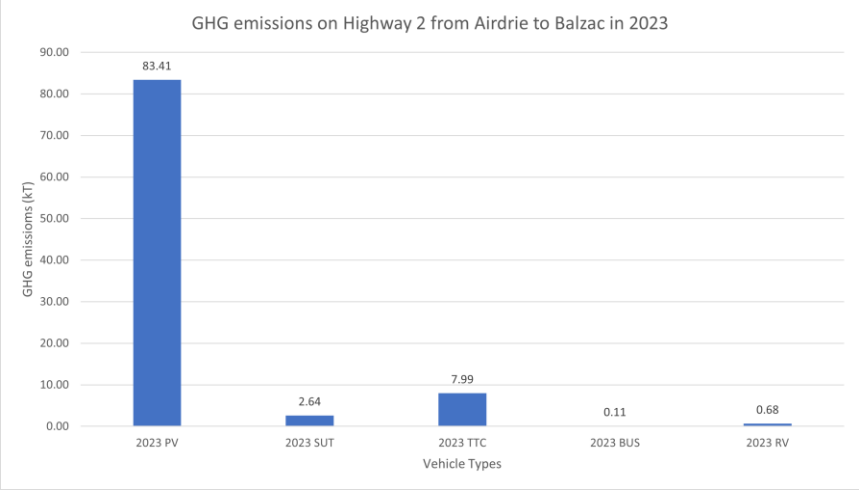


Figure 67: GHG emissions on Highway 2 from Airdrie to Balzac in 2023

Balzac to Calgary International Airport

The ninth one is Balzac (#80210) to Calgary International Airport (#10000022) shown in Figure 20. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Balzac to Calgary International Airport are shown in Figure 68.

PV dominated the traffic type on Highway 2 from Calgary International Airport to the center of Calgary, with 91.1% of all vehicle types. For public transportation, the BUS only occupied 0.18% of all vehicle types. For other types of vehicles, SUT occupied 2.7%, TTC was 5.48%, and RV was 0.55%.

For the GHG emissions shown in Figure 69, PV occupied 143.62 kT, then SUT had 4.79 kT, TTC had 10.61 kT, BUS had 0.28 kT, and RV had 0.91 kT. In 2023, PV was 11.36%, SUT was 10.63%, TTC was 6.22%, BUS was 8.8%, and RV was 4.72%.

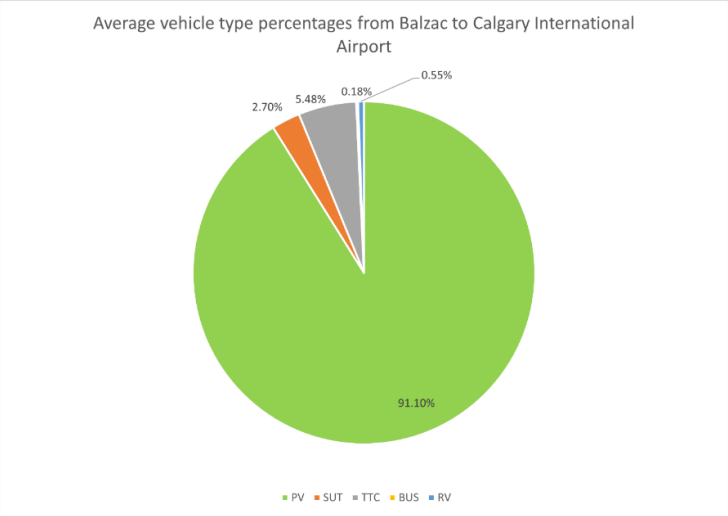


Figure 68: Average vehicle type percentages from Balzac to Calgary International Airport

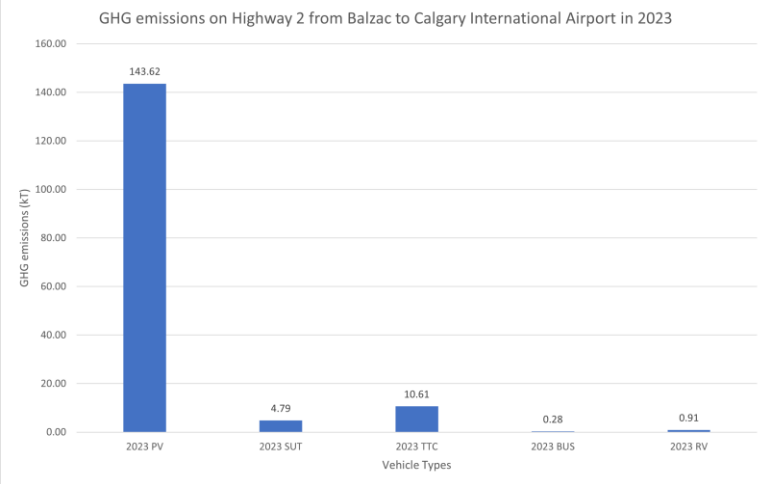


Figure 69: GHG emissions on Highway 2 from Balzac to Calgary International Airport in 2023

Calgary International Airport to Calgary

The last one is Calgary International Airport (#10000022) to Calgary (#10000007) shown in Figure 17. Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Calgary International Airport to Calgary are shown in Figure 70.

PV dominated the traffic type on Highway 2 from Calgary International Airport to the center of Calgary, with 93.69% of all vehicle types. For public transportation, the BUS only occupied 0.41% of all vehicle types. For other types of vehicles, SUT occupied 2.83%, TTC was 2.87%, and RV was 0.19%.

For the GHG emissions shown in Figure 71, PV occupied 207.38 kT, then SUT had 7.29 kT, TTC had 7.27 kT, BUS had 1.03 kT, and RV had 0.41 kT. In 2023, PV was 16.43%, SUT was 16.17%, TTC was 4.26%, BUS was 31.97%, and RV was 2.14%.

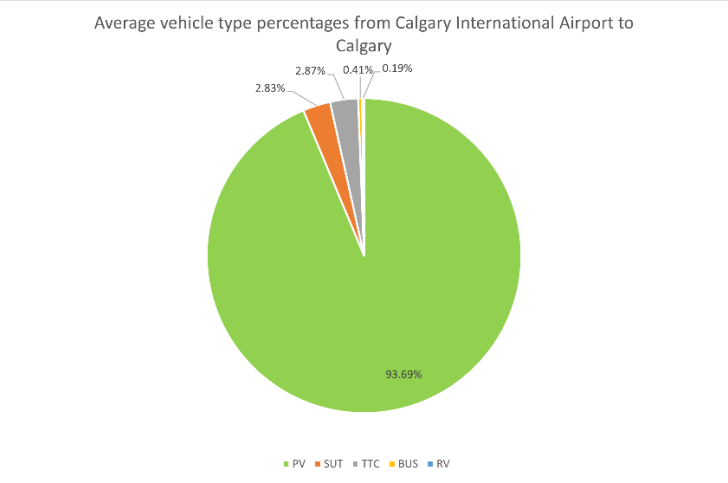


Figure 70: Average vehicle type percentages from Calgary International Airport to Calgary

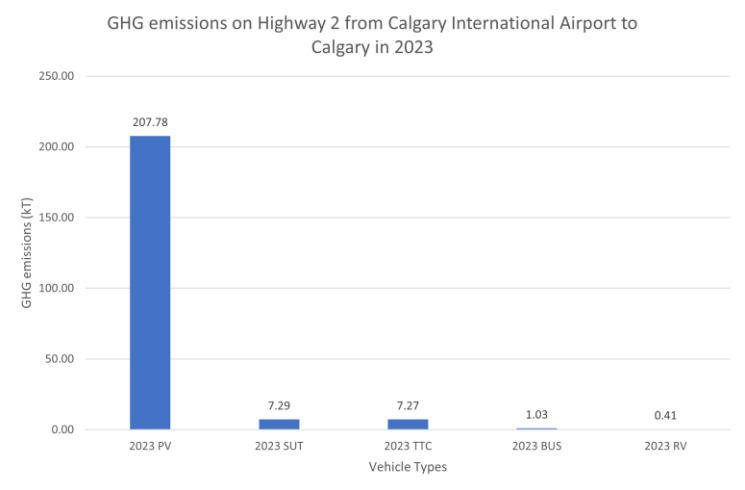


Figure 71: GHG emissions on Highway 2 from Calgary International Airport to Calgary in 2023

Impact of COVID-19 to GHG emissions

When the COVID-19 exploded, the GHG emission dropped 305.49 kT from 2019 to 2020. Specifically, based on Figure 12 and Figure 13, in 2019, PV created 1401.31 kT (84.25%) GHG emission, SUT created 49.97 kT (3.00%) GHG emission, TTC created 187.42 kT (11.27%) GHG emission, BUS created 3.58 kT (0.22%) GHG emission, and RV created 21.05 kT (1.27%) GHG emission. In 2020, PV created 1145.00 kT (84.32%) GHG emissions, SUT created 40.78 kT (3.00%) GHG emissions, TTC created 152.06 kT (11.20%) GHG emissions, BUS created 2.92 kT (0.22%) GHG emission, and RV created 17.09 kT (1.26%) GHG emission.

After the vaccine was invented in 2020, the GHG emission gradually increased and slightly decreased from 2020 to 2023. From 2020 to 2021, the GHG emission increased 85.36 kT. From 2021 to 2022, the GHG emission decreased 37.16 kT. From 2022 to 2023, the GHG emission increased 96.63 kT.

Highway 2A

GHG emissions on Highway 2A from Calgary to Edmonton (South to North)

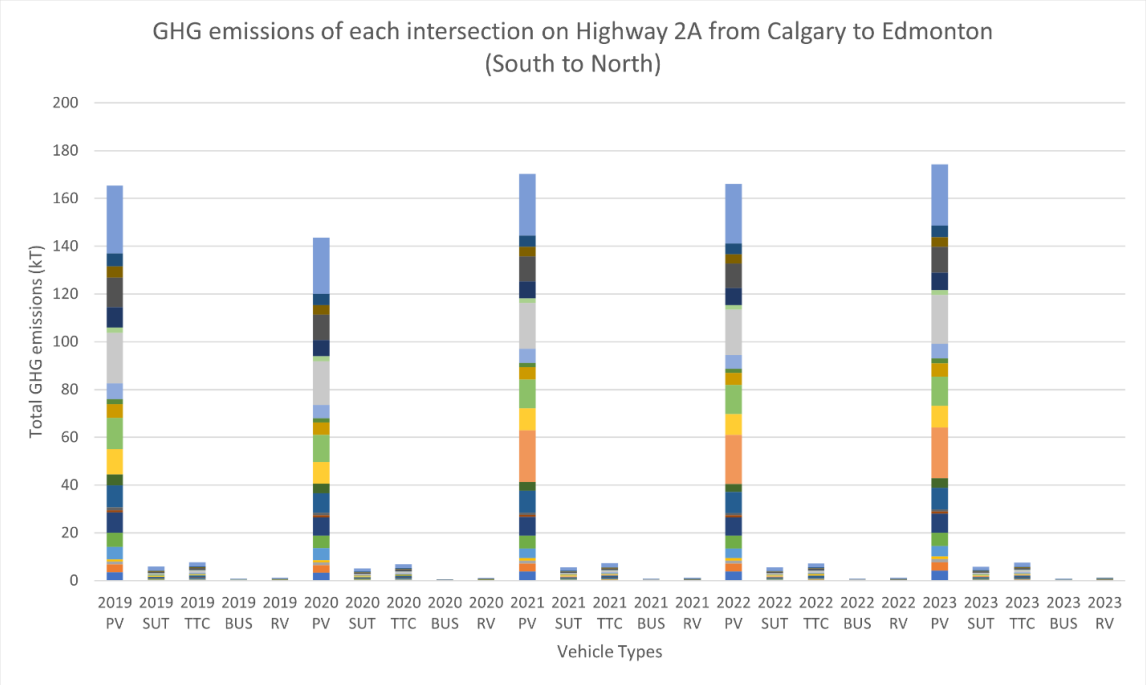


Figure 72: GHG emissions of each intersection onto Highway 2A from Calgary to Edmonton (South to North)

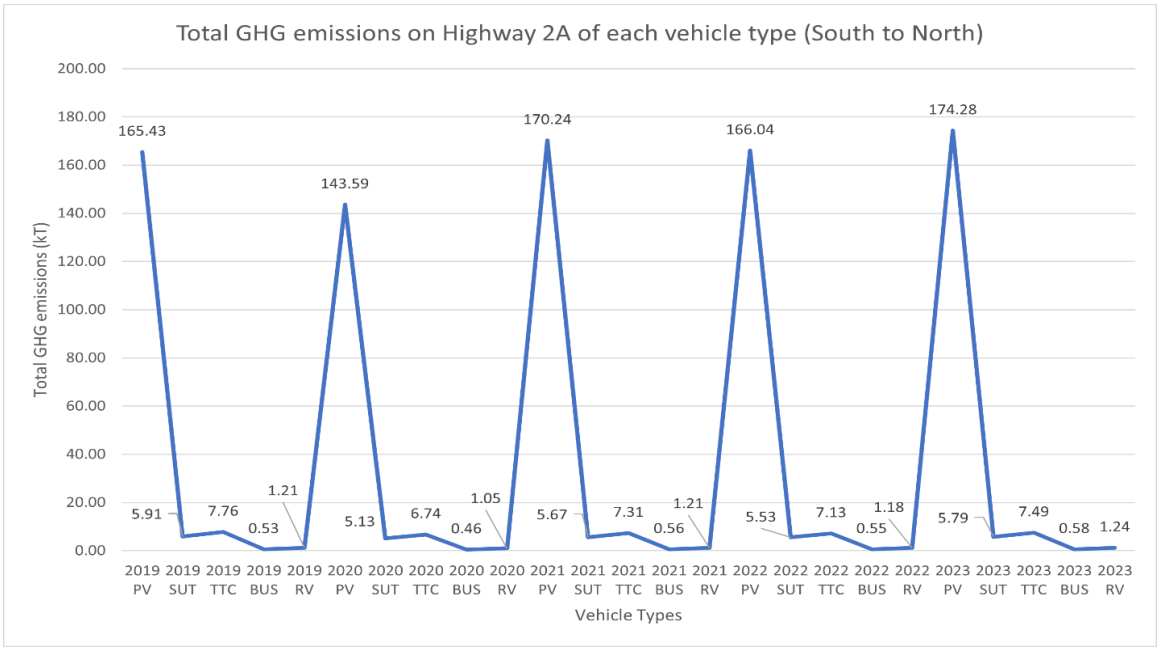


Figure 73: Total GHG emissions on Highway 2A of each vehicle type (South to North)

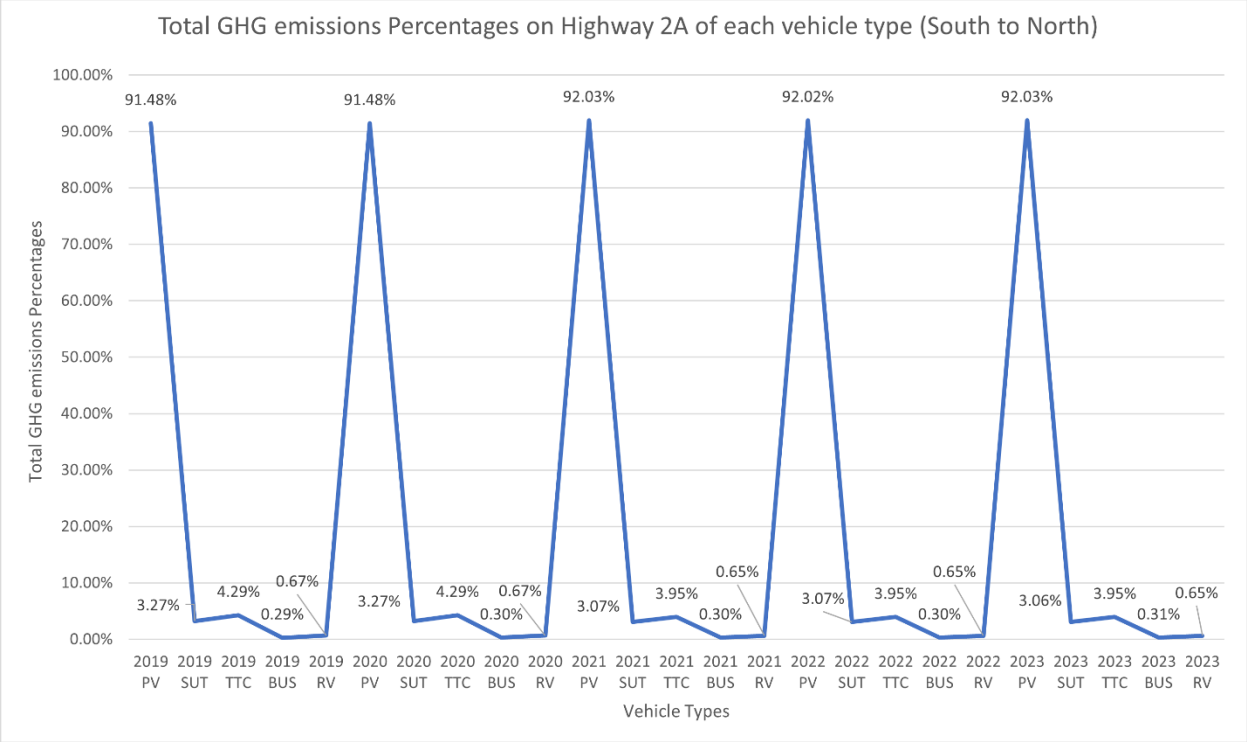


Figure 74: Total GHG emissions Percentages on Highway 2A of each vehicle type (South to North)

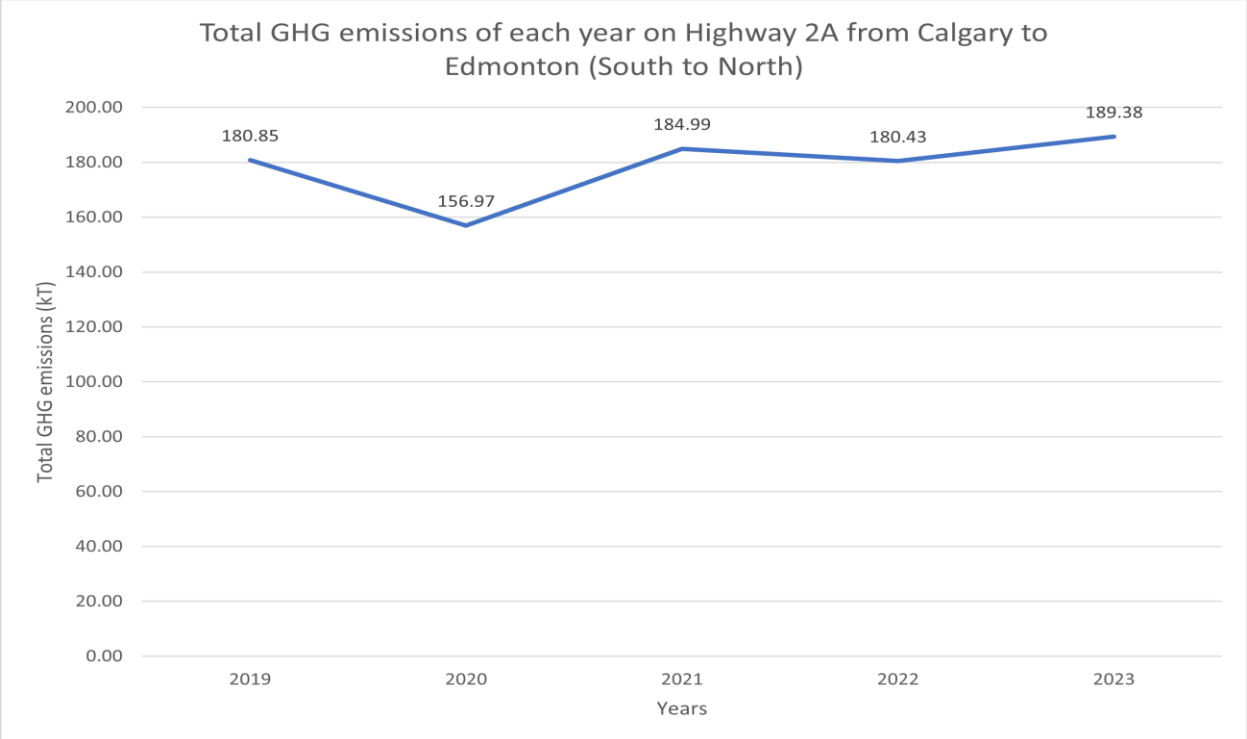


Figure 75: Total GHG emissions of each year on Highway 2A from Calgary to Edmonton (South to North)

For Highway 2A, Figures 72 to 75 are the total GHG emissions of each intersection, vehicle counts and types percentages, and total GHG emissions from South to North from 2019 to 2023. The vehicle types for Highway 2A are mostly PV in each section, approximately 91.81% in Highway 2A. For other type of vehicles, the average is 3.15% for SUT, 4.09% for TTC, 0.3% for BUS, and 0.66% for RV. Figure 72 highlights intersection from Calgary to Edmonton in Highway 2A via its color scheme. Because the Highway 2A doesn't fully connect from Calgary to Edmonton, we divided the Highway 2A into five sections for GHG emissions calculation. The following sections are: Crossfield-Bowden, Innisfail-Red Deer, Labuma-Lacombe, Morningside-Wetaskiwin, and Wetaskiwin-Leduc.

Impact of COVID-19 to GHG emissions

When COVID-19 first emerged, GHG emissions dropped by 23.88 kT from 2019 to 2020. According to Figures 73 and 74, in 2019, PV were responsible for 180.85 kT (91.48%) of GHG emissions, while SUT contributed 5.91 kT (3.27%), TTC 7.76 kT (4.29%), buses 0.53 kT (0.29%), and RV 1.21 kT (0.67%). In 2020, PV emissions decreased to 143.59 kT (91.48%), SUT to 5.13 kT (3.27%), TTC to 6.74 kT (4.29%), bus emissions to 0.46 kT (0.3%), and RV emissions to 1.05 kT (0.67%).

After introducing vaccines in 2020, GHG emissions gradually rose, followed by a slight decline. From 2020 to 2021, emissions increased by 28.02 kT, then dropped by 4.56 kT from 2021 to 2022. Finally, emissions rose again by 8.93 kT from 2022 to 2023.

Crossfield-Bowden Section

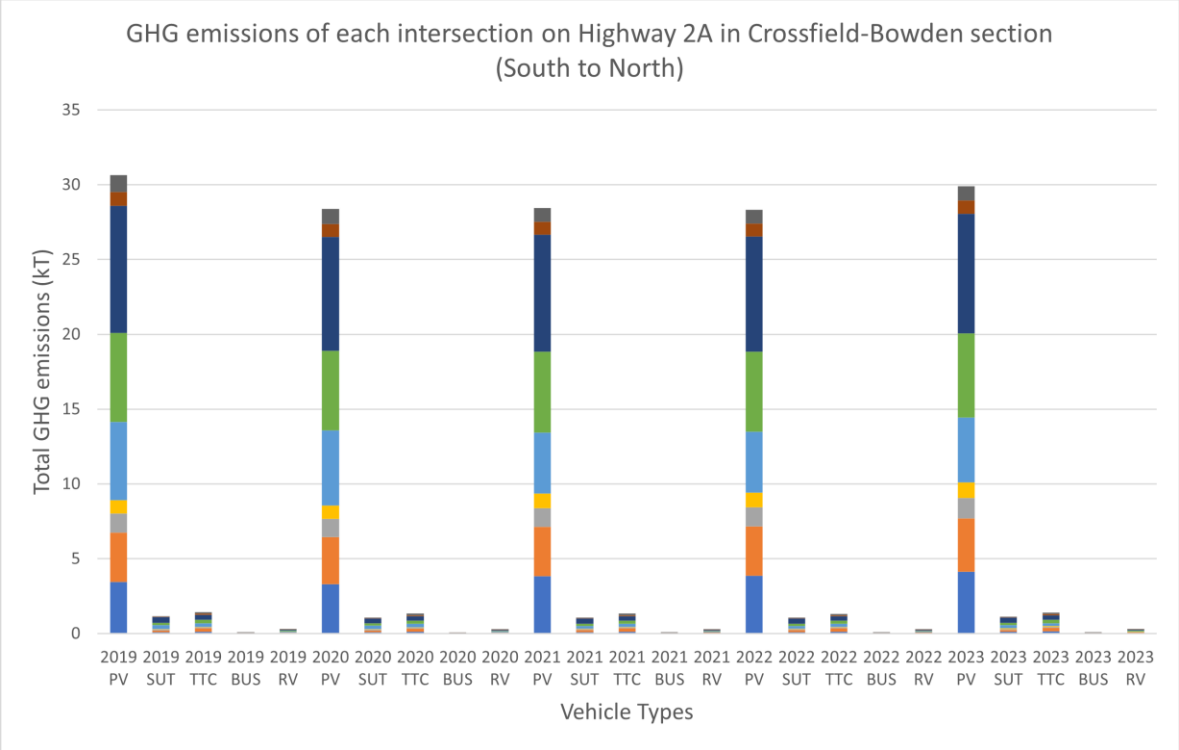


Figure 76: GHG emissions of each intersection along Highway 2A through the Crossfield-Bowden (South to North)

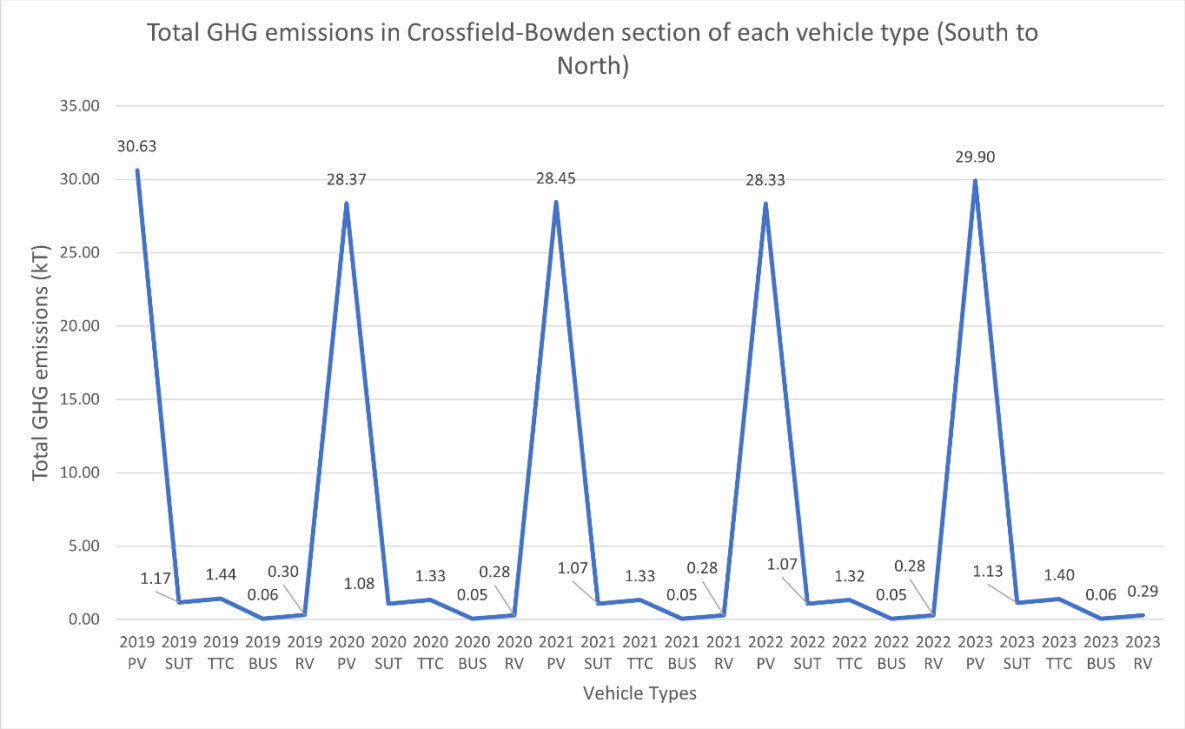


Figure 77: Total GHG emissions in Crossfield-Bowden section of each vehicle type (South to North)

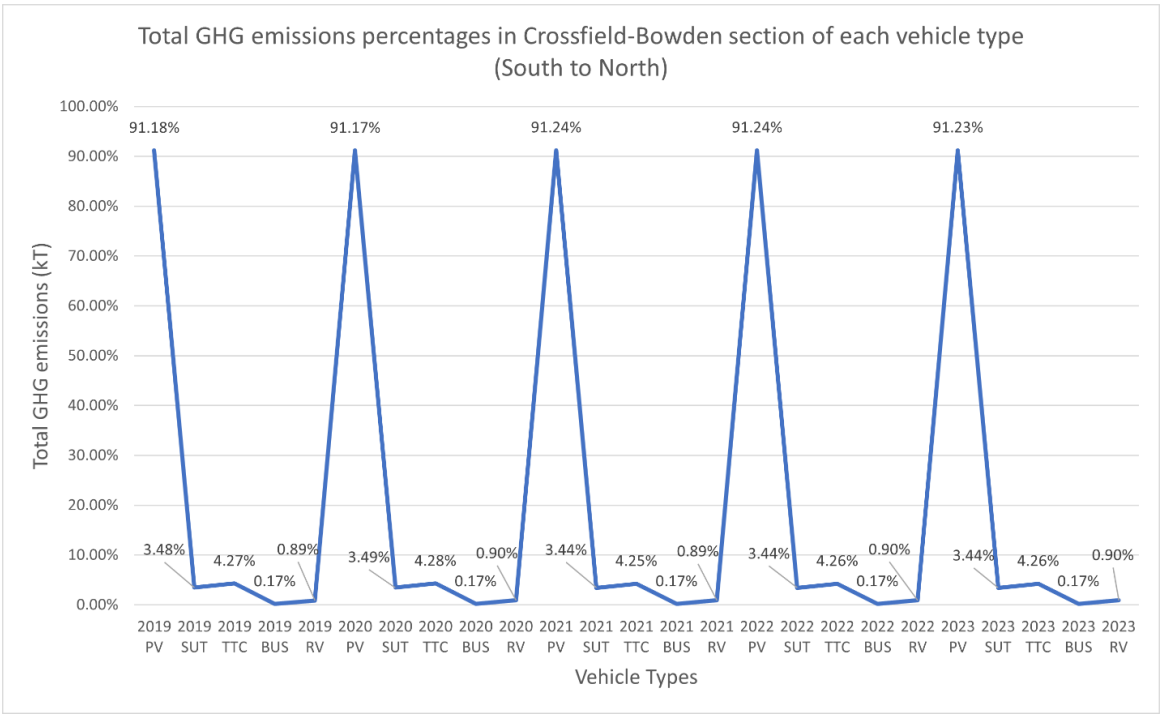


Figure 78: Total GHG emissions percentages in Crossfield-Bowden section of each vehicle type (South to North)

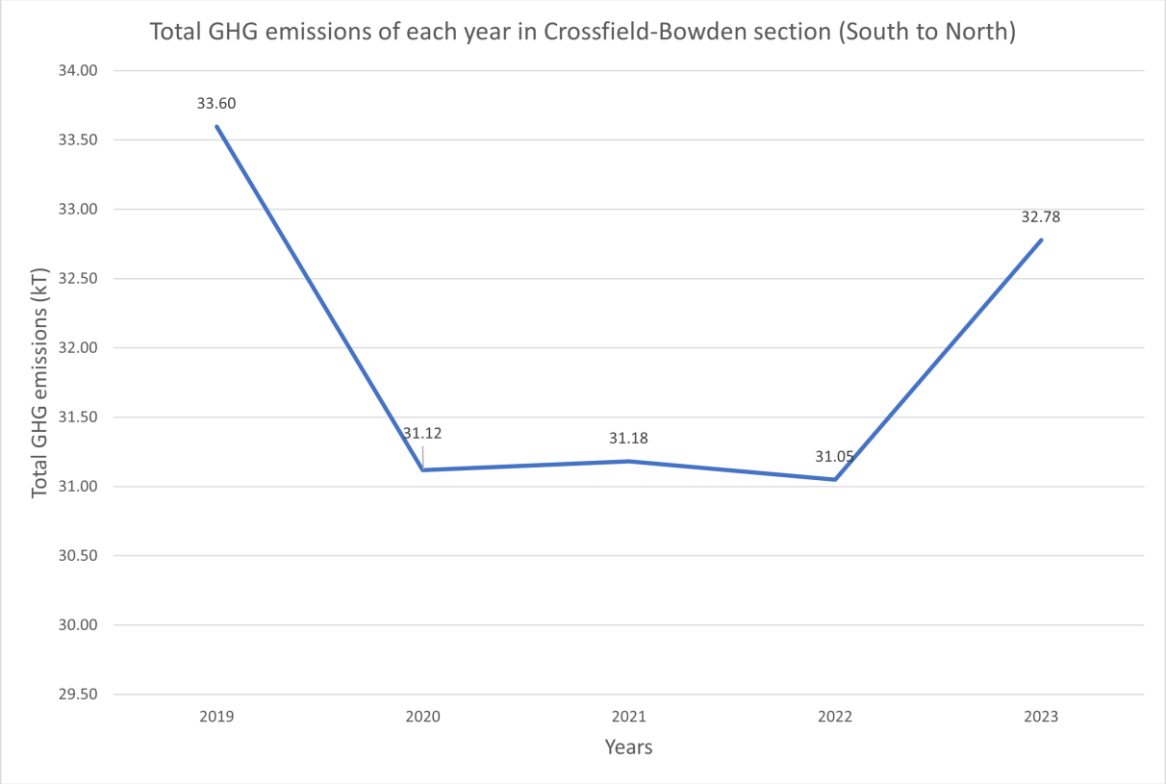


Figure 79: Total GHG emissions of each year in Crossfield-Bowden section (South to North)

Figure 80: Intersections from Crossfield to Bowden

Based on the GHG emission calculations, emissions along Highway 2A from South to North are predominantly from PVs, accounting for 91.21%, followed by SUT at 3.46%, TTC at 4.26%, BUS at 0.17%, and RV at 0.9%. The route from Crossfield to Bowden, begins in Crossfield, passing through the municipalities of Carstairs, Didsbury, Olds, and Bowden. Details showed in Figure 80. According to Figure 79, the total GHG emissions between 2019 and 2023 were 33.6, 31.12, 31.18, 31.05, and 32.78 kT, respectively.

From the AADT traffic dataset for Highway 2A (South to North), starting in Crossfield, vehicle counts rose after arrival in Carstairs, increasing from 1270 to 2450 vehicles in 2023. Between Carstairs and Didsbury, the count further dropped from 2450 to 1990 vehicles. From Didsbury to Olds, it rose to 2380 cars; from Olds to Bowden, the count dropped again from 2380 to 1890. The highest traffic load was observed in Olds. From 2019 to 2023, the AADT traffic counts in this section were approximately 2530, 2270, 2320, 2290, and 2380 vehicles annually. In contrast, the lowest traffic load was recorded Crossfield, with AADT counts of approximately 1170, 1120, 1170, 1180, and 1270 vehicles annually during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 2.48 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 30.63 kT (91.18%) and 28.37 kT (91.17%), respectively, while SUT contributed 1.17 kT (3.48%) in 2019 and 1.08 kT (3.49%) in 2020. TTC created 1.44 kT (4.27%) in 2019 and 1.33 kT (4.28%) in 2020. BUS contributed 0.06 kT (0.17%) in 2019 and 0.05 kT (0.17) in 2020, and RV created 0.3 kT (0.89%) in 2019 and 0.28 kT (0.9%) in 2020. After the vaccine rollout in 2020, GHG emissions began to rise again. From 2020 to 2021, emissions increased by 0.06 kT, then decreased by 0.13 kT between 2021 and 2022, before rising again by 1.73 kT from 2022 to 2023.

Innisfail-Red Deer Section

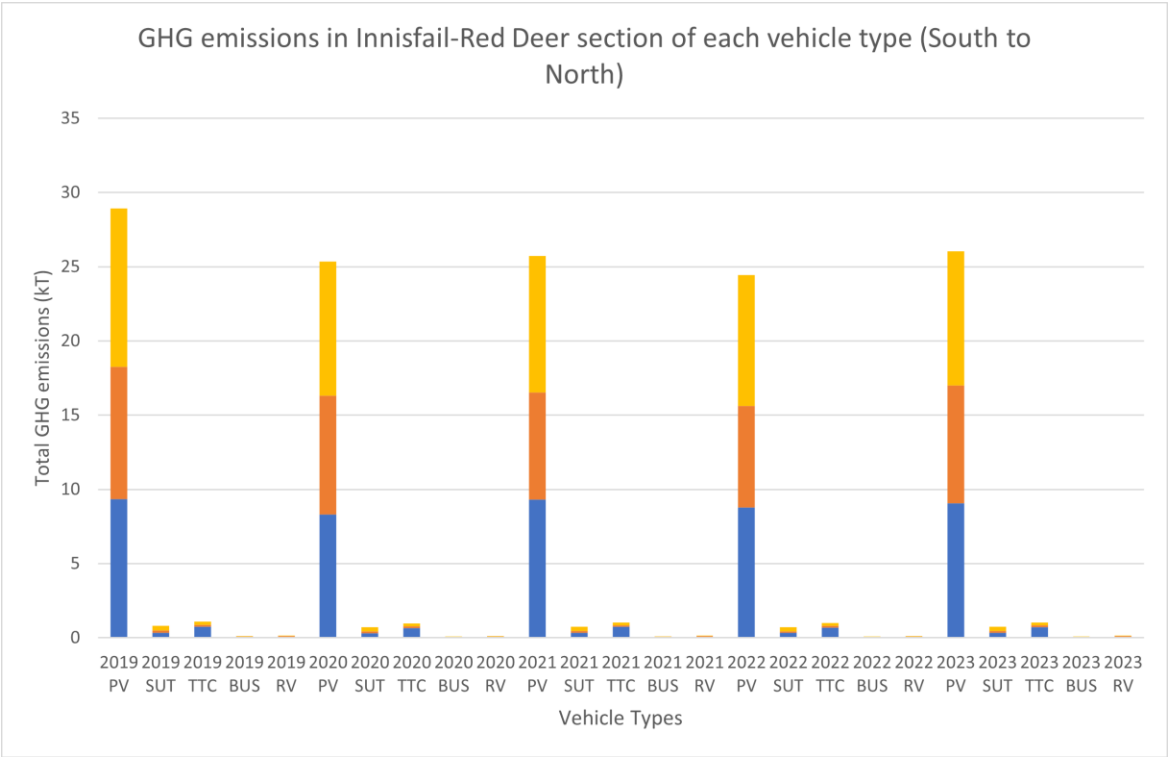


Figure 81: GHG emissions in Innisfail-Red Deer section of each vehicle type (South to North)

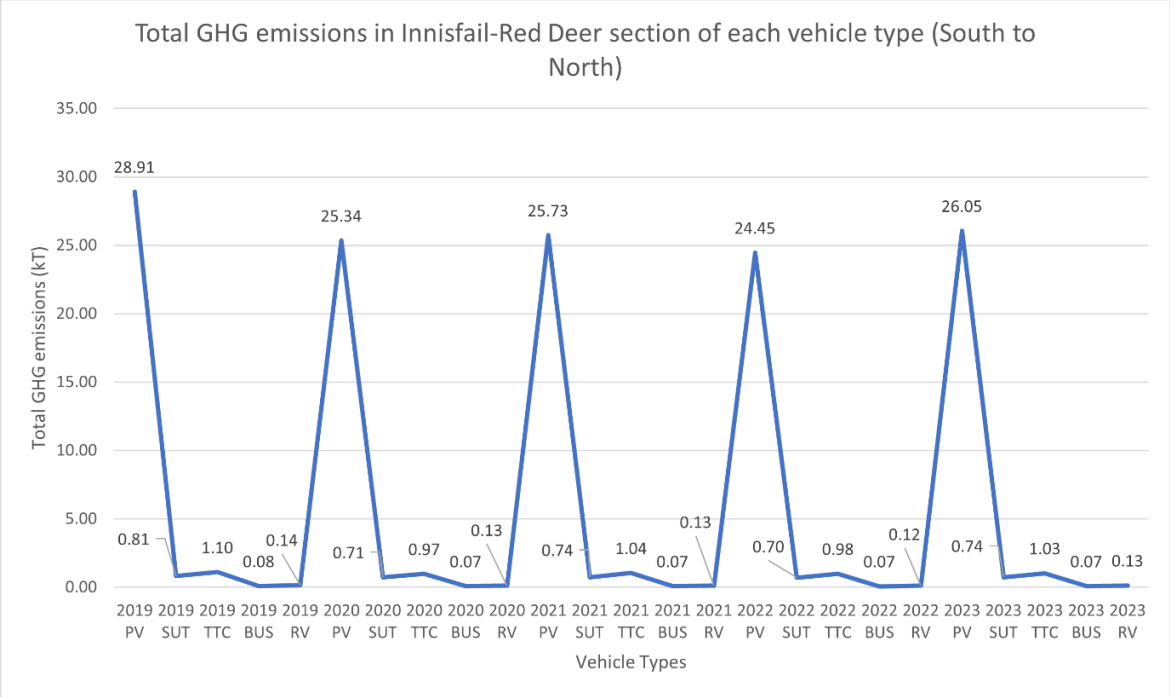


Figure 82: Total GHG emissions in Innisfail-Red Deer section of each vehicle type (South to North)

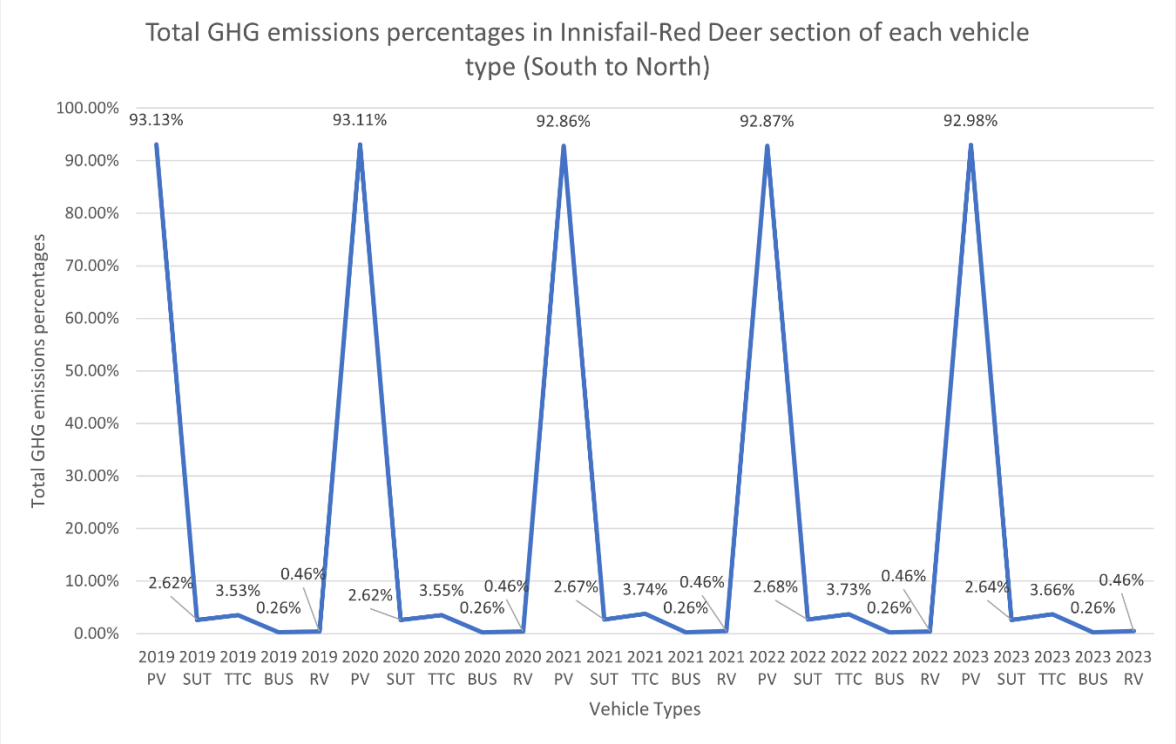


Figure 83: Total GHG emissions percentages in Innisfail-Red Deer section of each vehicle type (South to North)

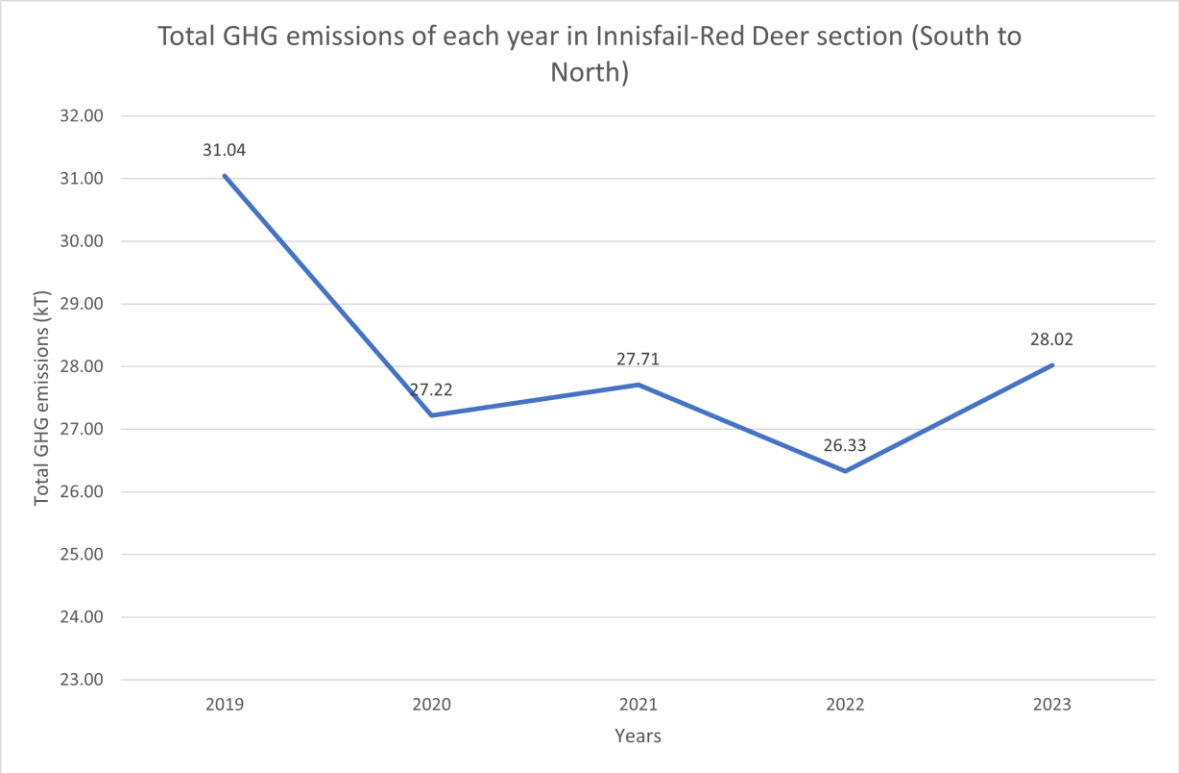


Figure 84: Total GHG emissions of each year in Innisfail-Red Deer section (South to North)

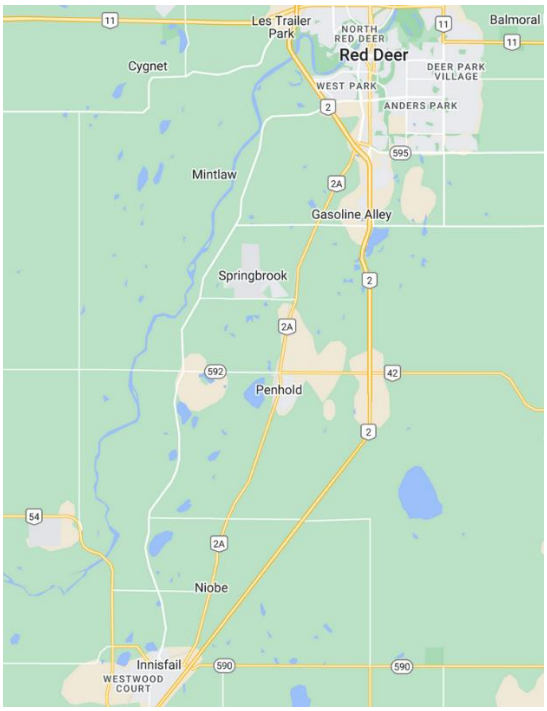


Figure 85: Intersections from Innisfail to Red Deer

The intersection of reference #70000960 was excluded from the GHG emission calculations due to the need for datasets for 2019 and 2020.

Based on the GHG emission calculations, emissions on Highway 2A from South to North are predominantly from PVs, accounting for 92.99%, followed by SUT at 2.62%, TTC at 3.53%, BUS at 0.26%, and RV at 0.46%. The route from Innisfail to Red Deer begins in Innisfail, passes through Penhold, and ends in Red Deer. Details showed in Figure 85. According to Figure 84, the total GHG emissions between 2019 and 2023 were 31.04, 27.22, 27.71, 26.33, 28.02 kT, respectively.

From the AADT traffic dataset for Highway 2A (South to North), vehicle counts increased after Penhold, rising from 2,950 to 3,035 vehicles in 2023. The count surged between Penhold and Red Deer from 3,035 to 5,940 cars. The highest traffic load was recorded in Red Deer, with AADT traffic counts of approximately 6,990, 5,930, 6,020,

5,800, and 5,940 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Innisfail, with AADT counts of approximately 3,040, 2,710, 3,030, 2,860, and 2,950 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 3.83 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 28.91 kT (93.13%) and 25.34 kT (93.11%). SUT contributed 0.81 kT (2.62%) in 2019 and 0.71 kT (2.62%) in 2020. TTC created 1.1 kT (3.53%) in 2019 and 0.97 kT (3.55%) in 2020. BUS contributed 0.08 kT (0.26%) in 2019 and 0.07 kT (0.26%) in 2020, and RV created 0.14 kT (0.46%) in 2019 and 0.13 kT (0.46%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 0.49 kT from 2020 to 2021, then decreasing by 1.38 kT from 2021 to 2022, before rising by 1.69 kT from 2022 to 2023.

Labuma-Lacombe Section

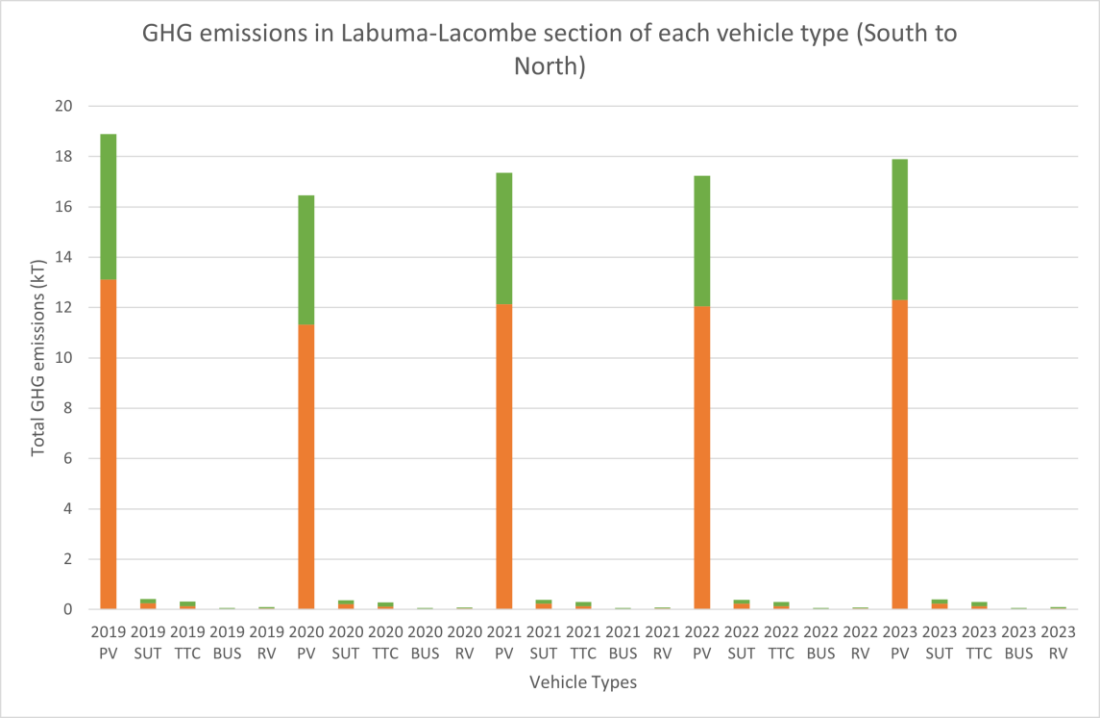


Figure 86: GHG emissions in Labuma-Lacombe section of each vehicle type (South to North)

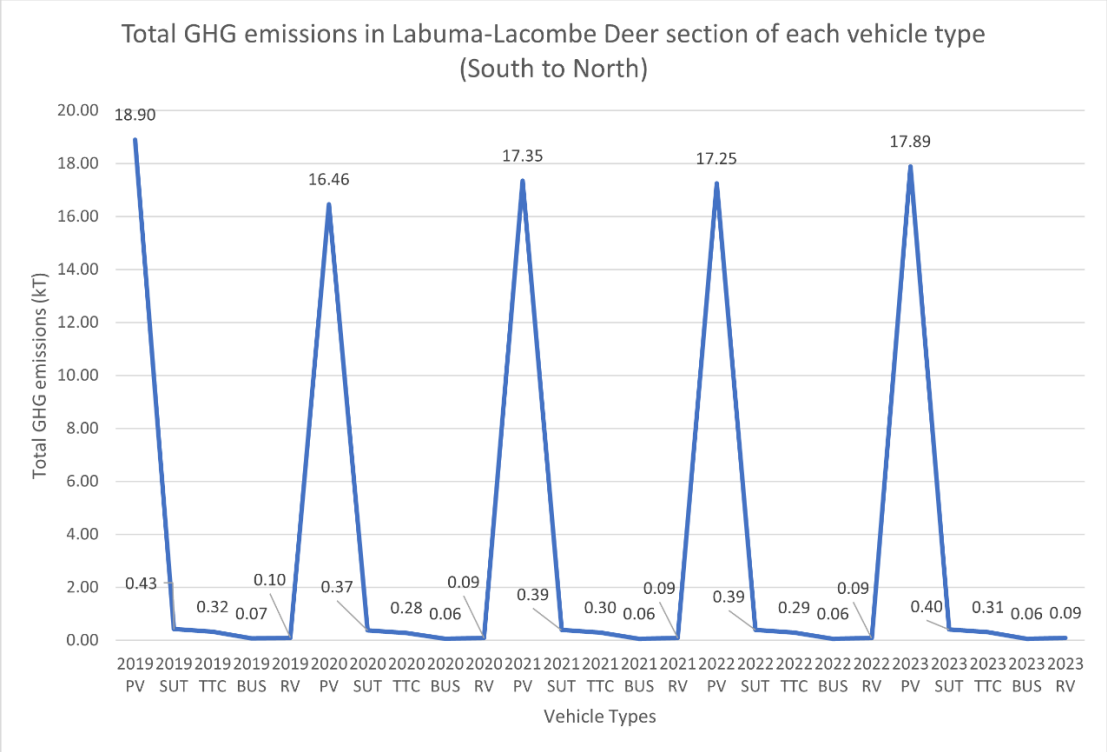


Figure 87: Total GHG emissions in Labuma-Lacombe Deer section of each vehicle type (South to North)

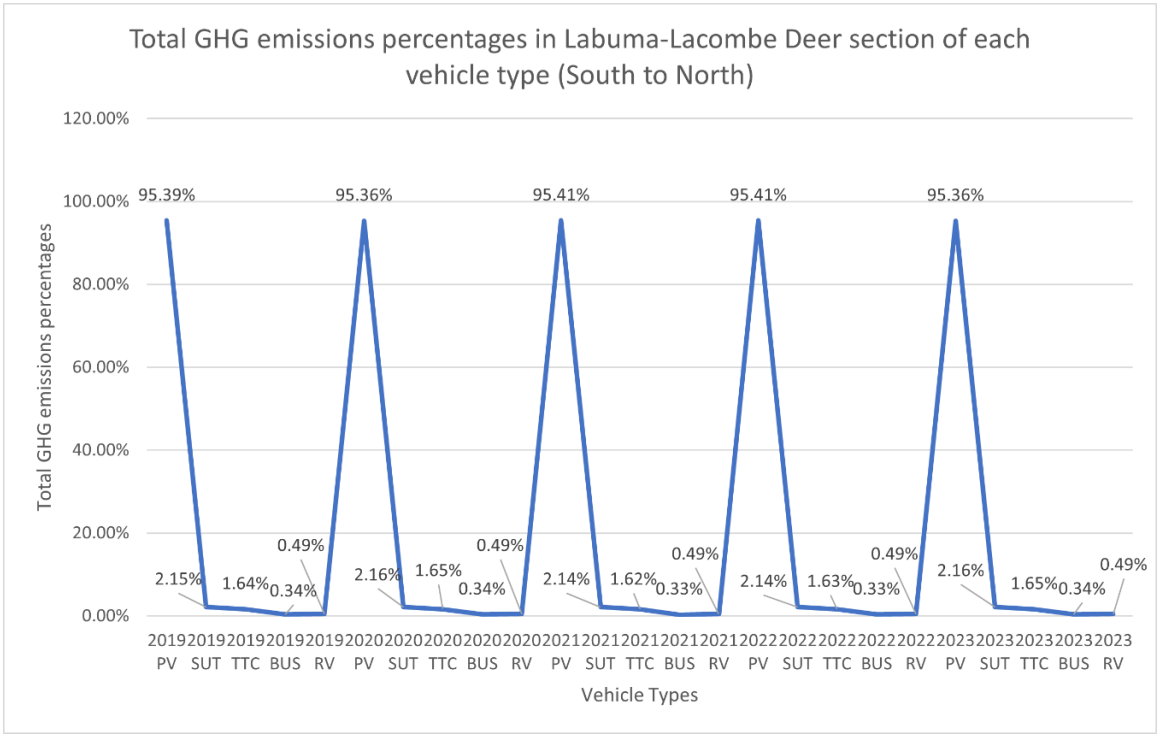


Figure 88: Total GHG emissions percentages in Labuma-Lacombe Deer section of each vehicle type (South to North)

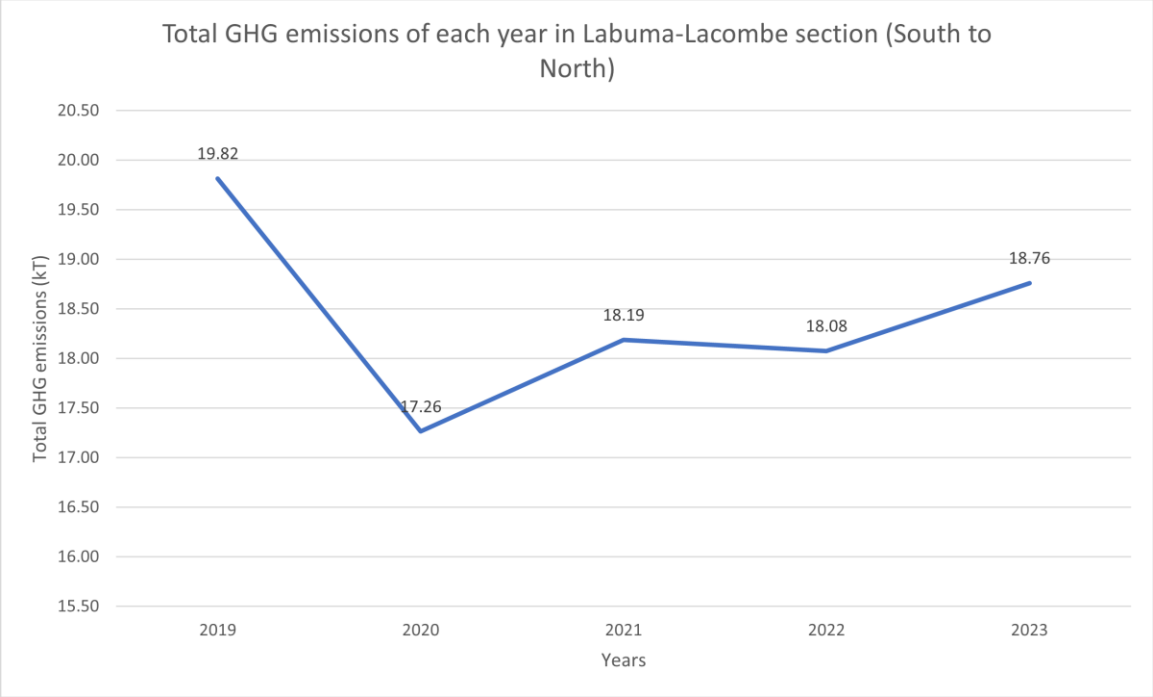


Figure 89: Total GHG emissions of each year in Labuma-Lacombe section (South to North)

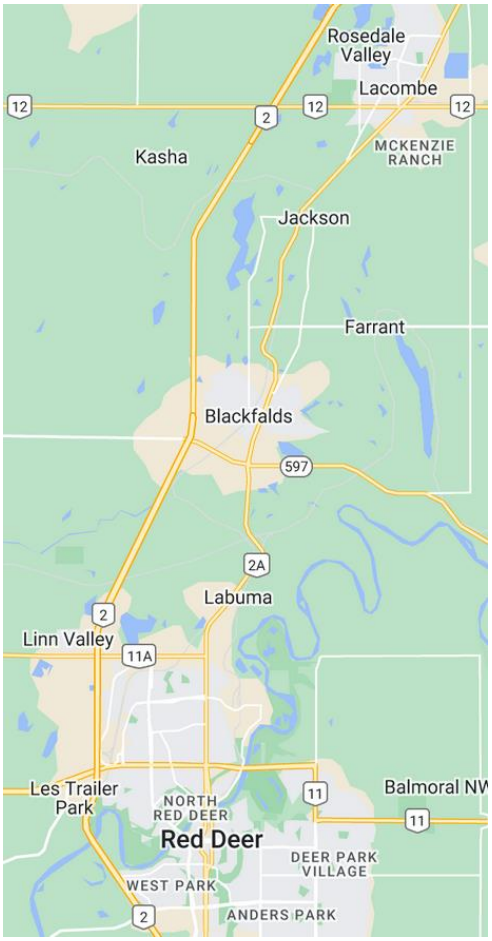


Figure 90: Intersections from Labuma to Lacombe

Based on the GHG emission calculations, emissions on Highway 2A from South to North are predominantly from PVs, accounting for 95.39%, followed by SUT at 2.15%, TTC at 1.64%, BUS at 0.34%, and RV at 0.49%. The route from Labuma to Lacombe begins in Labuma, passes through Blackfalds, Jackson, and Lacombe, and ends in Heritage Estates. Details showed in Figure 90. According to Figure 89, the total GHG emissions between 2019 and 2023 were 19.82, 17.26, 18.19, 18.08, and 18.76 kT, respectively.

From the AADT traffic dataset for Highway 2A (South to North), vehicle counts decreased after Heritage Estates, falling from 6,900 to 3,240 vehicles in 2023. The highest traffic load was recorded in Blackfalds, with AADT traffic counts of approximately 7,360, 6,350, 6,810, 6,760, and 6,900 cars annually from 2019 to 2023. In contrast, the lowest traffic load was in Heritage Estates, with AADT counts of approximately 3,350, 2,980, 3,020, 3,010, and 3,240 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 2.55 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 19.82 kT (95.39%) and 16.46 kT (95.36%), respectively. SUT contributed 17.26 kT (2.15%) in 2019 and 0.37 kT (2.16%) in 2020. TTC created 0.32 kT (1.64%) in 2019 and 0.28 kT (1.65%) in 2020. BUS contributed 0.07 kT (0.34%) in 2019 and 0.06 kT (0.34%) in 2020, while RV emissions were 0.10 kT (0.49%) in 2019 and 0.09 kT (0.49%) in 2020. After the vaccine rollout in 2020, GHG emissions increased by 0.92 kT from 2020 to 2021, decreased by 0.11 kT from 2021 to 2022 and rose by 0.69 kT from 2022 to 2023.

Morningside-Wetaskiwin Section

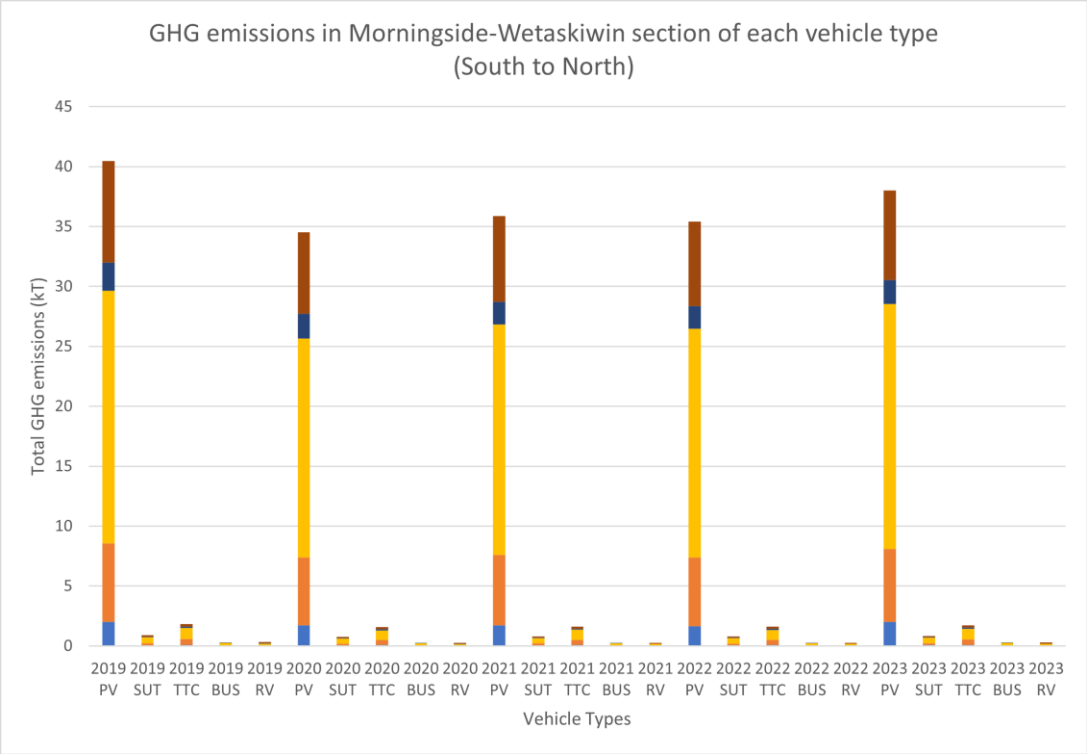


Figure 91: GHG emissions in Morningside-Wetaskiwin section of each vehicle type (South to North)

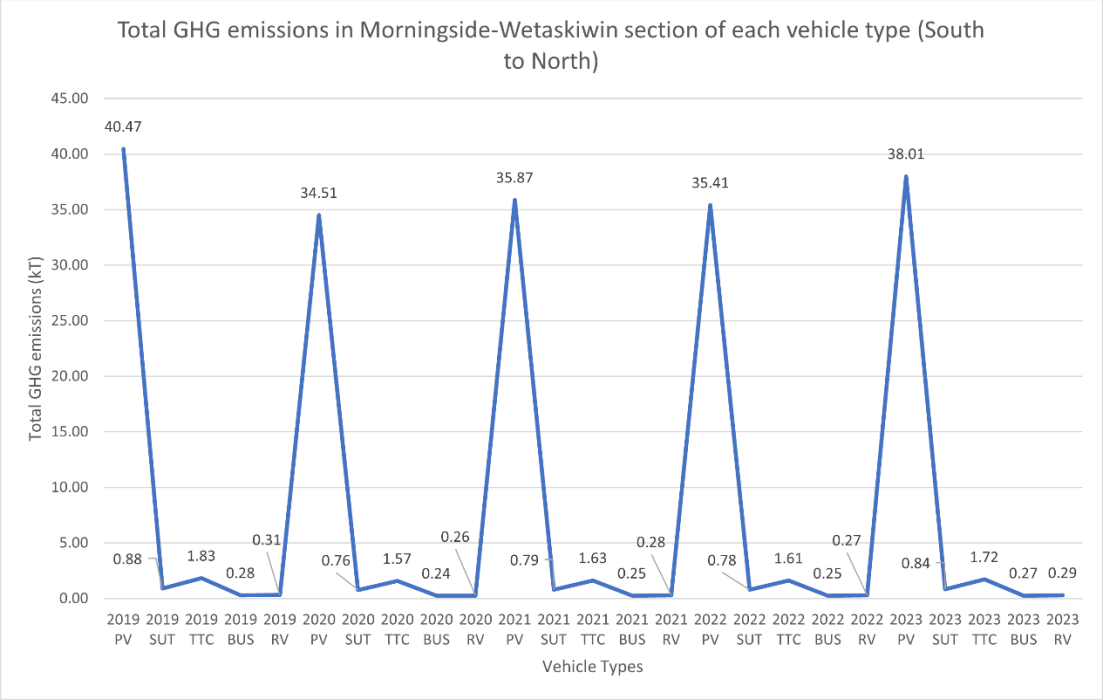


Figure 92: Total GHG emissions in Morningside-Wetaskiwin section of each vehicle type (South to North)

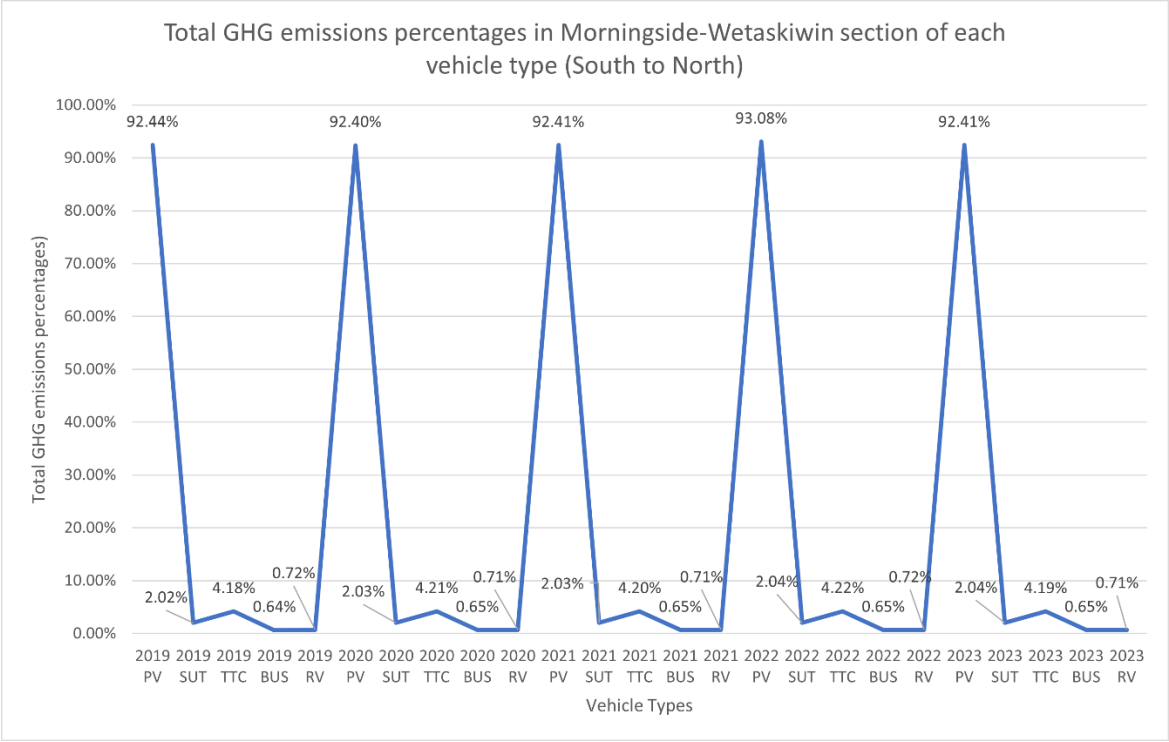


Figure 93: Total GHG emissions percentages in Morningside-Wetaskiwin section of each vehicle type (South to North)

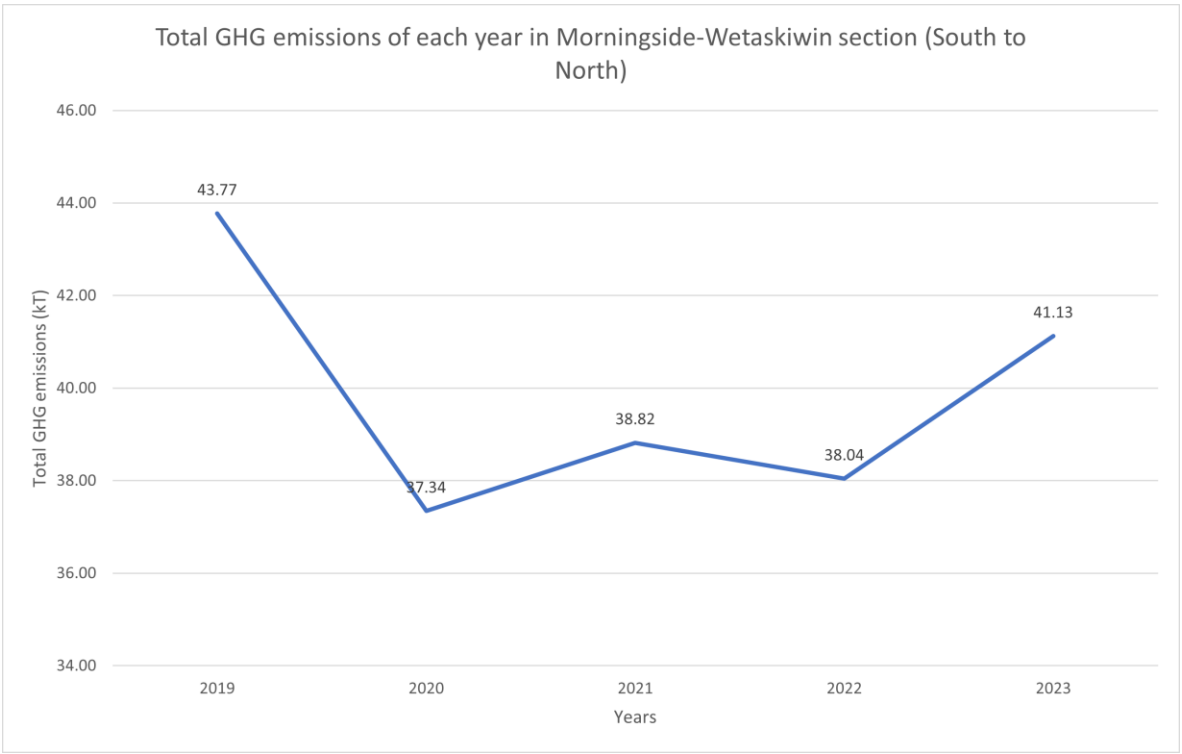


Figure 94: Total GHG emissions of each year in Morningside-Wetaskiwin section (South to North)

Figure 95: Intersections from Morningside to Wetaskiwin

Based on the GHG emission calculations, emissions on Highway 2A from South to North are predominantly from PVs, accounting for 92.55%, followed by SUT at 2.03%, TTC at 4.2%, BUS at 0.65%, and RV at 0.71%. The route from Morningside to Wetaskiwin begins in Morningside, passes through Ponoka Industrial Airport, Ponoka, Menaik, Maskwacis, and ends in Wetaskiwin. Details showed in Figure 95. According to Figure 94, the total GHG emissions between 2019 and 2023 were 43.77, 37.34, 38.82, 38.04, and 41.13 kT, respectively.

From the AADT traffic dataset for Highway 2A (South to North), vehicle counts increased after Ponoka Industrial Airport, rising from 2390 to 4620 vehicles in 2023, then falling after passing through Ponoka, Menaik, and arriving at Maskwacis, decreasing from 4620 to 3040 vehicles in 2023. From Maskwacis to Wetaskiwin, the vehicle counts fell from 3040 to 2650 in 2023. The highest traffic load was recorded in Ponoka Industrial Airport, with AADT traffic counts of approximately 4770, 4130, 4350, 4320, and 4620 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Morningside, with AADT counts of approximately 2570, 2220, 2300, 2240, and 2390 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 6.43 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 40.47 kT (92.44%) and 34.51 kT (92.4%). SUT contributed 0.88 kT (2.02%) in 2019 and 0.76 kT (2.03%) in 2020. TTC created 1.83 kT (4.18%) in 2019 and 1.57 kT (4.21%) in 2020. BUS contributed 0.28 kT (0.64%) in 2019 and 0.24 kT (0.65%) in 2020, and RV created 0.31 kT (0.72%) in 2019 and 0.26 kT (0.71%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 1.48 kT from 2020 to 2021, then decreasing by 0.78 kT from 2021 to 2022, before rising by 3.08 kT from 2022 to 2023.

Wetaskiwin-Leduc Section

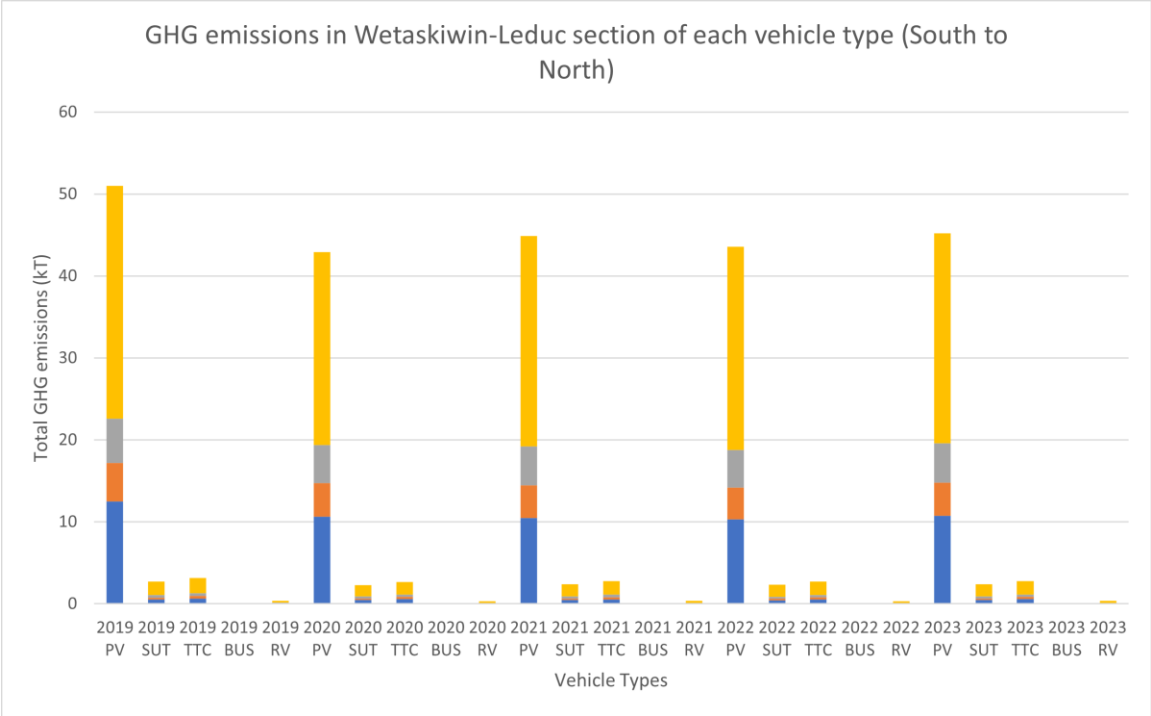


Figure 96: GHG emissions in Wetaskiwin-Leduc section of each vehicle type (South to North)

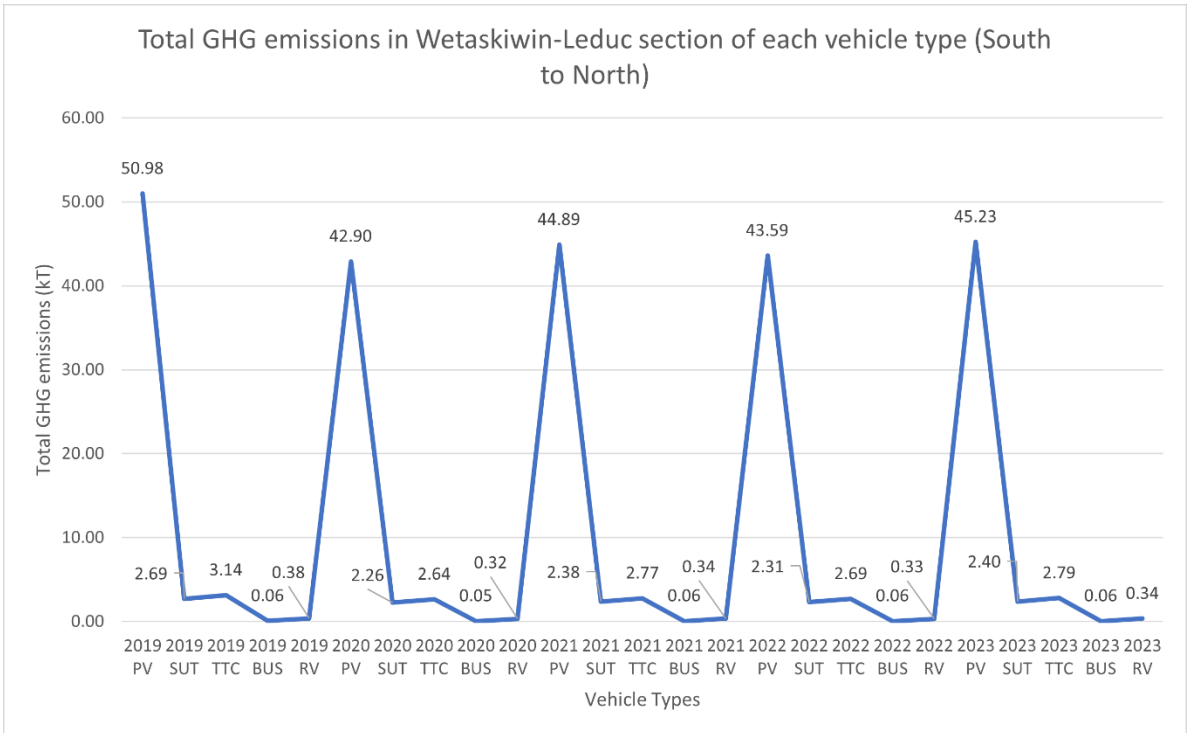


Figure 97: Total GHG emissions in Wetaskiwin-Leduc section of each vehicle type (South to North)

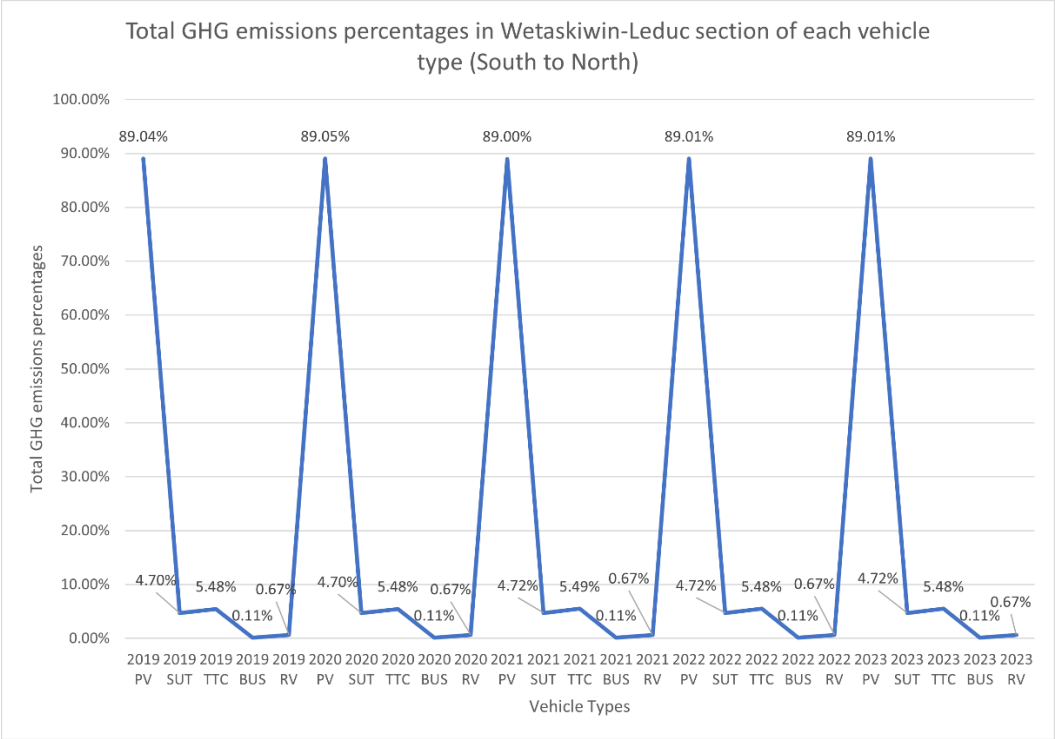


Figure 98: Total GHG emissions percentages in Wetaskiwin-Leduc section of each vehicle type (South to North)

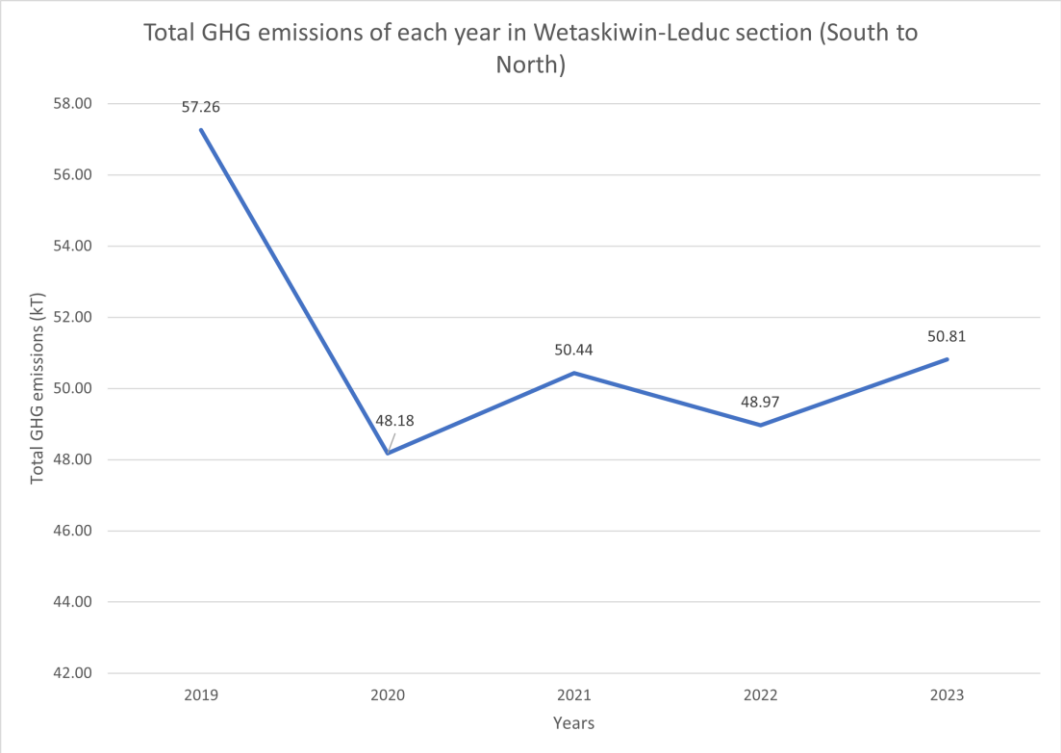


Figure 99: Total GHG emissions of each year in Wetaskiwin-Leduc section (South to North)

Figure 100: Intersections from Wetaskiwin to Leduc

Based on the GHG emission calculations, emissions on Highway 2A from South to North are predominantly from PVs, accounting for 89.02%, followed by SUT at 4.71%, TTC at 5.48%, BUS at 0.11%, and RV at 0.67%. The route from Wetaskiwin to Leduc begins in Wetaskiwin, passes through Milet, and ends in Leduc. Details showed in Figure 100. According to Figure 99, the total GHG emissions between 2019 and 2023 were 57.26, 48.18, 50.44, 48.97, and 50.81 kT, respectively.

From the AADT traffic dataset for Highway 2A (South to North), vehicle counts decreased after Milet, falling from 3690 to 3530 vehicles in 2023, then rising after arriving at Leduc, increasing from 3530 to 19570 vehicles in 2023. The highest traffic load was recorded in Leduc, with AADT traffic counts of approximately 21660, 17980, 19620, 18930, and 19570 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Milet, with AADT counts of approximately 4110, 3550, 3470, 3380, and 3530 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 9.08 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 50.98 kT (89.04%) and 42.9 kT (89.05%). SUT contributed 2.69 kT (4.7%) in 2019 and 2.26 kT (4.7%) in 2020. TTC created 3.14 kT (5.48%) in 2019 and 2.64 kT (5.48%) in 2020. BUS contributed 0.06 kT (0.11%) in 2019 and 0.05 kT (0.11%) in 2020, and RV created 0.38 kT (0.67%) in 2019 and 0.32 kT (0.67%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 2.26 kT from 2020 to 2021, then decreasing by 1.47 kT from 2021 to 2022, before rising by 1.84 kT from 2022 to 2023.

GHG emissions on Highway 2A from Edmonton to Calgary (North to South)

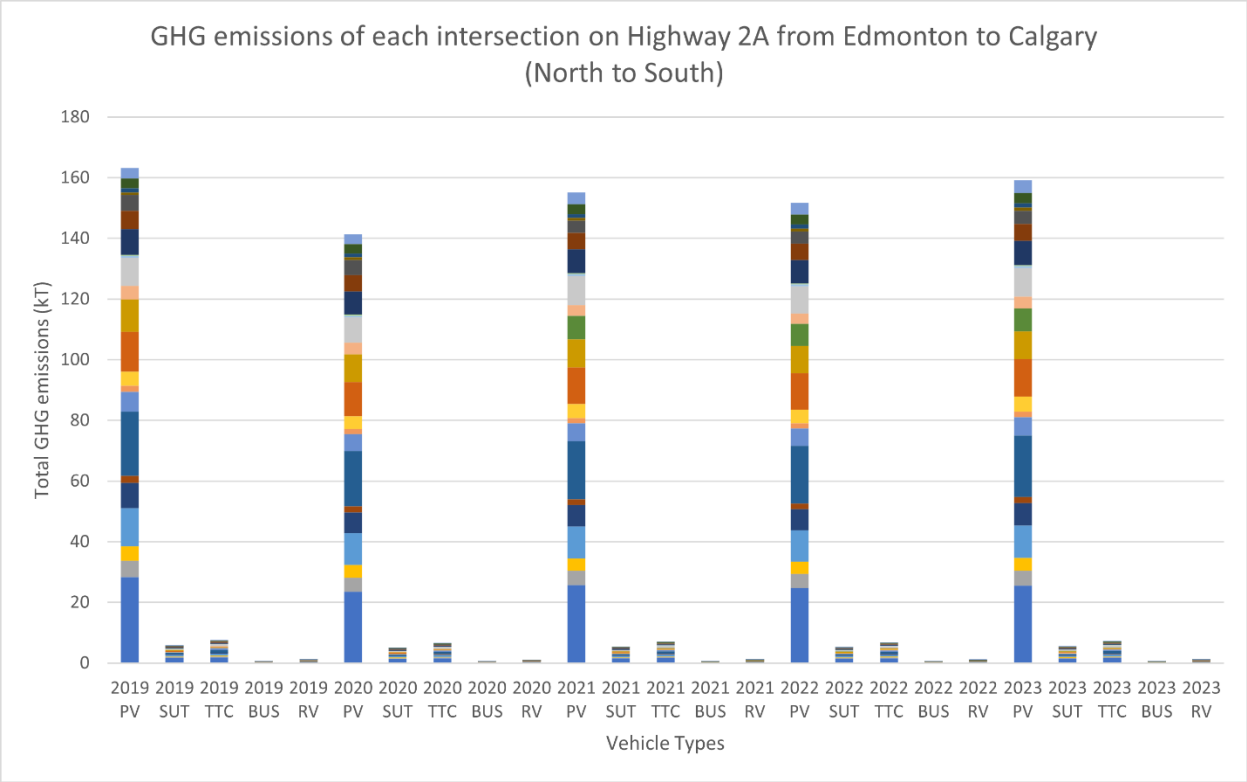


Figure 101: GHG emissions of each intersection on Highway 2A from Edmonton to Calgary (North to South)

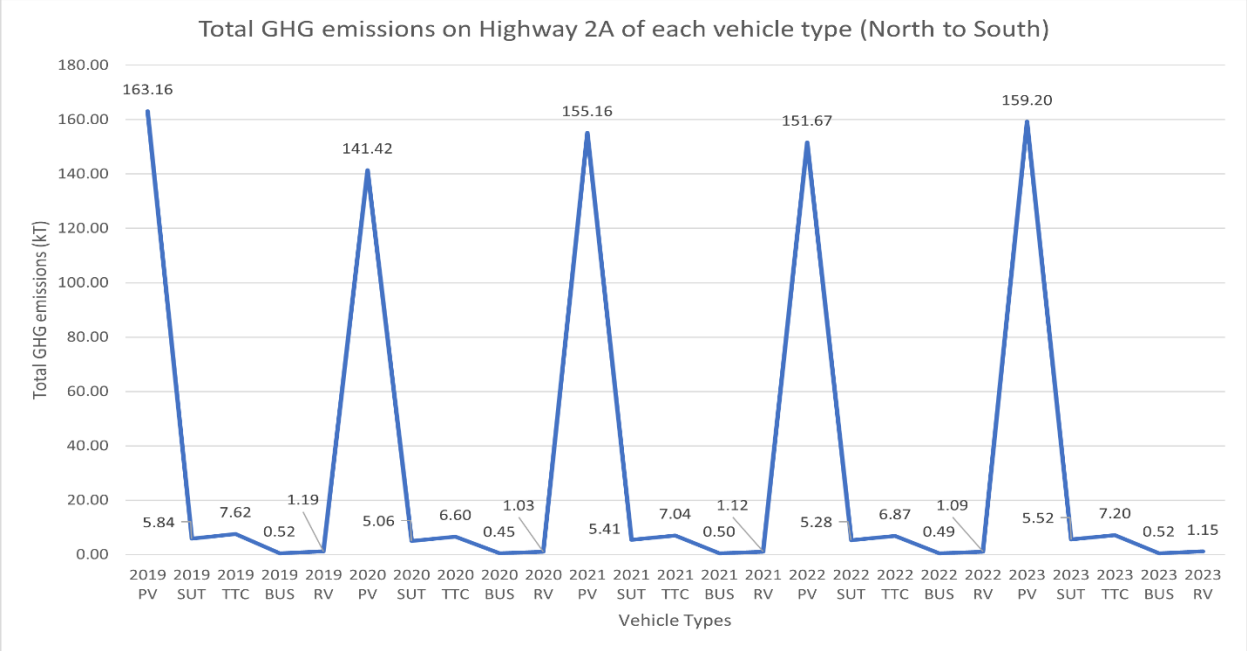


Figure 102: Total GHG emissions on Highway 2A of each vehicle type (North to South)

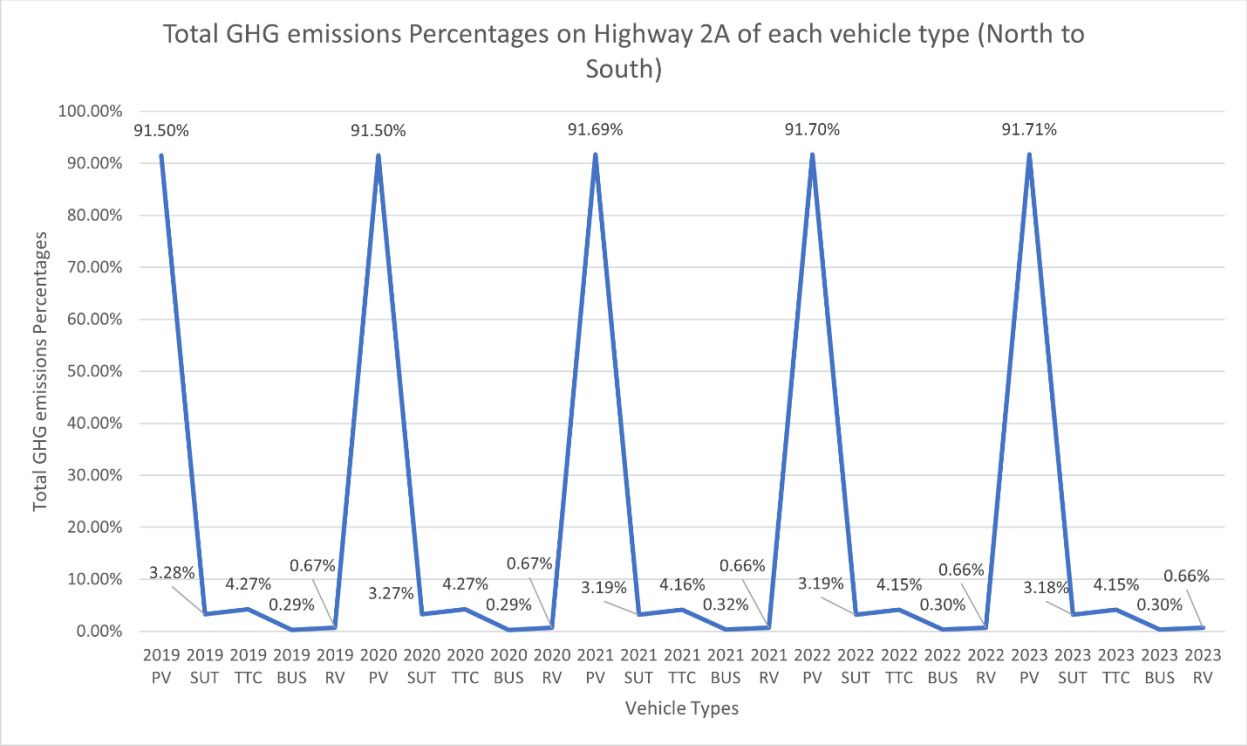


Figure 103: Total GHG emissions Percentages on Highway 2A of each vehicle type (North to South)

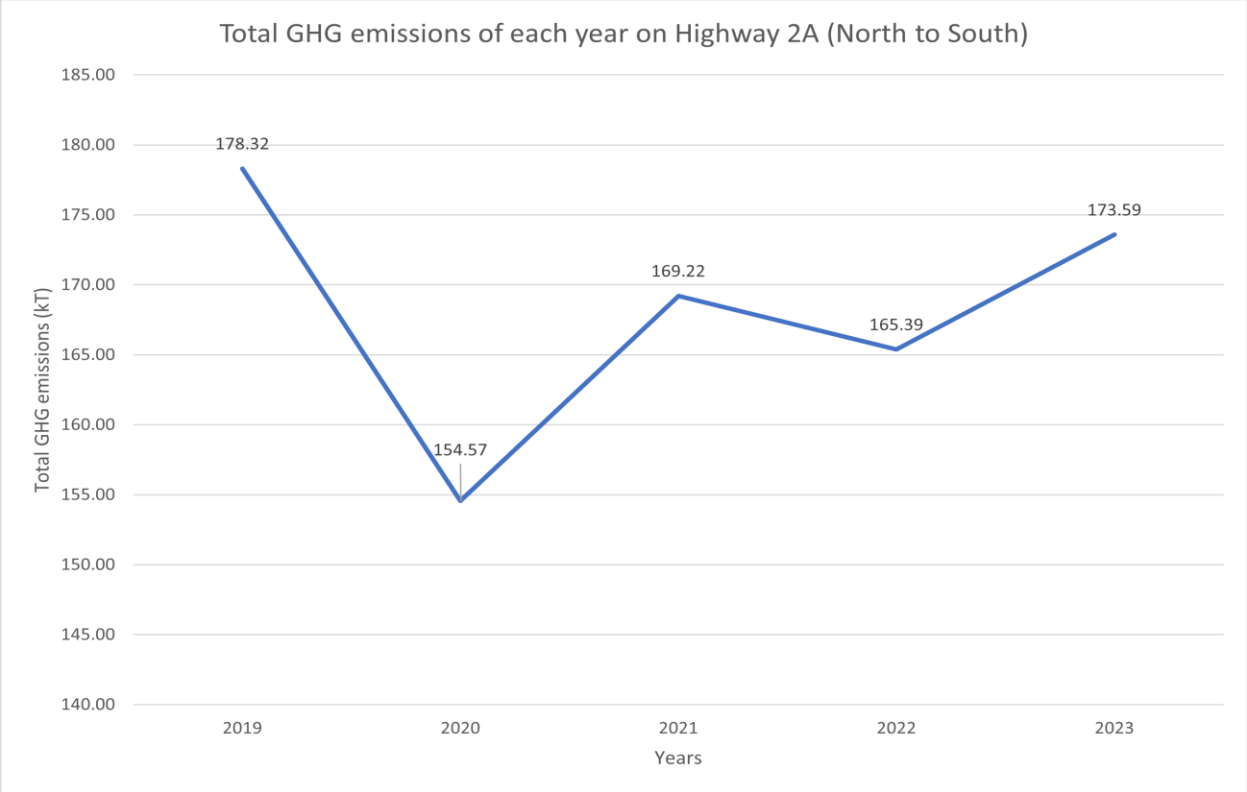


Figure 104: Total GHG emissions of each year on Highway 2A (North to South)

For the Highway 2A, Figure 101 to 104 are the total GHG emissions of each intersection, vehicle counts and types percentages, and total GHG emissions from North to South from 2019 to 2023. The vehicle types for Highway 2A are mostly PV in each section, approximately 91.36% in Highway 2A. For other type of vehicles, the average is 3.48% for SUT, 4.12% for TTC, 0.16% for BUS, and 0.88% for RV. From Figure 101, each color means different intersection from Edmonton to Calgary in Highway 2A. Because the Highway 2A doesn't fully connect from Edmonton to Calgary, we divided the Highway 2A into five sections for GHG emissions calculation. The following sections are: Leduc-Wetaskiwin, Wetaskiwin-Morningside, Lacombe-Labuma, Red Deer-Innisfail, and Bowden-Crossfield.

Impact of COVID-19 to GHG emissions

When COVID-19 first emerged, GHG emissions dropped by 23.76 kT from 2019 to 2020. According to Figures 102 and 103, in 2019, PV were responsible for 163.16 kT (91.5%) of GHG emissions, while SUT contributed 5.84 kT (3.28%), TTC 7.62 kT (4.27%), buses 0.52 kT (0.29%), and RV 1.19 kT (0.67%). In 2020, PV emissions decreased to 141.42 kT (91.5%), SUT to 5.06 kT (3.27%), TTC to 6.6 kT (4.27%), bus emissions to 0.45 kT (0.29%), and RV emissions to 1.03 kT (0.67%).

After introducing vaccines in 2020, GHG emissions surged, followed by a slight decline. From 2020 to 2021, emissions increased by 14.66 kT, then dropped by 3.83 kT from 2021 to 2022. Finally, emissions rose again by 8.2 kT from 2022 to 2023.

Leduc-Wetaskiwin Section

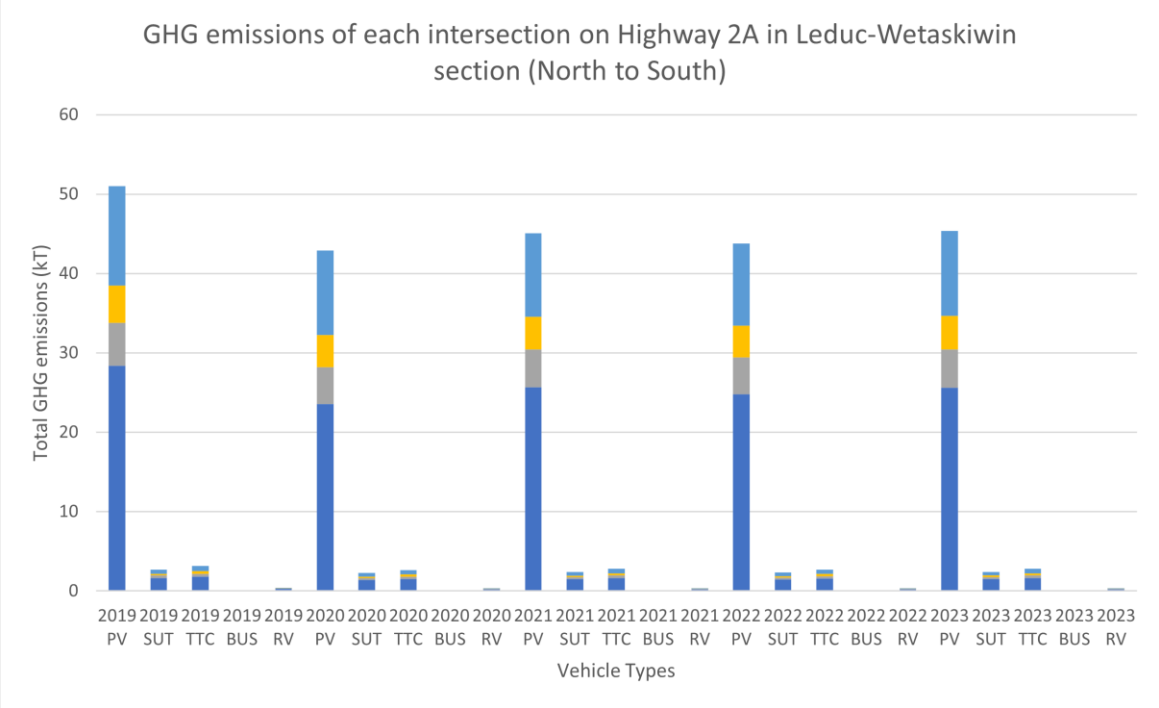


Figure 105: GHG emissions of each intersection on Highway 2A in Leduc-Wetaskiwin section (North to South)

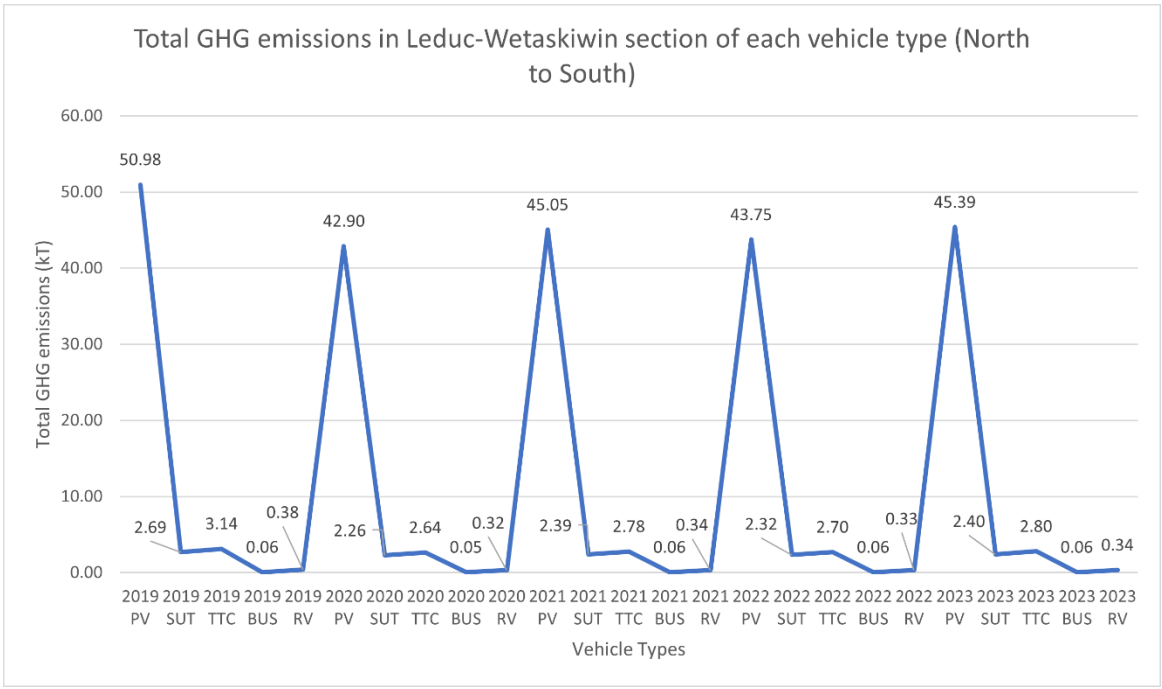


Figure 106: Total GHG emissions in Leduc-Wetaskiwin section of each vehicle type (North to South)

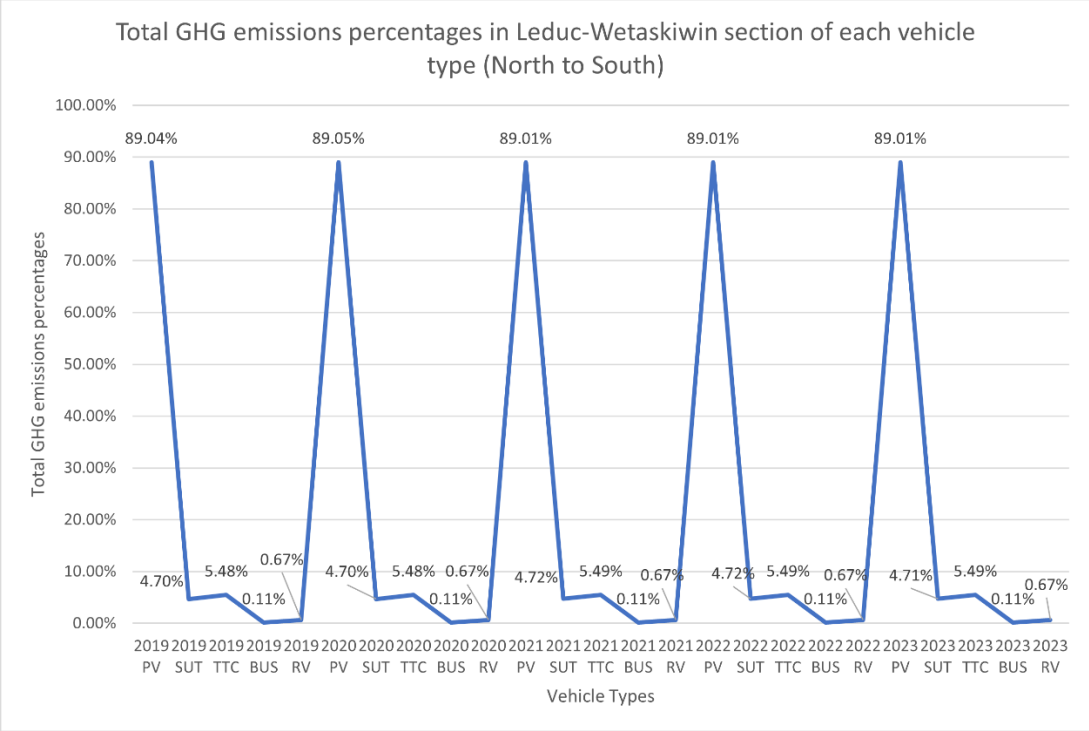


Figure 107: Total GHG emissions percentages in Leduc-Wetaskiwin section of each vehicle type (North to South)

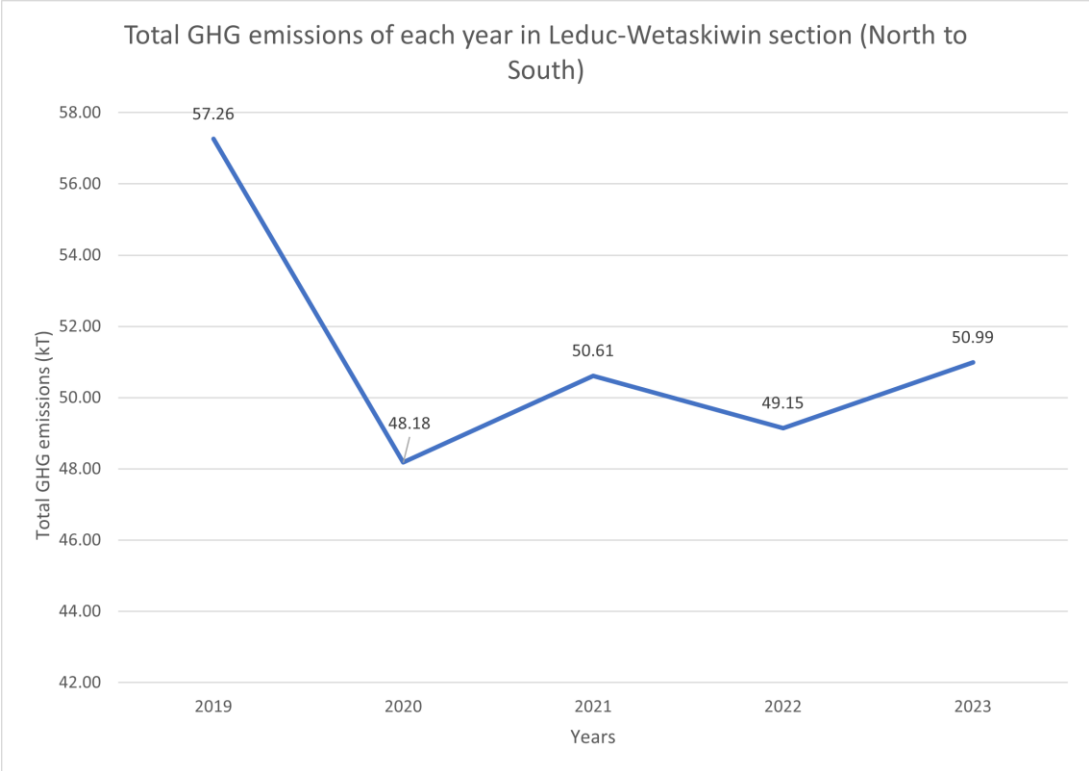


Figure 108: Total GHG emissions of each year in Leduc-Wetaskiwin section (North to South)

Based on the GHG emission calculations, emissions on Highway 2A from North to South are predominantly from PVs, accounting for 89.02%, followed by SUT at 4.71%, TTC at 5.48%, BUS at 0.11%, and RV at 0.67%. The route from Leduc to Wetaskiwin begins in Leduc, passes through Kavanagh, Milet, and ends in Wetaskiwin. Details showed in Figure 100. According to Figure 108, the total GHG emissions between 2019 and 2023 were 57.26, 48.18, 50.61, 49.15, and 50.99 kT, respectively.

From the AADT traffic dataset for Highway 2A (North to South), vehicle counts slashed after Kavanagh, falling from 19550 to 3690 vehicles in 2023, then remaining the same to Milet and Wetaskiwin in 2023. The highest traffic load was recorded in Leduc, with AADT traffic counts of approximately 21660, 17980, 19610, 18910, and 19550 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Milet, with AADT counts of approximately 4110, 3550, 3620, 3540, and 3690 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 9.08 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 50.98 kT (89.04%) and 42.9 kT (89.05%). SUT contributed 2.69 kT (4.7%) in 2019 and 2.26 kT (4.7%) in 2020. TTC created 3.14 kT (5.48%) in 2019 and 2.64 kT (5.48%) in 2020. BUS contributed 0.06 kT (0.11%) in 2019 and 0.05 kT (0.11%) in 2020, and RV created 0.38 kT (0.67%) in 2019 and 0.32 kT (0.67%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 2.44 kT from 2020 to 2021, then decreasing by 1.47 kT from 2021 to 2022, before rising by 1.84 kT from 2022 to 2023.

Wetaskiwin-Morningside Section

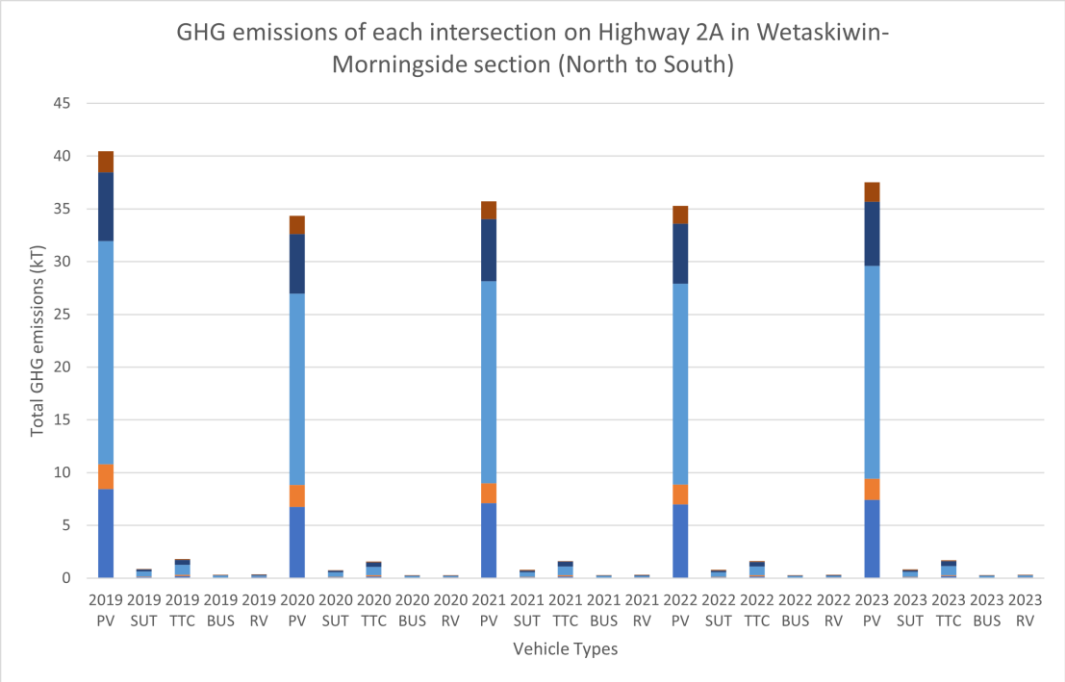


Figure 109: GHG emissions of each intersection on Highway 2A in Wetaskiwin-Morningside section (North to South)

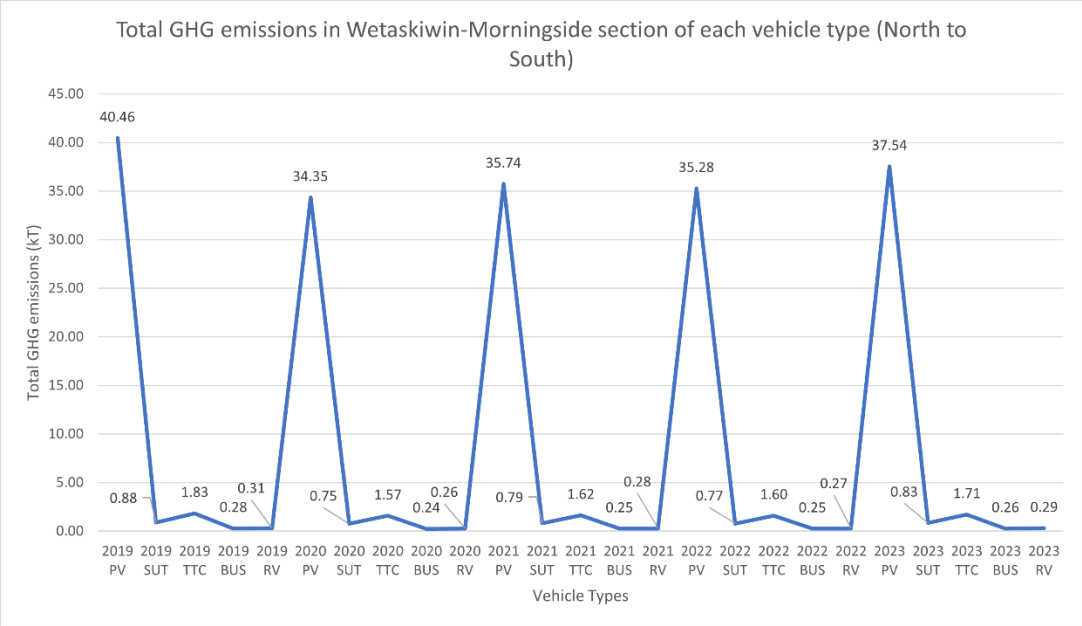


Figure 110: Total GHG emissions in Wetaskiwin-Morningside section of each vehicle type (North to South)

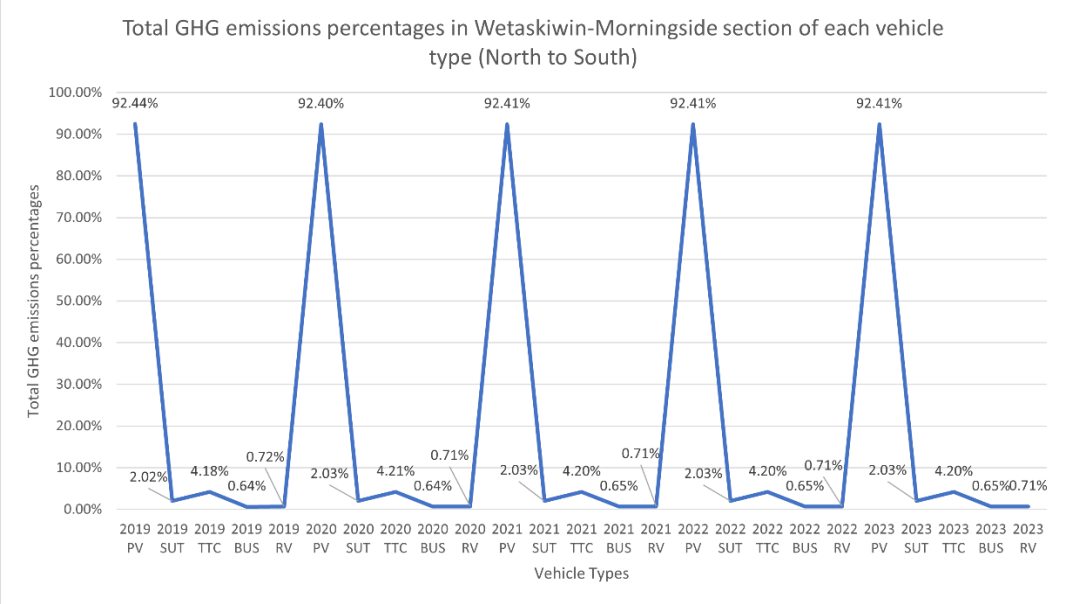


Figure 111: Total GHG emissions percentages in Wetaskiwin-Morningside section of each vehicle type (North to South)

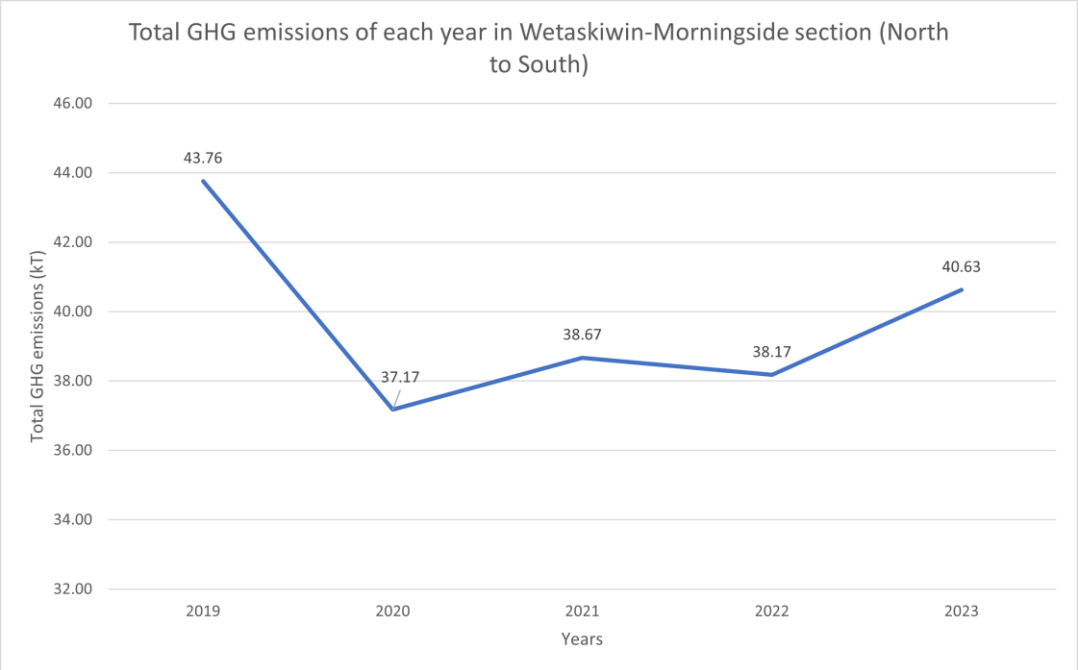


Figure 112: Total GHG emissions of each year in Wetaskiwin-Morningside section (North to South)

Based on the GHG emission calculations, emissions on Highway 2A from North to South are predominantly from PVs, accounting for 92.44%, followed by SUT at 2.03%, TTC at 4.2%, BUS at 0.65%, and RV at 0.71%. The route from Wetaskiwin to Morningside begins in Wetaskiwin, passes through Maskwacis, Menaik, Ponoka, Ponoka Industrial Airport, and ends in Morningside. Details showed in Figure 95. According to Figure 112, the total GHG emissions between 2019 and 2023 were 43.76, 37.17, 38.67, 38.17, and 40.63 kT, respectively.

From the AADT traffic dataset for Highway 2A (North to South), vehicle counts rose after Maskwacis, rising from 2630 to 3060 vehicles in 2023, then keep rising from 3060 to 4560 vehicles after crossing through Ponoka in 2023. From Ponoka to Morningside, passing through Ponoka Industrial Airport, the vehicle counts fell from 4560 to 2419 in 2023. The highest traffic load was recorded in Ponoka, with AADT traffic counts of approximately 4780, 4100, 4330, 4300, and 4560 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Maskwacis, with AADT counts of approximately 3610, 3190, 2900, 2890, and 3060 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 6.05 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 40.46 kT (92.44%) and 34.35 kT (92.4%). SUT contributed 0.88 kT (2.02%) in 2019 and 0.75 kT (2.03%) in 2020. TTC created 1.83 kT (4.18%) in 2019 and 1.57 kT (4.21%) in 2020. BUS contributed 0.28 kT (0.64%) in 2019 and 0.24 kT (0.64%) in 2020, and RV created 0.31 kT (0.72%) in 2019 and 0.26 kT (0.71%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 1.5 kT from 2020 to 2021, then decreasing by 0.5 kT from 2021 to 2022, before rising by 2.45 kT from 2022 to 2023.

Lacombe-Labuma Section

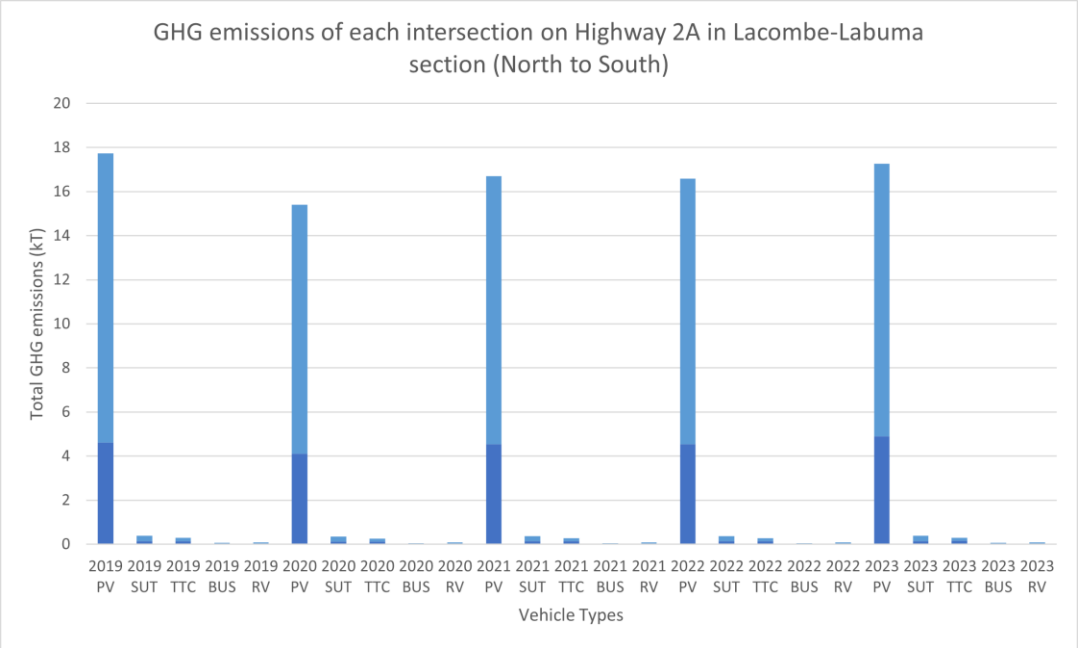


Figure 113: GHG emissions of each intersection on Highway 2A in Lacombe-Labuma section (North to South)

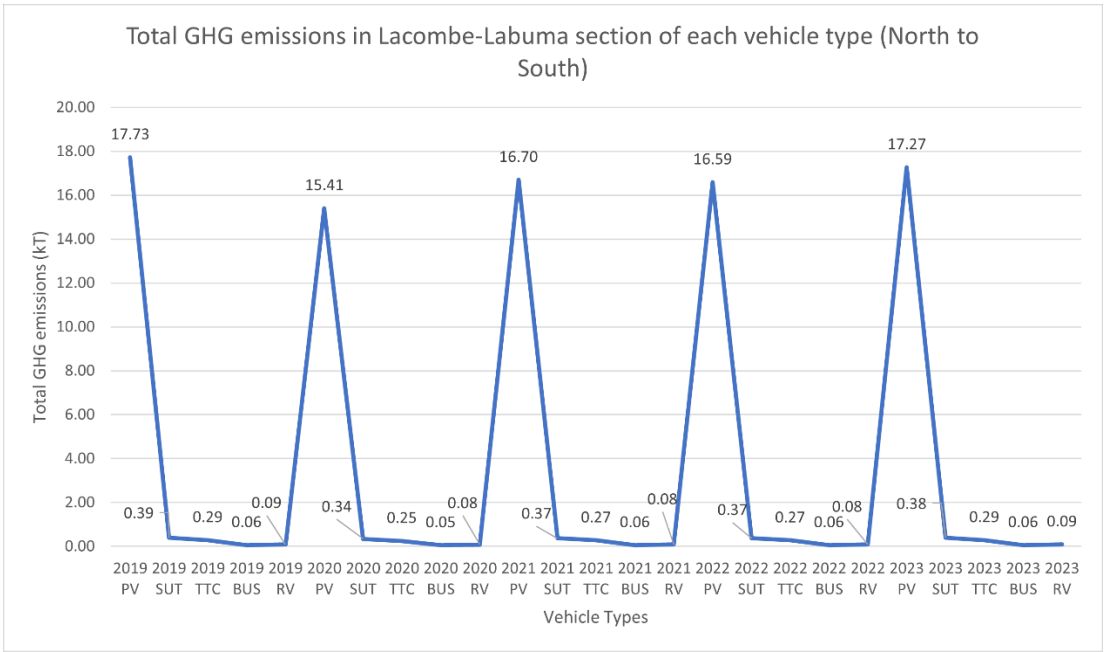


Figure 114: Total GHG emissions in Lacombe-Labuma section of each vehicle type (North to South)

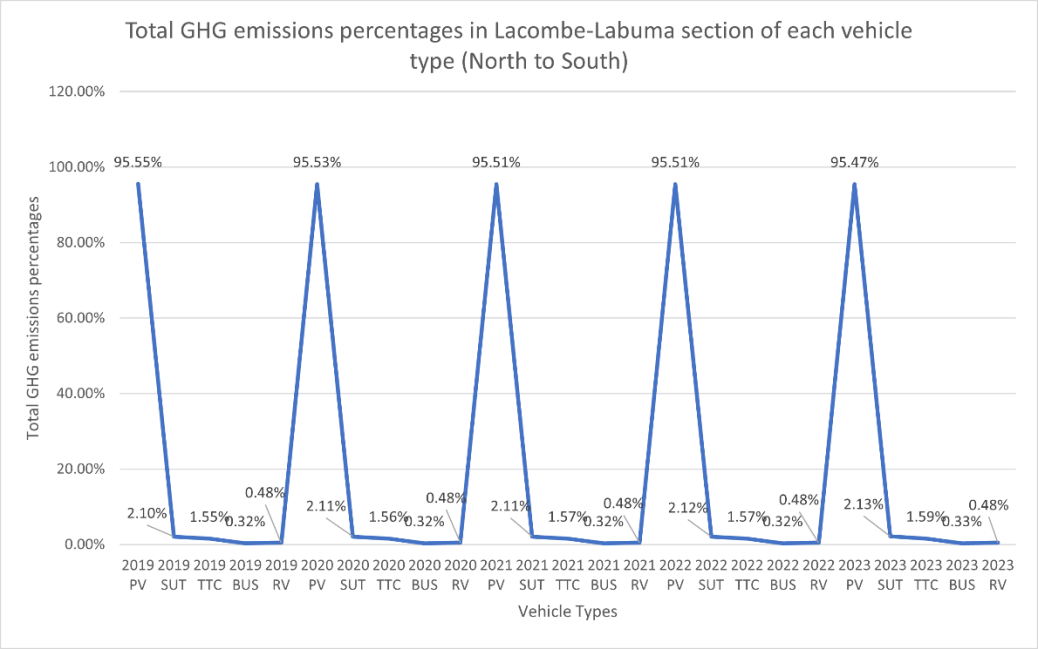


Figure 115: Total GHG emissions percentages in Lacombe-Labuma section of each vehicle type (North to South)

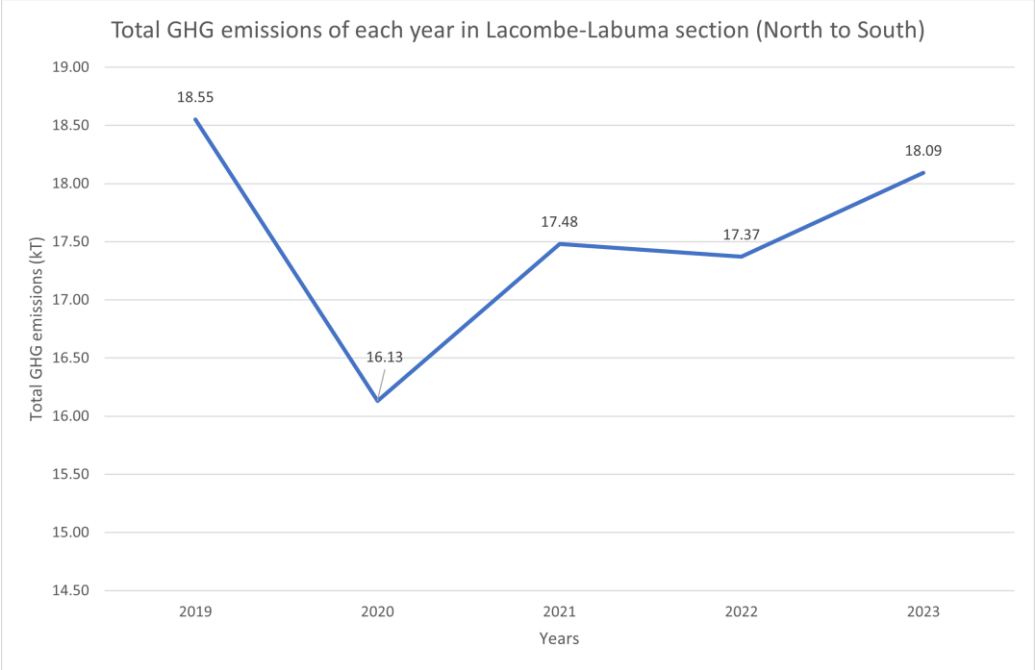


Figure 116: Total GHG emissions of each year in Lacombe-Labuma section (North to South)

Based on the GHG emission calculations, emissions on Highway 2A from North to South are predominantly from PVs, accounting for 95.51%, followed by SUT at 2.11%, TTC at 1.57%, BUS at 0.32%, and RV at 0.48%. The route from Lacombe to Labuma begins in Heritage Estates, passes through Lacombe, Jackson, Blackfalds, and ends in Labuma. Details showed in Figure 90. According to Figure 116, the total GHG emissions between 2019 and 2023 were 18.55, 16.13, 17.48, 17.37, and 18.09 kT, respectively.

From the AADT traffic dataset for Highway 2A (North to South), vehicle counts rose after Blackfalds, rising from 2840 to 6940 vehicles in 2023. The highest traffic load was recorded in Blackfalds, with AADT traffic counts of approximately 7350, 6340, 6820, 6760, and 6940 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Heritage Estates, with AADT counts of approximately 2680, 2380, 2630, 2630, and 2840 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 2.42 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 17.73 kT (95.55%) and 15.41 kT (95.53%). SUT contributed 0.39 kT (2.11%) in 2019 and 0.34 kT (2.11%) in 2020. TTC created 0.29 kT (1.55%) in 2019 and 0.25 kT (1.56%) in 2020. BUS contributed 0.06 kT (0.32%) in 2019 and 0.05 kT (0.32%) in 2020, and RV created 0.09 kT (0.48%) in 2019 and 0.08 kT (0.48%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 1.35 kT from 2020 to 2021, then decreasing by 0.11 kT from 2021 to 2022, before rising by 0.72 kT from 2022 to 2023.

Red Deer-Innisfail Section

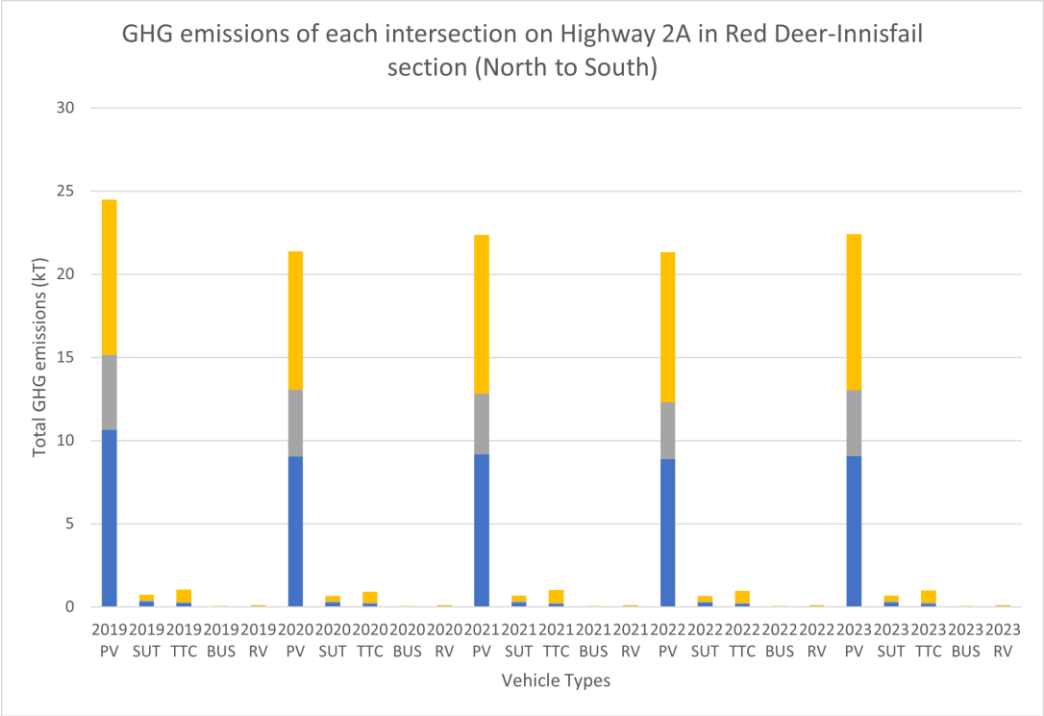


Figure 117: GHG emissions of each intersection on Highway 2A in Red Deer-Innisfail section (North to South)

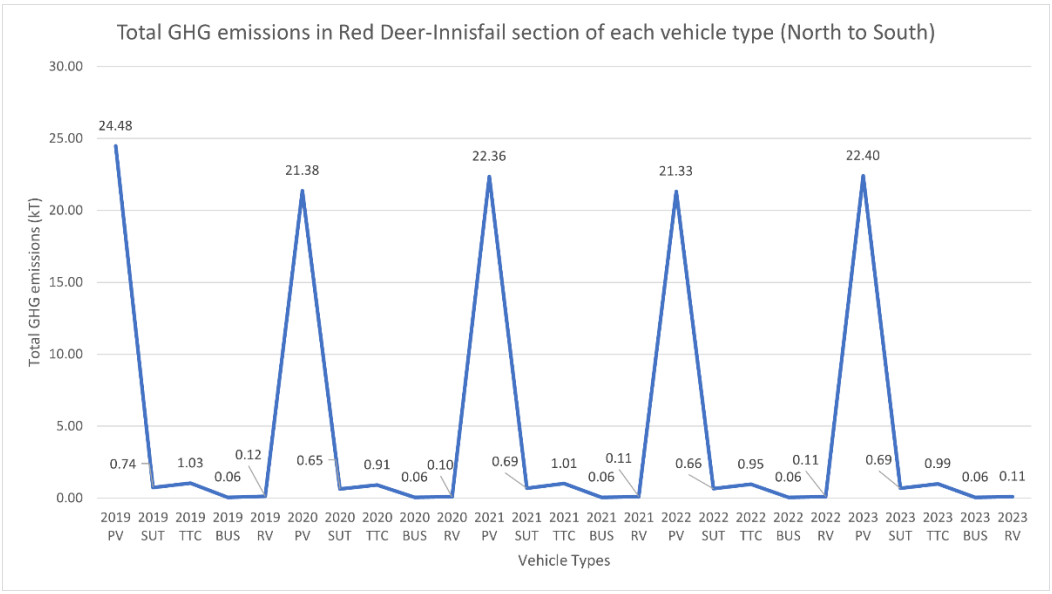


Figure 118: Total GHG emissions in Red Deer-Innisfail section of each vehicle type (North to South)

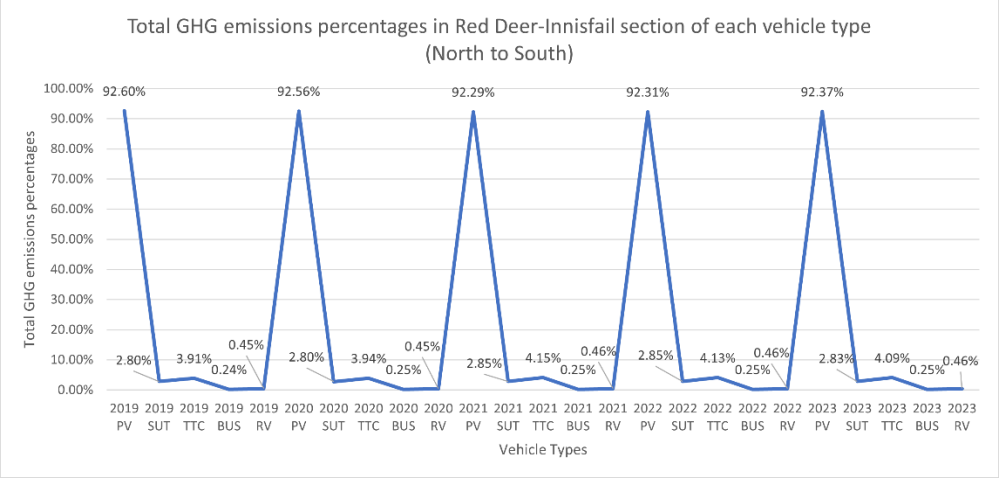


Figure 119: Total GHG emissions percentages in Red Deer-Innisfail section of each vehicle type (North to South)

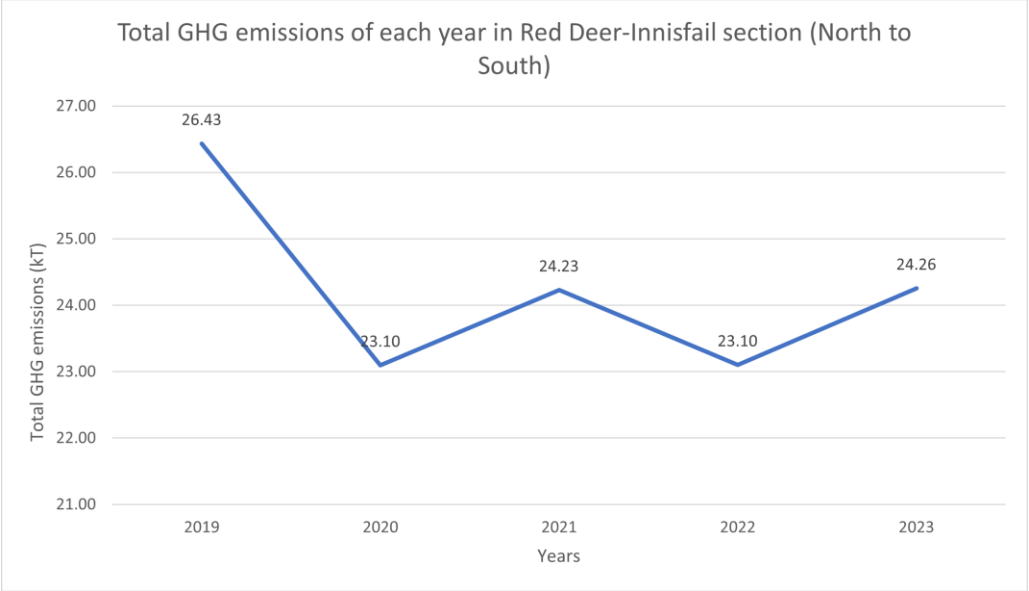


Figure 120: Total GHG emissions of each year in Red Deer-Innisfail section (North to South)

The intersection of reference #70000960 was excluded from the GHG emission calculations due to the need for datasets for 2019 and 2020.

Based on the GHG emission calculations, emissions on Highway 2A from North to South are predominantly from PVs, accounting for 92.43%, followed by SUT at 2.8%, TTC at 4.04%, BUS at 0.25%, and RV at 0.46%. The route from Red Deer to Innisfail begins in Red Deer, passes through Penhold, and ends in Innisfail. Details showed in Figure 85. According to Figure 120, the total GHG emissions between 2019 and 2023 were 26.43, 23.1, 24.23, 23.1, and 24.26 kT, respectively.

From the AADT traffic dataset for Highway 2A (North to South), vehicle counts fell after Penhold, decreasing from 5950 to 3035 vehicles in 2023, then rose after arriving at Innisfail, increasing from 3035 to 3050. The highest traffic load was recorded in Red Deer, with AADT traffic counts of approximately 6990, 5930, 6020, 5820, and 5950 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Innisfail, with AADT counts of approximately 3040, 2710, 3110, 2940, and 3050 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 3.34 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 24.48 kT (92.6%) and 21.38 kT (92.56%). SUT contributed 0.74 kT (2.8%) in 2019 and 0.65 kT (2.8%) in 2020. TTC created 1.03 kT (3.91%) in 2019 and 0.91 kT (3.94%) in 2020. BUS contributed 0.06 kT (0.24%) in 2019 and 0.06 kT (0.25%) in 2020, and RV created 0.12 kT (0.45%) in 2019 and 0.1 kT (0.45%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 1.13 kT from 2020 to 2021, then decreasing by 0.13 kT from 2021 to 2022, before rising by 1.15 kT from 2022 to 2023.

Bowden-Crossfield Section

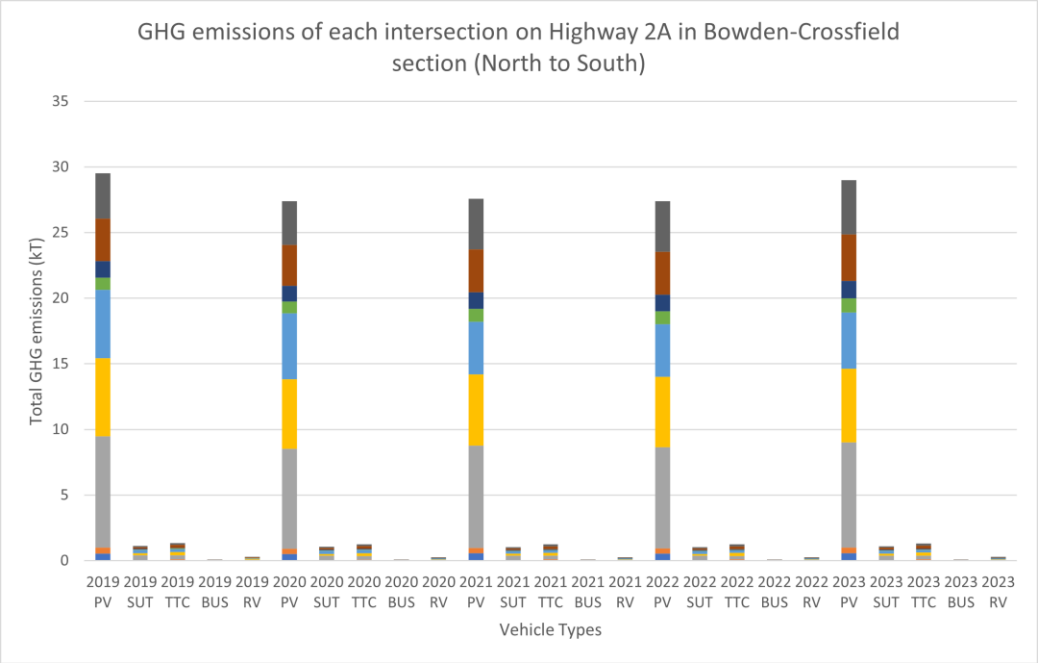


Figure 121: GHG emissions of each intersection on Highway 2A in Bowden-Crossfield section (North to South)

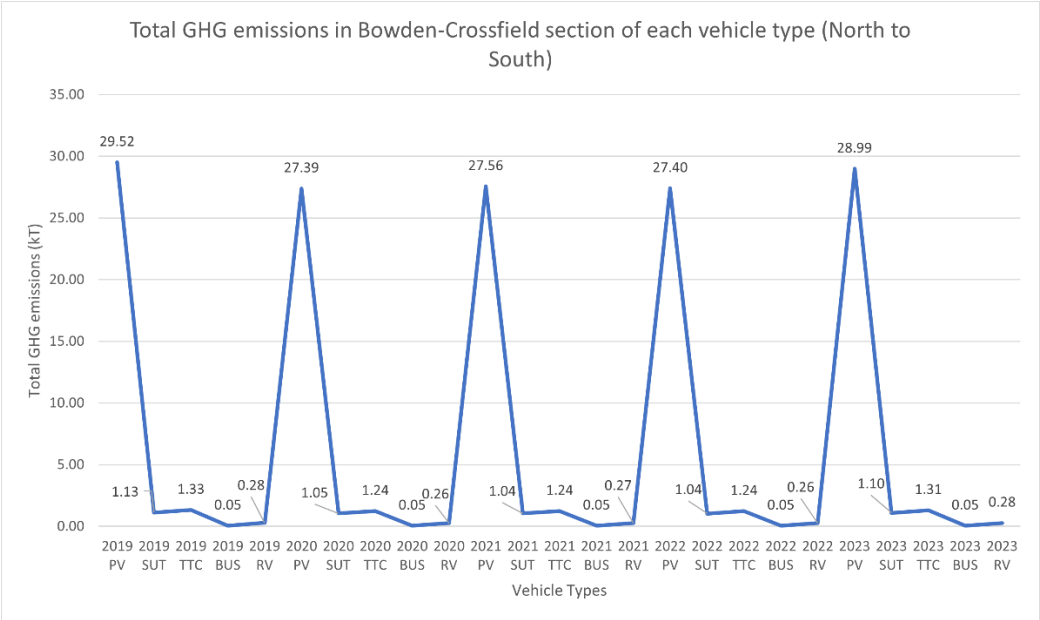


Figure 122: Total GHG emissions in Bowden-Crossfield section of each vehicle type (North to South)

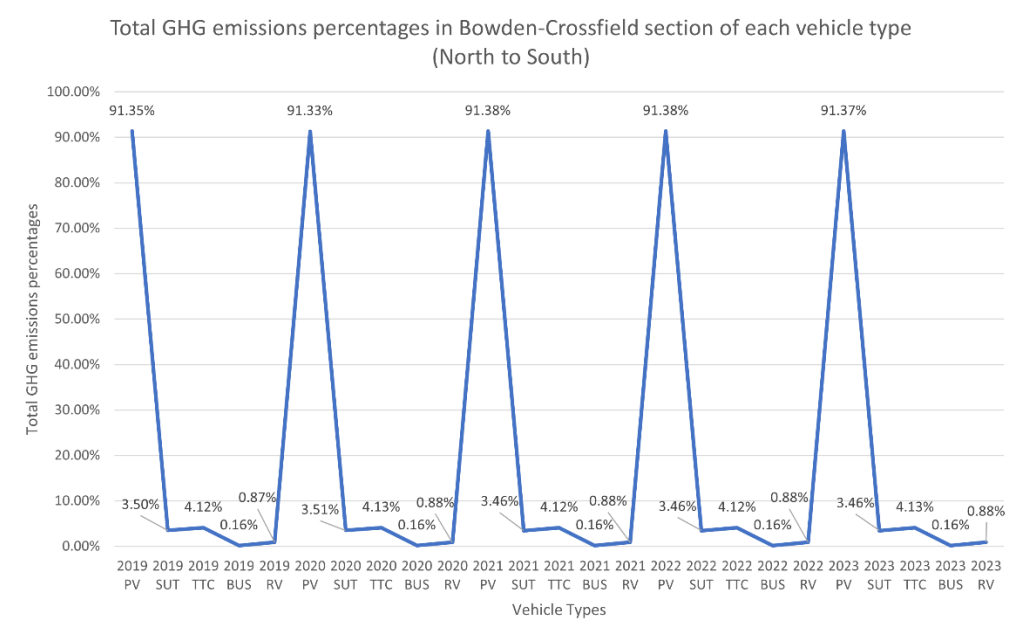


Figure 123: Total GHG emissions percentages in Bowden-Crossfield section of each vehicle type (North to South)

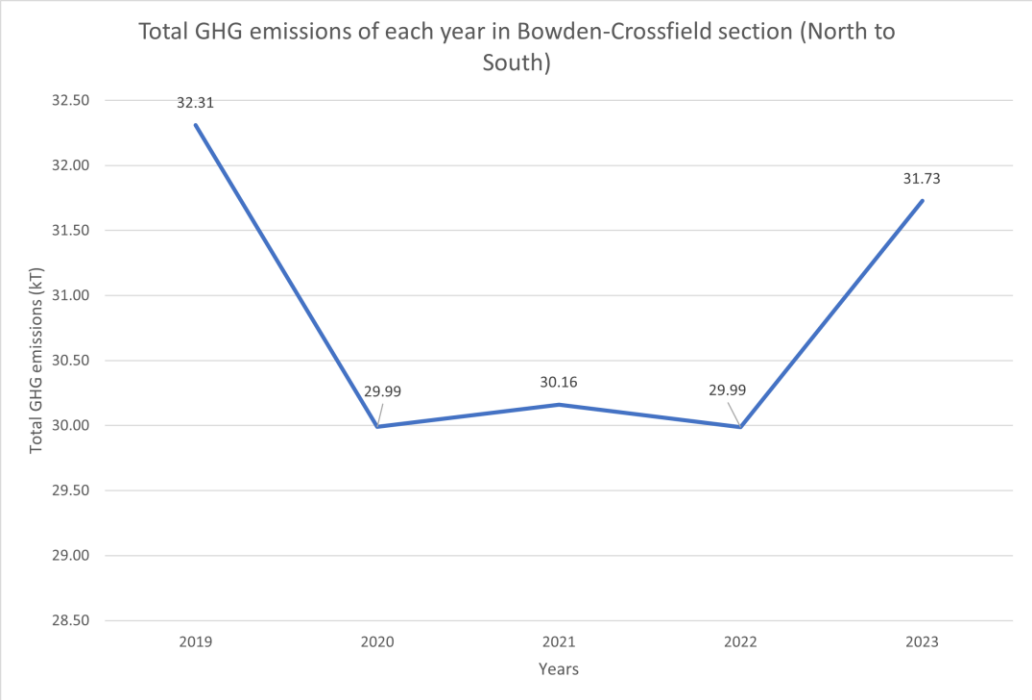


Figure 124: Total GHG emissions of each year in Bowden-Crossfield section (North to South)

Based on the GHG emission calculations, emissions on Highway 2A from North to South are predominantly from PVs, accounting for 91.36%, followed by SUT at 3.48%, TTC at 4.12%, BUS at 0.16%, and RV at 0.88%. The route from Bowden to Crossfield begins in Bowden, passes through Olds, Didsbury, Carstars, and ends in Crossfield. Details showed in Figure 80. According to Figure 124, the total GHG emissions between 2019 and 2023 were 32.31, 29.99, 30.16, 29.99, and 31.73 kT, respectively.

From the AADT traffic dataset for Highway 2A (North to South), vehicle counts rose after Olds, increasing from 1130 to 2390 vehicles in 2023, then fell after arriving at Didsbury, decreasing from 2390 to 1990. After arriving at Carstars, the vehicle counts rose from 1990 to 2480 in 2023. From Didsbury to Crossfield, the vehicle counts fell from 2480 to 1250 in 2023. The highest traffic load was recorded in Olds, with AADT traffic counts of approximately 2530, 2270, 2320, 2290, and 2390 vehicles annually from 2019 to 2023. In contrast, the lowest traffic load was in Bowden, with AADT counts of approximately 1080, 970, 1100, 1070, and 1130 vehicles during the same period.

Impact of COVID-19 on GHG emissions

GHG emissions dropped by 2.32 kT from 2019 to 2020 due to the pandemic. In 2019 and 2020, PV emissions were 29.52 kT (91.35%) and 27.39 kT (91.33%). SUT contributed 1.13 kT (3.5%) in 2019 and 1.05 kT (3.51%) in 2020. TTC created 1.33 kT (4.12%) in 2019 and 1.24 kT (4.13%) in 2020. BUS contributed 0.05 kT (0.16%) in 2019 and 0.05 kT (0.16%) in 2020, and RV created 0.28 kT (0.87%) in 2019 and 0.26 kT (0.88%) in 2020. After the vaccine rollout in 2020, GHG emissions rose again, increasing by 0.17 kT from 2020 to 2021, then decreasing by 0.18 kT from 2021 to 2022, before rising by 1.74 kT from 2022 to 2023.

Discussions

Traffic counts, vehicle types & the impact of COVID-19

Highway 2

Based on the datasets from the Government of Alberta for WAADT traffic counts and vehicle types, Highway 2 contributes higher traffic counts than Highway 2A. As you can see from the result in Figure 3, the traffic load is mainly located in Calgary city, especially the center of Calgary to Calgary International Airport, with the average WAADT vehicle count of approximately 147912 vehicles in 2023. After passing through the airport, the average traffic count fell rapidly to the Balzac, with approximately 104326 vehicles in this intersection. The traffic counts dropped a lot until they reached the Gasoline Alley. From the Balzac to Airdrie, the average traffic counts approximately 70390 vehicles. From Airdrie to Bowden, the average traffic counts approximately 33424 vehicles. From Bowden to Innisfail, the average traffic counts approximately 27480 vehicles. From the Innisfail to Gasoline Alley, the average traffic counts slightly increased to 30998 vehicles. From Gasoline Alley to the Highway 11 Interchange, the average traffic counts still rose from 30998 to 34375 vehicles. However, the average traffic counts lost almost 7000 vehicles in the Highway 11 Interchange-Lochinvar and Lochinvar-Leduc intersections, with 32574 and 25427 vehicles in both intersections. Finally, in the last intersection from Leduc to Edmonton, the number of vehicle counts surged by almost 33000 vehicles, from 25427 to 58327 vehicles in this intersection.

Figure 4 shows the total WAADT from 2019 to 2023, demonstrating that total vehicle counts are gradually increasing from 2020 to 2023. Although the impact of COVID caused traffic counts to plunge from 2019 to 2020, we still have to prepare for the number of vehicles on Highway 2.

For the vehicle types on Highway 2 in Figure 6, PV occupied the most significant proportion of all kinds of vehicles, with an average of 85.92%. Even though other cars didn’t have as many as PV, TTC was another vehicle type we should focus on. From the dataset in Sep 16-22_Highway 2 & 2A, the average of TTC is higher than 10% from Airdrie to Leduc, with approximately 12.68% within all types of vehicles. The highest proportion even reached 17.7% in Lochinvar. This proportion is still considerable for the traffic counts on Highway 2. SUT and RV only occupied almost 4% of the total proportion. As a result, PV and TTC need to focus on reducing GHG emissions. On the other hand, BUS has the lowest proportion of all types of vehicles, with only 0.19% on Highway 2. The government should figure out how to reduce the number of PV and TTC, increasing the proportion of BUS to save energy and achieve sustainability in the future.

Highway 2A

Instead of the high traffic pressure on Highway 2, based on the WAADT traffic counts datasets in Figures 7 and 8, the total traffic counts are approximately 149633 vehicles per year. Also, since the connection of Highway 2A from Calgary to Edmonton is not straightforward, we separate Highway 2A into five main sections to analyze the traffic counts and vehicle types.

The first is the Crossfield-Bowden section; the average WAADT traffic counts from 2019 to 2023 are 3678, 3390, 3386, 3416, and 3591 vehicles. This section starts from Crossfield, passing through Carstairs, Olds, and Netook, and arrives at Bowden. The following WAADT traffic counts will be based on the dataset in 2023. From Crossfield to Carstairs, the average WAADT traffic count is 3935 vehicles. From Carstairs to Olds, the average WAADT traffic count is 3886 vehicles. From Olds to Netook, the average WAADT traffic count is 4037 vehicles. Finally, from Netook to Bowden, the average WAADT traffic count is 2270 vehicles. The average WAADT traffic count from Crossfield to Netook is almost 4000 vehicles. However, after arriving at Bowden, the average WAADT traffic count was only 2270 vehicles.

The vehicle types in the Crossfield-Bowden section are still mainly PV, with a proportion of 91.58%. Other vehicles, such as SUT, TTC, BUS, and RV, occupied 3.1%, 4.06%, 0.22%, and 1.05%, respectively. Although other vehicles have less than 8% in total proportion, the TTC in Bowden should be noticed because the proportion reached 7.4%, much higher than other intersections.

The total WAADT from 2019 to 2023, shown in Figure 7, demonstrates that total vehicle counts gradually increase from 2020 to 2023. Although the impact of COVID caused traffic counts to fall by approximately 3500 vehicles from 2019 to 2020, the trend of traffic counts increased in the Crossfield-Bowden section from 2020 to 2023.

The second one is the Innisfail-Red Deer section, the average WAADT traffic counts from 2019 to 2023 are 5643, 5057, 5287, 5020, and 5347 vehicles. This section starts from Innisfail, passing through Penhold, and arrives at Red Deer. The following WAADT traffic counts will be based on the dataset in 2023. From Innisfail to Penhold, the average WAADT traffic count is 3625 vehicles. From Penhold to Red Deer, the average WAADT traffic count is 6235 vehicles. The average WAADT traffic count from Innisfail to Penhold increased to 110 vehicles. After arriving at Red Deer, the average WAADT traffic count surged from 3680 to 8790 vehicles.

Vehicle types in the Innisfail-Red Deer section are still mainly PV, with a proportion of 94.13% in all types of vehicles. Other vehicles, such as SUT, TTC, BUS, and RV, occupied 2.07%, 2.97%, 0.3%, and 0.57% of all vehicles. Although other vehicles have less than 6% in total proportion, the TTC in Innisfail should be noticed because the proportion reached 6.2%, much higher than other intersections.

The total WAADT from 2019 to 2023, shown in Figure 7, demonstrates that total vehicle counts gradually increase from 2020 to 2023. Although the impact of COVID caused traffic counts to fall by approximately 1770 vehicles from 2019 to 2020, the trend of traffic counts increased in the Innisfail-Red Deer section from 2020 to 2023.

The third one is the Labuma-Lacombe section. The average WAADT traffic counts from 2019 to 2023 are 9307, 8057, 8183, 8070, and 8483 vehicles. This section starts from Labuma, passing through Blackfalds, and arrives at Lacombe. The following WAADT traffic counts will be based on the dataset in 2023. From Labuma to Blackfalds, the average WAADT traffic count is 9365 vehicles. From Blackfalds to Lacombe, the average WAADT traffic count is 7235 vehicles. The average WAADT traffic count from Labuma to Lacombe plunged from 10980 to 7750 vehicles. After arriving at Lacombe, the average WAADT traffic count decreased from 7750 to 6720 vehicles.

Vehicle types in the Labuma-Lacombe section are still mainly PV, with a proportion of 95.23% in all types of vehicles. Other vehicles, such as SUT, TTC, BUS, and RV, occupied 2.2%, 1.77%, 0.27%, and 0.47% of all vehicles. Although other vehicles have less than 5% in total proportion, the TTC in Lacombe should be noticed because the proportion reached 2.6%, higher than other intersections.

The total WAADT from 2019 to 2023, shown in Figure 7, demonstrates that total vehicle counts gradually increase from 2020 to 2023. Although the impact of COVID caused traffic counts to fall by approximately 3750 vehicles from 2019 to 2020, the trend of traffic counts grew in the Labuma-Lacombe section from 2020 to 2023.

The fourth one is the Morningside-Navarre section, the average WAADT traffic counts from 2019 to 2023 are 5834, 4963, 5026, 4919, and 5234 vehicles. This section starts from Morningside, passes through Ponoka, Menaik, and Maskwacis, and arrives at Navarre. The following WAADT traffic counts will be based on the dataset in 2023. From Morningside to Ponoka, the average WAADT traffic count is 5520 vehicles. From Ponoka to Menaik, the average WAADT traffic count is 5130 vehicles. From Menaik to Maskwacis, the average WAADT traffic count is 4585 vehicles. Finally, from Maskwacis to Navarre, the average WAADT traffic count is 5670 vehicles. The average WAADT traffic count slightly decreased from 5520 to 4585 vehicles from Morningside to Maskwacis. After arriving at Navarre, the average WAADT traffic count increased from 4585 to 5670 vehicles.

Vehicle types in the Morningside-Navarre section are still mainly PV, with a proportion of 93.00% in all types of vehicles. Other vehicles, such as SUT, TTC, BUS, and RV, occupied 1.84%, 4.06%, 0.3%, and 0.8% of all vehicles. Although other vehicles have less than 6% in total proportion, the TTC in the intersections between Morningside and Ponoka and Menaik should be noticed because the proportion reached 6.1% and 6.0%, higher than other intersections.

The total WAADT from 2019 to 2023, shown in Figure 7, demonstrates that total vehicle counts gradually increase from 2020 to 2023. Although the impact of COVID caused traffic counts to fall by approximately 6,100 vehicles from 2019 to 2020, the trend of traffic counts gained in the Morningside-Navarre section from 2020 to 2023.

The fifth is the Wetaskiwin-Leduc section; the average WAADT traffic counts from 2019 to 2023 are 8585, 7360, 7288, 7173, and 7458 vehicles. This section starts from Wetaskiwin, passing through Milet, and arrives at Leduc. The following WAADT traffic counts will be based on the dataset in 2023. From Wetaskiwin to Milet, the average WAADT traffic count is 7525 vehicles. From Milet to Leduc, the average WAADT traffic count is 7270 vehicles. The average WAADT traffic count slightly decreased from 8020 to 7030 vehicles from Wetaskiwin to Milet. After arriving at Leduc, the average WAADT traffic count increased from 7030 to 7540 vehicles.

Vehicle types in the Wetaskiwin-Leduc section are still mainly PV, with a proportion of 91.45% in all types of vehicles. Other vehicles, such as SUT, TTC, BUS, and RV, occupied 3.58%, 4.3%, 0.08%, and 0.58% of all vehicles. Although other vehicles have less than 9% in total proportion, the SUT and TTC in the intersections between Milet and Leduc should be noticed because the average proportion of SUT reached 3.83%. TTC reached 4.83%, which is higher than other intersections.

The total WAADT from 2019 to 2023, shown in Figure 7, demonstrates that total vehicle counts gradually increase from 2020 to 2023. Although the impact of COVID caused traffic counts to fall by approximately 4900 vehicles from 2019 to 2020, the trend of traffic counts grew in the Wetaskiwin-Leduc section from 2020 to 2023.

GHG emissions

Highway 2

TRB's Cooperative Research Programs website calculates GHG emissions, applying AADT, vehicle percentage, segment length, and EPA EF to calculate the results. EF for PV and RV uses 0.4 as an emission factor and 0.459 for SUT, BUS, and TTC.

We separated Highway 2 into two routes: from Calgary to Edmonton and Edmonton to Calgary. We aim to analyze the traffic load from Calgary to Edmonton to better understand the traffic load from city to city. Neglecting subsections on Highway 2, we collected AADT data from the Government of Alberta in 2023 to calculate GHG emissions.

Highway 2 from South to North (C-E)

The first route is from Calgary to Edmonton. Starting from the center of Calgary, passing through Calgary International Airport, Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, West Park Extension, the Highway 11 Interchange, the Highway 12 Interchange, The Highway 39 intersection, Leduc, and arrived at Edmonton. Based on the result from Figure 68, Calgary to Calgary International Airport took up most of the traffic load on Highway 2 from Calgary to Edmonton, with 66366 vehicles. Reaching at Balzac, the average traffic counts sharply dropped from 66366 to 41918 vehicles. Until reaching the Highway 11 Interchange, the average traffic counts increased from 15410 to 18303 vehicles. However, the traffic counts fell when passing through the Highway 12 Interchange and The Highway 39 intersection. The average traffic counts began surging when we arrived at Leduc and Edmonton, with 22175 and 34728 vehicles from The Highway 39 intersection to Leduc and from Leduc to Edmonton.

We compared the traffic counts and GHG emissions on Highway 2 from South to North in Figures 16 and 125. Due to several factors in each section, such as segment length, traffic counts, vehicle type percentages, and EF, the GHG emissions will differ from the traffic count pattern. For example, the traffic counts in the Calgary-Calgary International Airport section are the highest in the traffic counts, with 66366 vehicles in this section. However, the segment length based on locations in Figure 127 showed that the Calgary-Calgary International Airport section only has 7.96 miles. The vehicle types are mainly PV (93.7%) in Figure 18, meaning the EF will multiply to 0.4. After the computation for the GHG emissions, this section was placed third among all the sections. On the contrary, the traffic counts in Airdrie-Bowden only had 17080 vehicles on Highway 2 in 2023. Nevertheless, the segment length in the Airdrie-Bowden section was 53.8 miles. The vehicle types occupied with PV (83.53%) and TTC (11.79%). Due to the difference in EF between gasoline and diesel vehicles, PV will multiply to 0.4, and TTC will multiply to 0.459. As a result, the section produced the most significant GHG emissions within all sections.

Based on the result from Figure 125, we noticed that GHG emissions sections from Calgary to Edmonton should be reckoned with the following arrangement:

- Airdrie-Bowden
- The Highway 11 Interchange - the Highway 12 Interchange
- Calgary-Calgary International Airport
- Leduc-Edmonton
- Calgary International Airport-Balzac
- Innisfail-the Highway 11 Interchange
- The Highway 12 Interchange-The Highway 39 intersection
- Bowden-Innisfail
- Balzac-Airdrie
- The Highway 39 intersection-Leduc

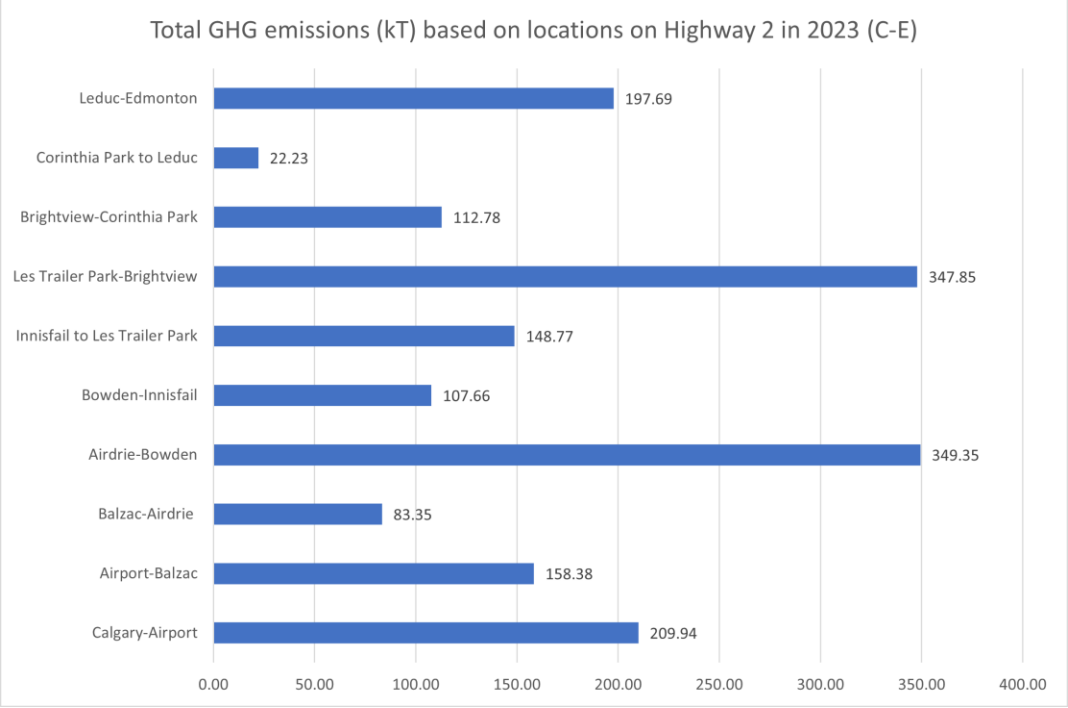


Figure 125: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (C-E)

Highway 2 from North to South (E-C)

The second route runs from Edmonton to Calgary, beginning at the center of Edmonton and passing through Leduc, the Highway 39 intersection, the Highway 12 Interchange, the Highway 11 Interchange, Innisfail, Bowden, Airdrie, Balzac, Calgary International Airport, and ending in Calgary. According to Figure 51, the Edmonton-Leduc segment recorded an average traffic count of 32578 vehicles, as per the WAADT dataset. Upon reaching the Leduc-The Highway 39 intersection segment, the average traffic count dropped to 16380 vehicles. From The Highway 39 intersection to the Highway 12 Interchange, and through the Highway 12 Interchange, the Highway 11 Interchange, Innisfail, Bowden, and Airdrie, the average traffic count remained relatively stable at around 15974 vehicles. However, upon reaching Balzac, the

count surged to 38,290 vehicles, increasing to 43243 at Calgary International Airport and finally spiking to 69931 vehicles upon entering Calgary.

It is the same as the GHG emissions on Highway 2 from North to South, as shown in Figures 51 and 126. The GHG emission pattern includes several factors and does not mirror the traffic counts. For instance, the Highway 12 Interchange-the Highway 11 Interchange produced the second-highest GHG emissions, as shown in Figure 126. This section won first place in the segment length in Figure 127. The vehicle types are mainly PV (80.59%) and TTC (14.88%), with PV multiple EF with a value of 0.4 and TTC multiple EF with a value of 0.459. Compared with the Balzac-Calgary International Airport section, even though the vehicle counts placed third in the section, with 43243 vehicles, vehicle types, with PV (91.1%) and TTC (5.48%), and the segment length stroke GHG emissions a lot, with only 6.06 miles in this section. As a result, the Highway 12 Interchange-the Highway 11 Interchange has higher GHG emissions than the Balzac-Calgary International Airport section.

As shown in Figure 126, we recommend the following priority for addressing GHG emissions between Calgary and Edmonton:

- Bowden-Airdrie
- The Highway 12 Interchange-The Highway 11 Interchange
- Edmonton-Leduc
- Balzac-Calgary International Airport
- The Highway 11 Interchange-Innisfail
- The Highway 39 intersection-the Highway 12 Interchange
- Innisfail-Bowden
- Airdrie-Balzac
- Leduc-The Highway 39 intersection

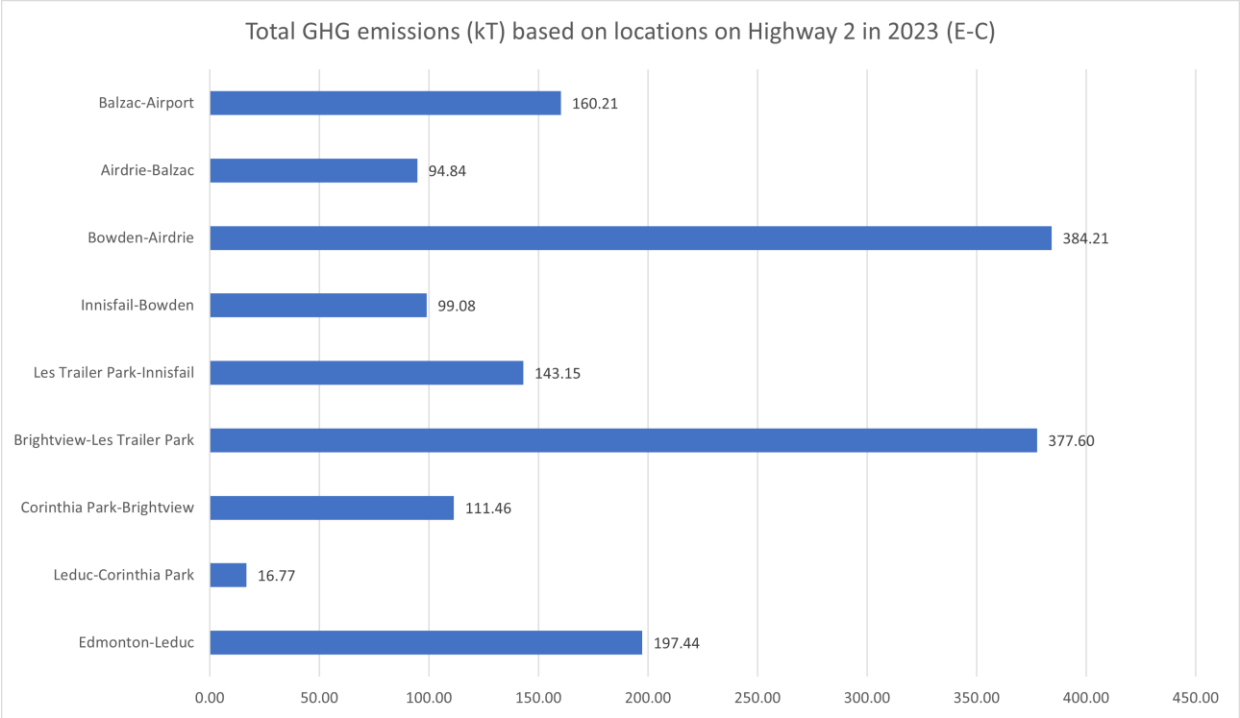


Figure 126: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (E-C)

Figure 127: Segment Length (miles) on Highway 2 based on locations

Highway 2A

For the Highway 2A, we separated to five routes and two directions for GHG emissions analyzation: Crossfield-Bowden, Innisfail-Red Deer, Labuma-Lacombe, Morningside-Wetaskiwin, and Wetaskiwin-Leduc. Each section applied AADT datasets which followed the direction on Highway 2A.

Highway 2A from South to North (C-E)

For the GHG emissions on Highway 2A from South to North, GHG emissions of each section has similar pattern from 2019 to 2023. Starting from the highest value in 2019, plunging in 2020, fluctuating between 2020 to 2022, and rising in 2023.

Crossfield-Bowden Section

In the Crossfield-Bowden section, Olds City produced the most numerous GHG emissions in this intersection, followed by Didsbury, Crossfield, Carstairs, and Bowden, as shown in Figure 128. Specifically, the Olds has the highest segment length and third place in traffic counts in all intersections, as shown in Figures 129 and 130. Since the main vehicle type was PV (91.38%), the EF will be occupied at 91.38%, multiplying by 0.4. The possibility of producing the most influential GHG emissions increases a lot with high values of variables such as segment length and traffic counts. For the Didsbury, it is second in GHG emissions, placing third in segment length and fifth in traffic counts. It was shocking that this intersection created such a high volume of GHG emissions. On the contrary, an intersection between Olds and Bowden produced the least GHG emissions in the Crossfield-Bowden section, placing the second but one in segment length and the third in traffic counts. Even though the EF included 89.6% multiplied by 0.4 and 10.4% multiplied by 0.459, the GHG emissions are still the lowest in this section. As a result, segment length and traffic counts expanded the differences in GHG emissions at each intersection.

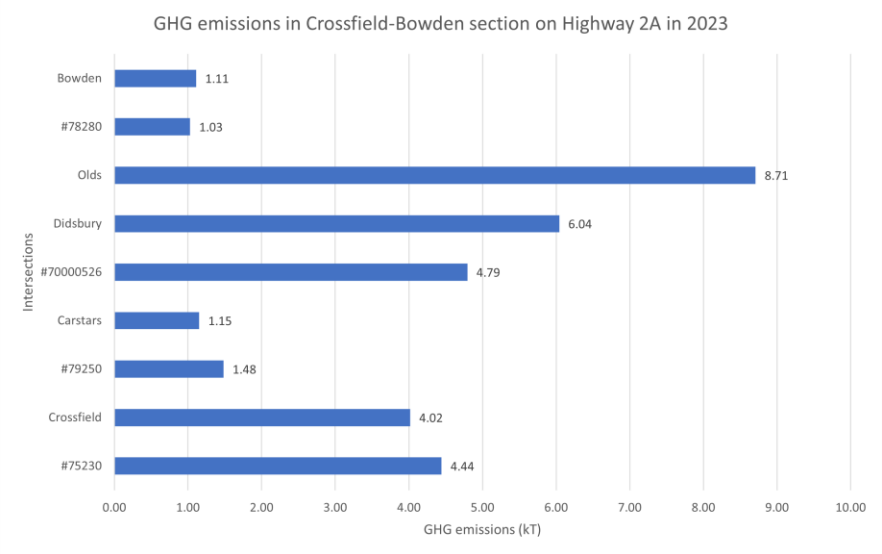


Figure 128: GHG emissions in Crossfield-Bowden section on Highway 2A in 2023

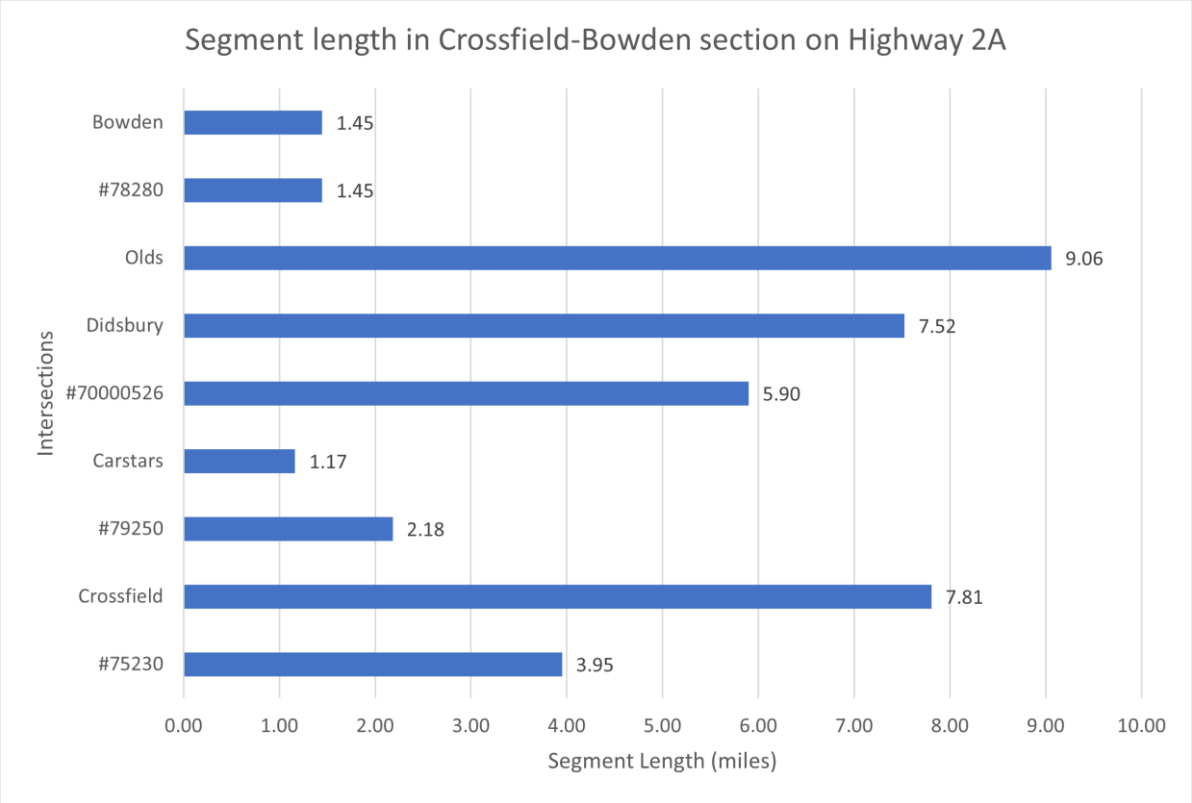


Figure 129: Segment length in Crossfield-Bowden section on Highway 2A

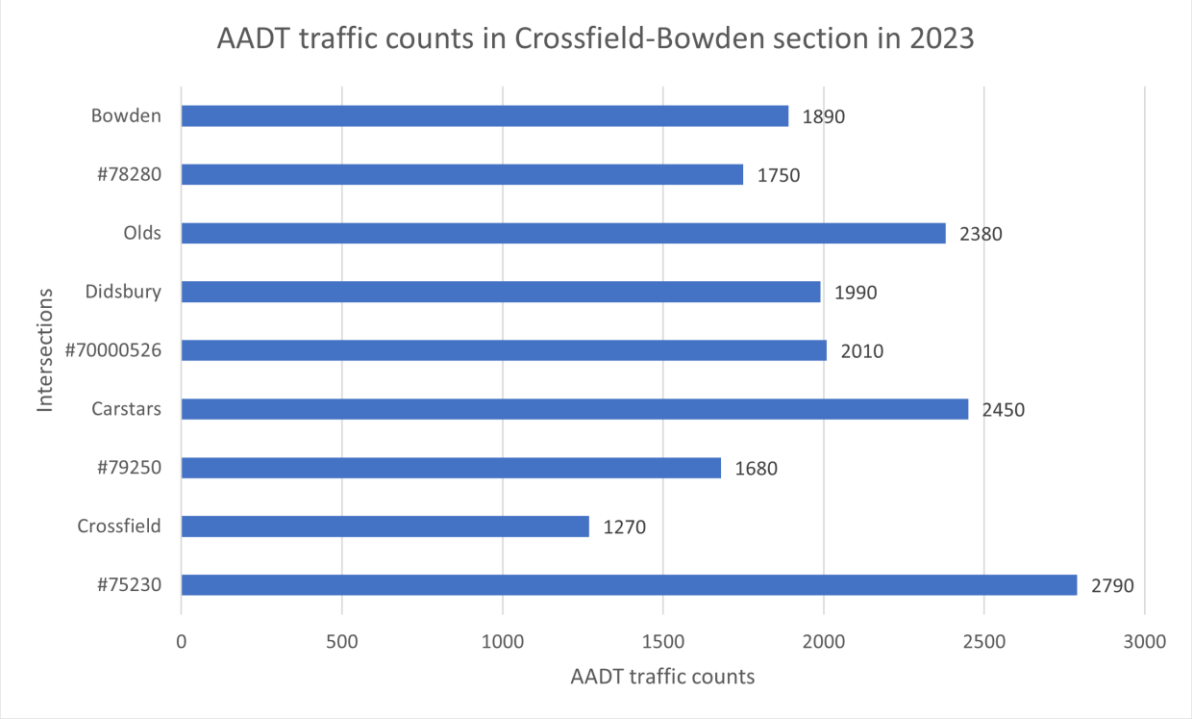


Figure 130: AADT traffic counts in Crossfield-Bowden section on Highway 2A in 2023

Innisfail-Red Deer Section

In the Innisfail-Red Deer section, Innisfail City produced the most numerous GHG emissions in this intersection, followed by Red Deer, and Penhold, as shown in Figure 131. Specifically, the Innisfail has the highest segment length and third place in traffic counts in all intersections, as shown in Figures 132 and 133. Since the main vehicle type was PV (94.65%), the EF will be occupied at 94.65%, multiplying by 0.4. The possibility of producing the most influential GHG emissions increases a lot with high values of variables such as segment length and traffic counts. For the Red Deer, it is second in GHG emissions, placing third in segment length and first in traffic counts. It was shocking that this intersection created such a high volume of GHG emissions. On the contrary, Penhold produced the least GHG emissions in the Innisfail-Red Deer section, placing the second in segment length and traffic counts. Even though the EF included 95.5% multiplied by 0.4 and 4.4% multiplied by 0.459, the GHG emissions are still the lowest in this section. As a result, segment length and traffic counts expanded the differences in GHG emissions at each intersection.

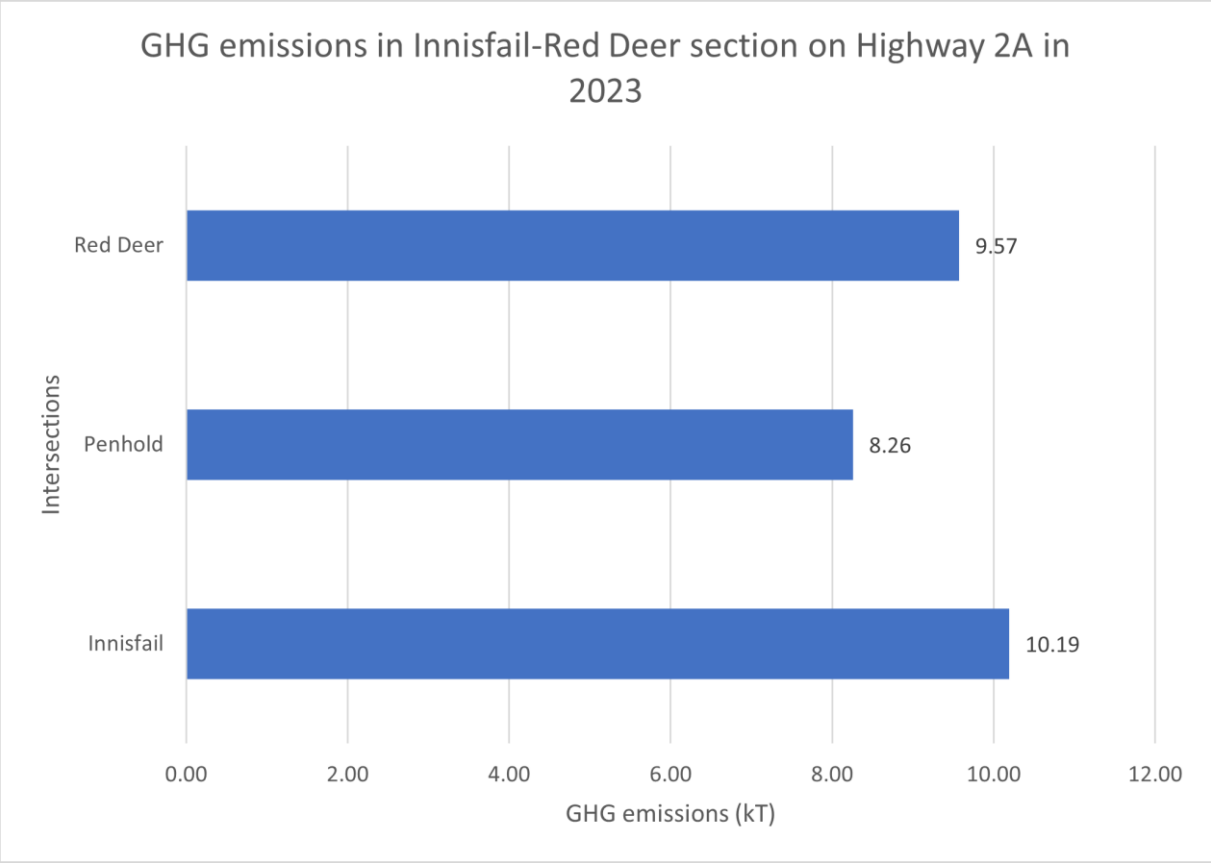


Figure 131: GHG emissions in Innisfail-Red Deer section on Highway 2A in 2023

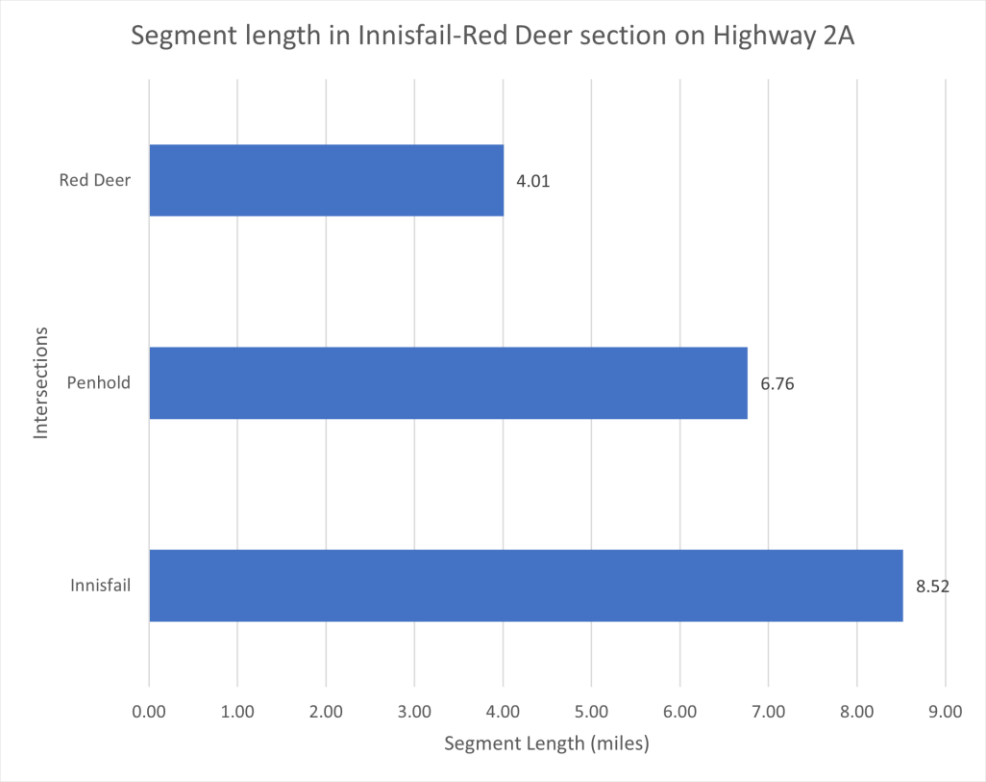


Figure 132: Segment length in Innisfail-Red Deer section on Highway 2A

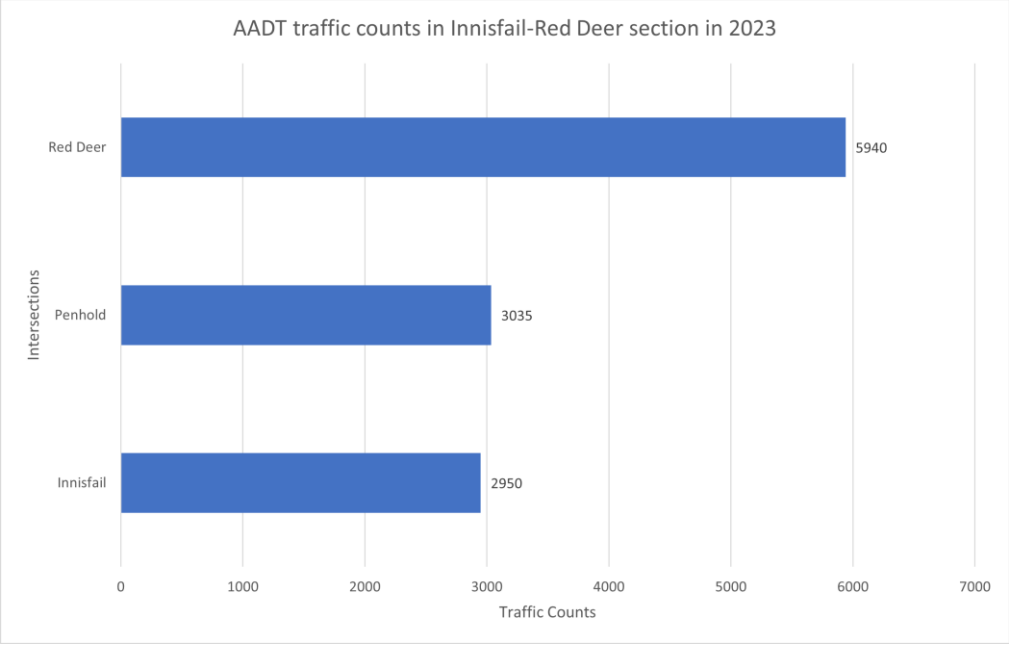


Figure 133: AADT traffic counts in Innisfail-Red Deer section in 2023

Labuma-Lacombe Section

In the Labuma-Lacombe section, several recorders are placed in the same segment. As a result, we selected the first and the end recorders, calculating the average value for each intersection and then counting the GHG emissions for this route. The result, as shown in Figure 134, is that the GHG emissions in Blackfalds produced twice as much as the intersection #70000004. Specifically, the segment length at intersection #70000004 was the same as that of Blackfalds. Traffic counts were the main reason Blackfalds produced more GHG emissions than intersection #70000004, with 6900 vehicles at Blackfalds and 3240 vehicles at intersection #70000004. The percentage of vehicle types didn't affect the result a lot. PV occupied the most significant percentage of all vehicle types. Consequently, the Blackfalds occupied the most substantial GHG emissions in the Labuma-Lacombe section.

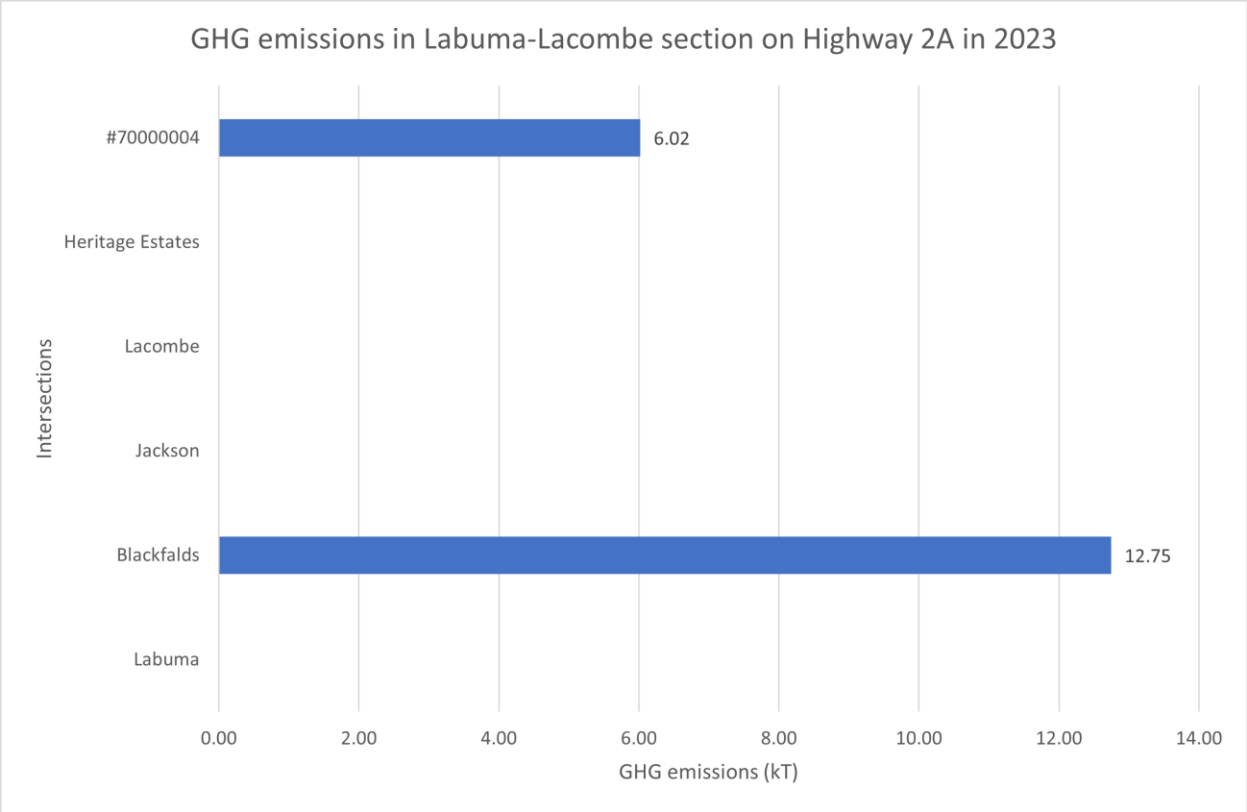


Figure 134: GHG emissions in Labuma-Lacombe section on Highway 2A in 2023

Morningside-Wetaskiwin Section

In the Morningside-Wetaskiwin section, several recorders are placed in the same segment. As a result, we selected the first and the end recorders, calculating the average value for each intersection and then counting the GHG emissions for this route. The result, as shown in Figure 135, is that the GHG emissions in Ponoka produced the highest GHG emissions within all intersections, with 22.15 kT GHG emissions in this area. Ponoka's segment length and traffic counts were also the highest in all intersections. The Wetaskiwin and Morningside had significant segment length and traffic counts, approximately 7 miles and 2520 vehicles on both intersections. The total GHG emissions in both intersections were 14.66 kT. For Maskwacis and the intersection at # 92360. Although Maskwacis has the second highest traffic counts, the segment length was only 2.15 miles in this intersection. As with the intersection at #92360, traffic counts are placed fourth in all intersections. However, the segment length was 2.05 in # 92360 intersection. As a result, Ponoka predominated in the Morningside-Wetaskiwin section. Wetaskiwin and Morningside placed second and third in producing GHG emissions.

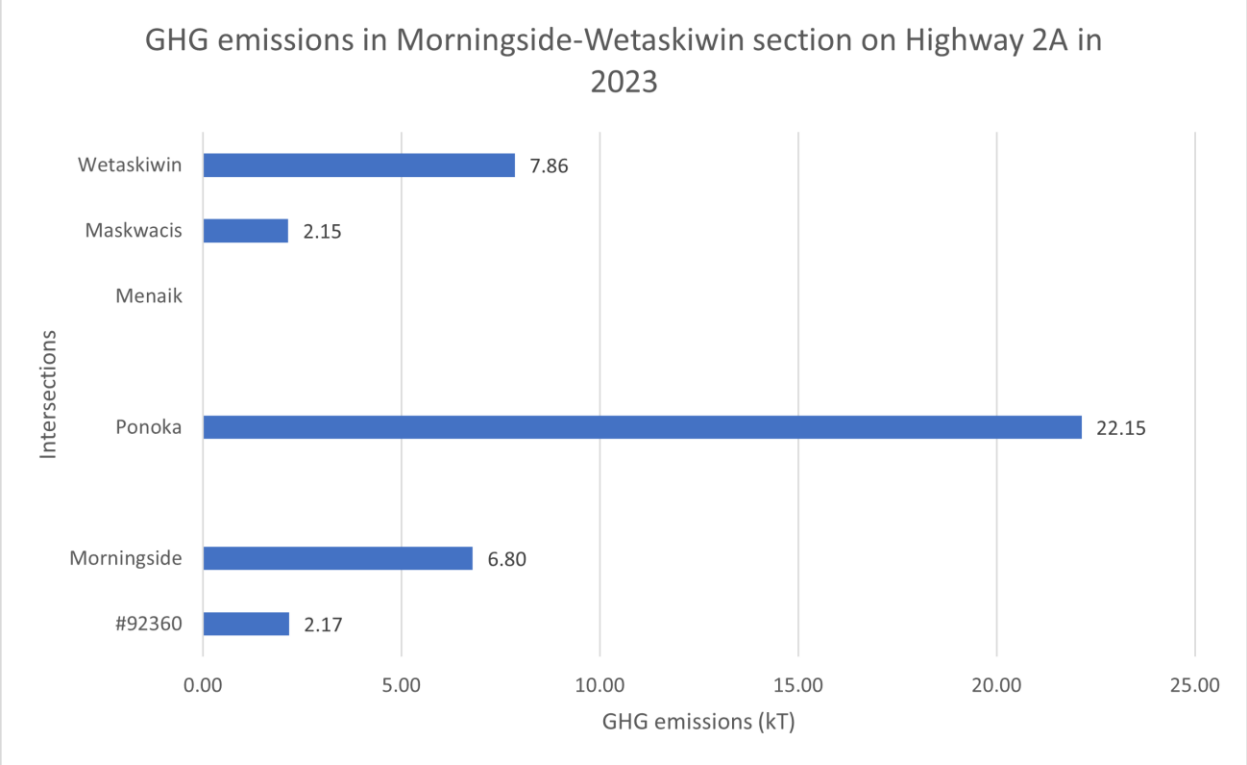


Figure 135: GHG emissions in Morningside-Wetaskiwin section on Highway 2A in 2023

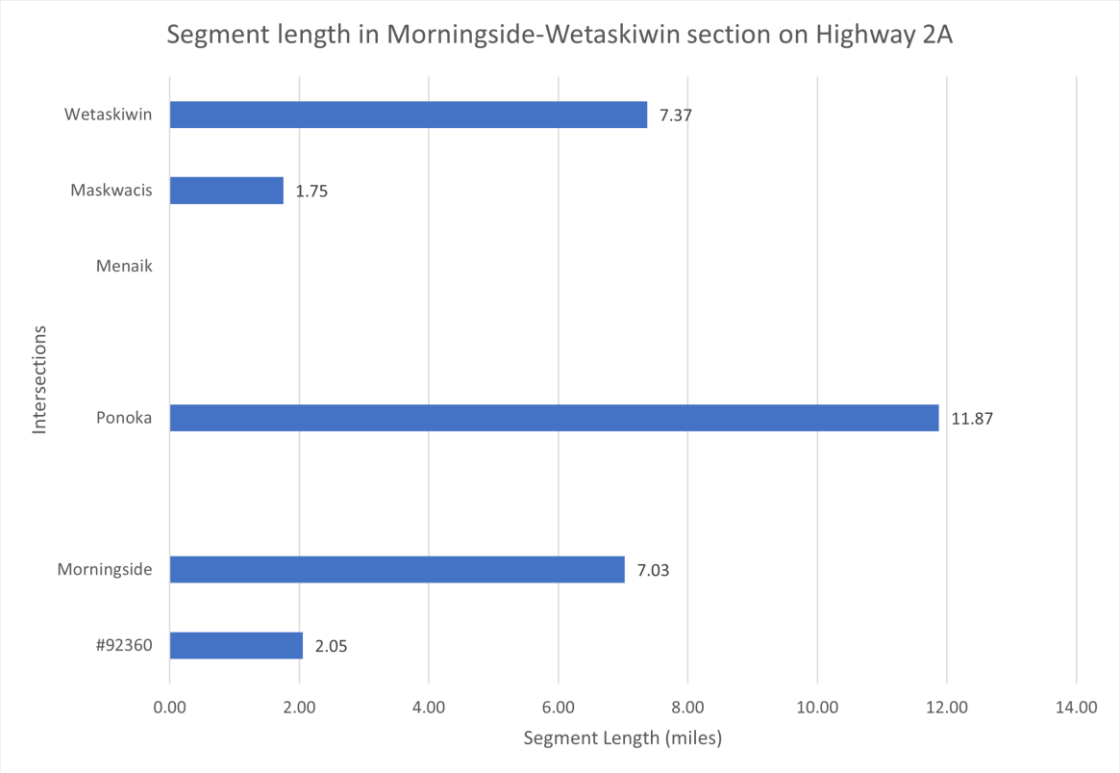


Figure 136: Segment length in Morningside-Wetaskiwin section on Highway 2A

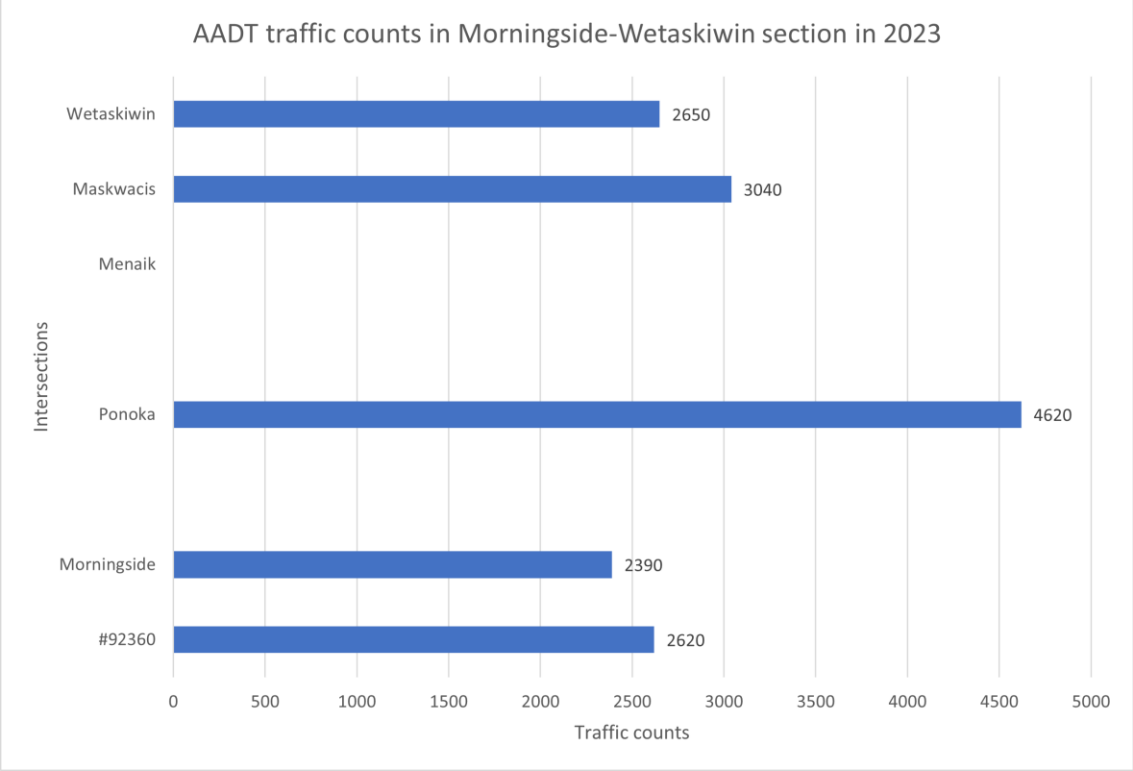


Figure 137: AADT traffic counts in Morningside-Wetaskiwin section in 2023

Wetaskiwin-Leduc Section

In the Wetaskiwin-Leduc section, Leduc City produced the most numerous GHG emissions in this intersection, followed by Wetaskiwin, Milet, and the intersection between Milet and Leduc, as shown in Figure 138. Specifically, the Leduc has the second-highest segment length and first place in traffic counts in all intersections, as shown in Figures 139 and 140. From the chart of vehicle types in the Sep 23-29_Highway 2A (Calgary to Edmonton) dataset, EF with 0.4 multiplied to 90.2% includes PV and RV percentages, and 0.459 multiplied by 9.8% including SUT, TTC, and BUS percentages. Although the vehicle type percentages in other intersections did not change much, the traffic counts in Leduc pushed the GHG emissions farther than other intersections, with 19570 vehicle counts in 2023. Compared to Wetaskiwin, with 7.91 segment length and 3690 vehicle counts in 2023, though the segment length at Wetaskiwin was twice as high as Leduc, the vehicle counts in Leduc were fifth higher than Wetaskiwin. As a result, Leduc predominated the GHG emissions, and Wetaskiwin placed second highest in the Wetaskiwin-Leduc section.

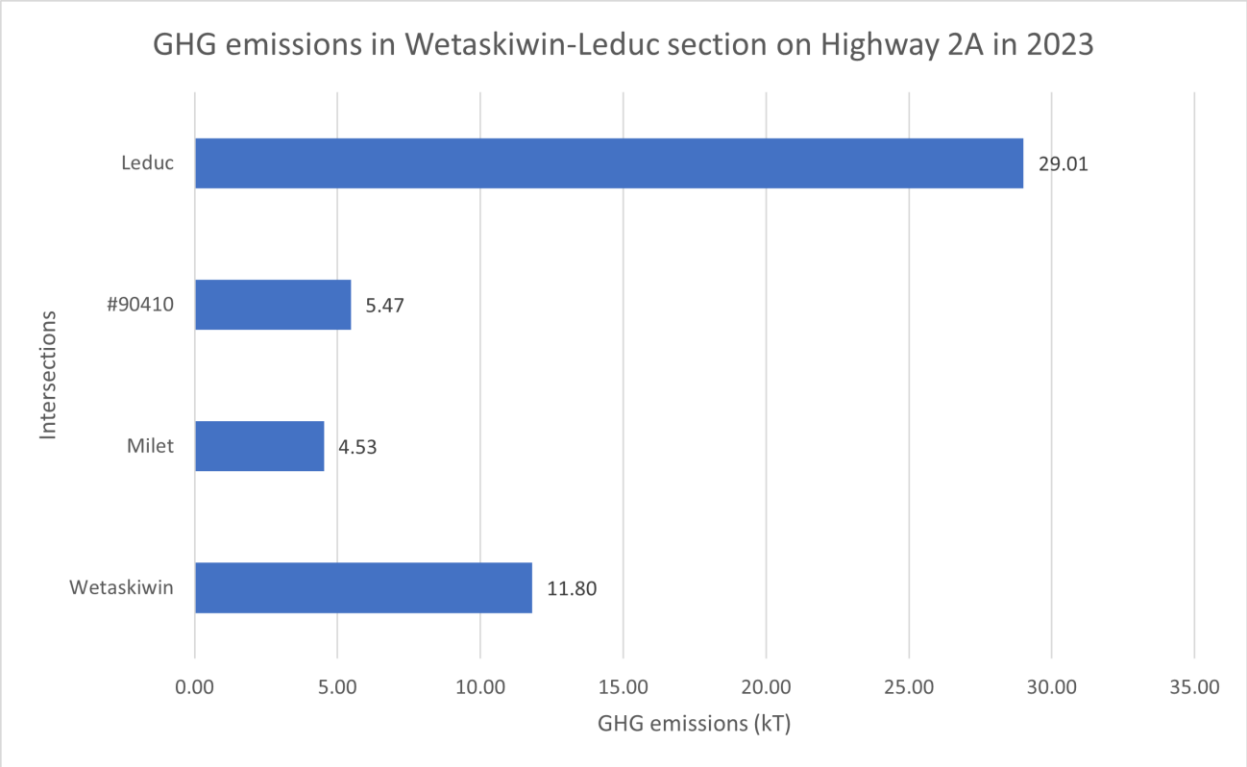


Figure 138: GHG emissions in Wetaskiwin-Leduc section on Highway 2A in 2023

Figure 139: Segment length in Wetaskiwin-Leduc section on Highway 2A

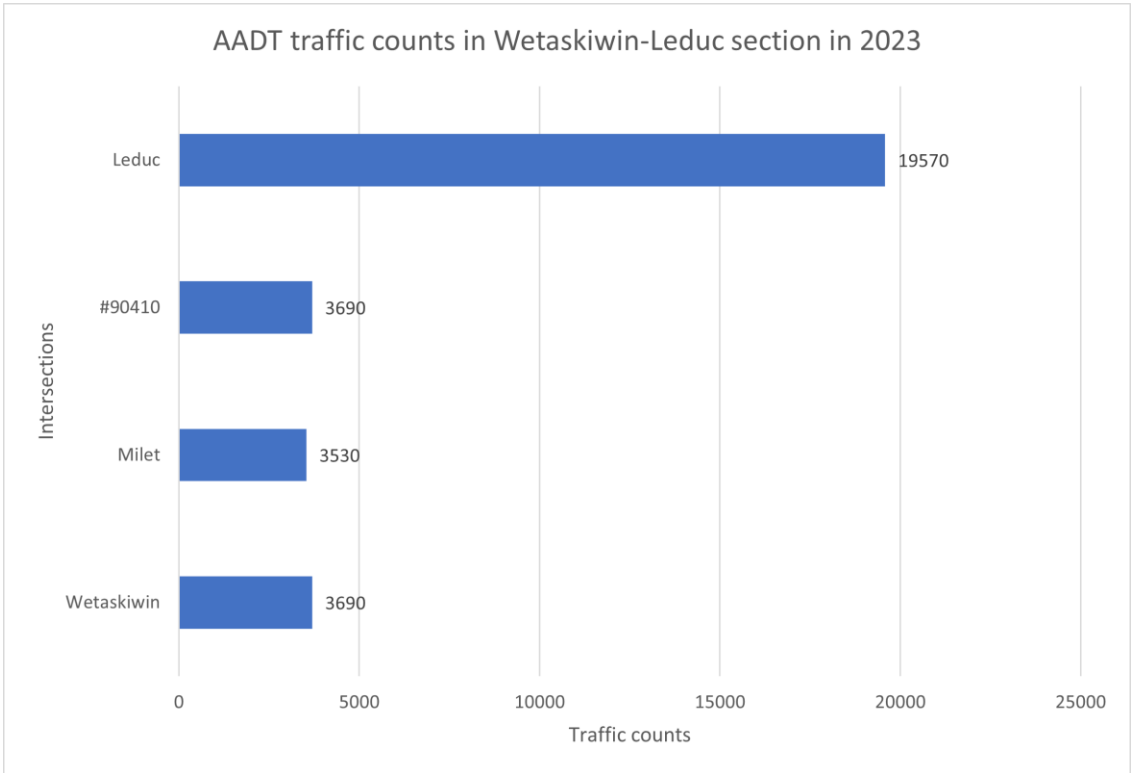


Figure 140: AADT traffic counts in Wetaskiwin-Leduc section in 2023

Highway 2A from North to South (E-C)

Leduc-Wetaskiwin Section

In the Leduc-Wetaskiwin section, Leduc produced the highest GHG emissions, followed by Wetaskiwin, intersection #90410, and Milet on Highway 2A from North to South. The GHG emissions at Leduc were almost twice as high as those at Wetaskiwin. We compared the vehicle types, segment length, and traffic counts to analyze the critical reasons for the GHG emissions. From the perspective of vehicle types, all intersections slightly differed on each type. Based on the datasets in Sep 23-29_Highway 2A (Edmonton to Calgary), PV occupied up to 90% within all vehicle types, 9% of SUT and TTC, and 2% of BUS and RV. From the perspective of traffic counts 2023 in Figure 142, Leduc dominated all intersections and was five times higher than the other three intersections, head and shoulder above other intersections in the Leduc-Wetaskiwin section. From the perspective of segment length in Figure 139, Wetaskiwin was the longest intersection, followed by Leduc, intersection #90410, and finally, Milet. The segment length at Wetaskiwin was twice as long as Leduc. Leduc, intersection #90410, and Milet had little difference in segment length. As a result, Leduc had such an influence on GHG emissions due to the large vehicle counts. Even though the segment length wasn't the top in all intersections, the GHG emissions still greatly outdistanced other intersections.

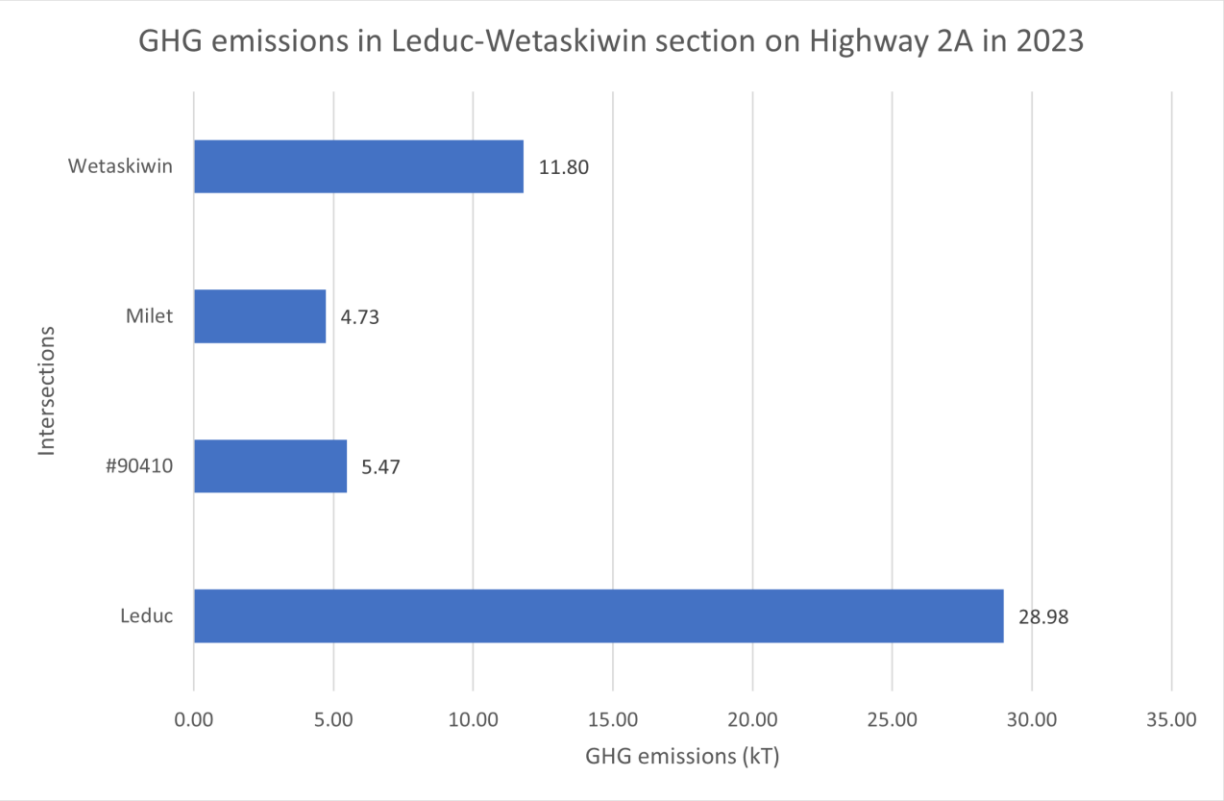


Figure 141: GHG emissions in Leduc-Wetaskiwin section on Highway 2A in 2023

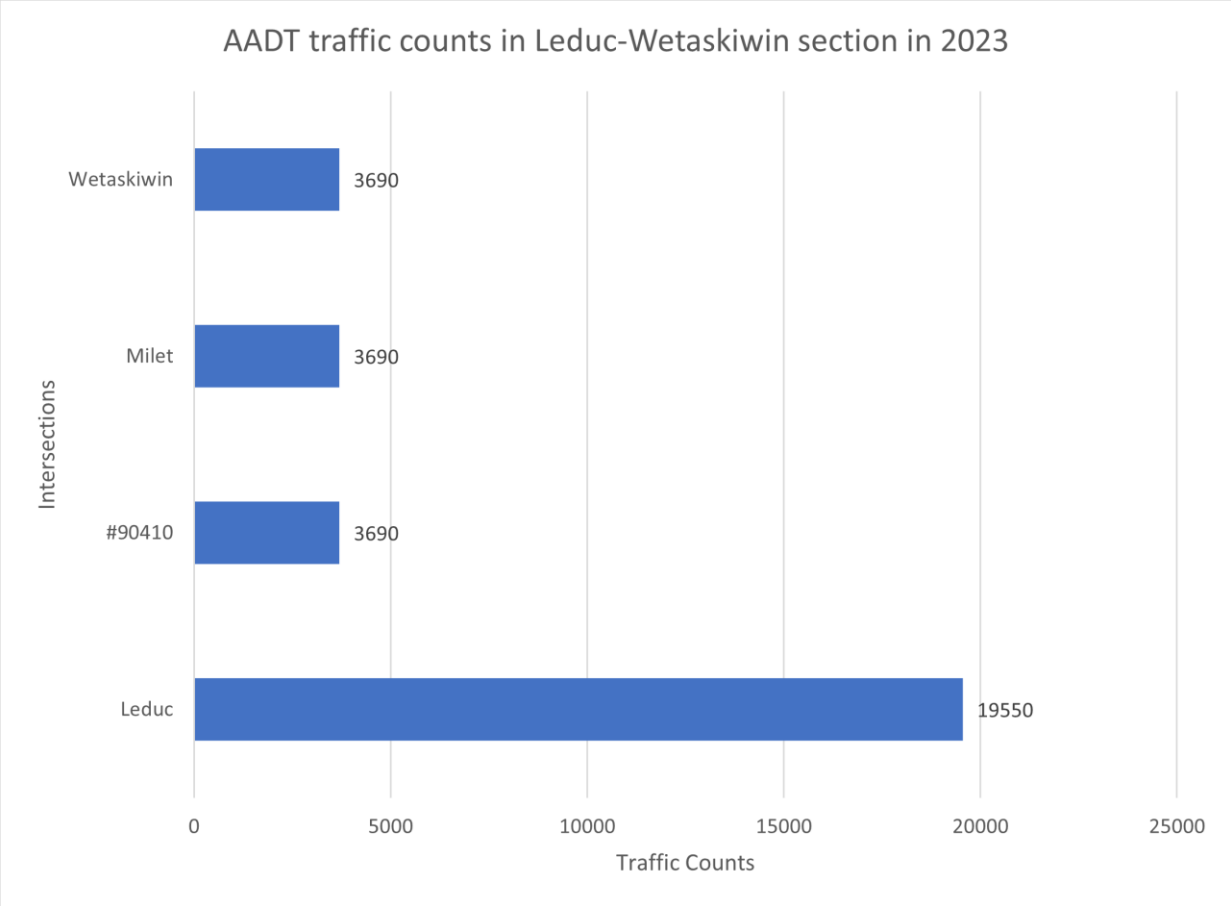


Figure 142: AADT traffic counts in Leduc-Wetaskiwin section in 2023

Wetaskiwin-Morningside Section

Ponoka recorded the highest GHG emissions in the Wetaskiwin-Morning section, followed by Wetaskiwin, Morningside, Maskwacis, and intersection #92360 on Highway 2A, from North to South. The GHG emissions at Ponoka were nearly three times higher than those at Wetaskiwin. We examined vehicle types, segment lengths, and traffic counts using data from September 23-29 along Highway 2A (Edmonton to Calgary) to analyze the key factors behind this.

Morningside had the highest proportion of SUT and TTC, totaling 8.2% at the intersection. Other intersections ranged from 3.2% to 5.8%. PV made up the majority of traffic at 93.3% across all intersections.

Regarding traffic counts (as shown in Figure 144), Ponoka had the highest volume, nearly double that of intersection #92360 and Morningside. However, the traffic counts across all intersections were relatively uniformly distributed, ranging from 2,400 to 4,500 vehicles.

Figure 136 shows the segment lengths, where Ponoka had the longest stretch at 4.5 miles, followed by Wetaskiwin and Morningside, which had similar lengths. In contrast, intersection #92360 and Maskwacis had much shorter segments at 1.75 and 2.1 miles, respectively.

Ultimately, Ponoka's elevated GHG emissions can be attributed to its higher traffic volume and the most extended segment length.

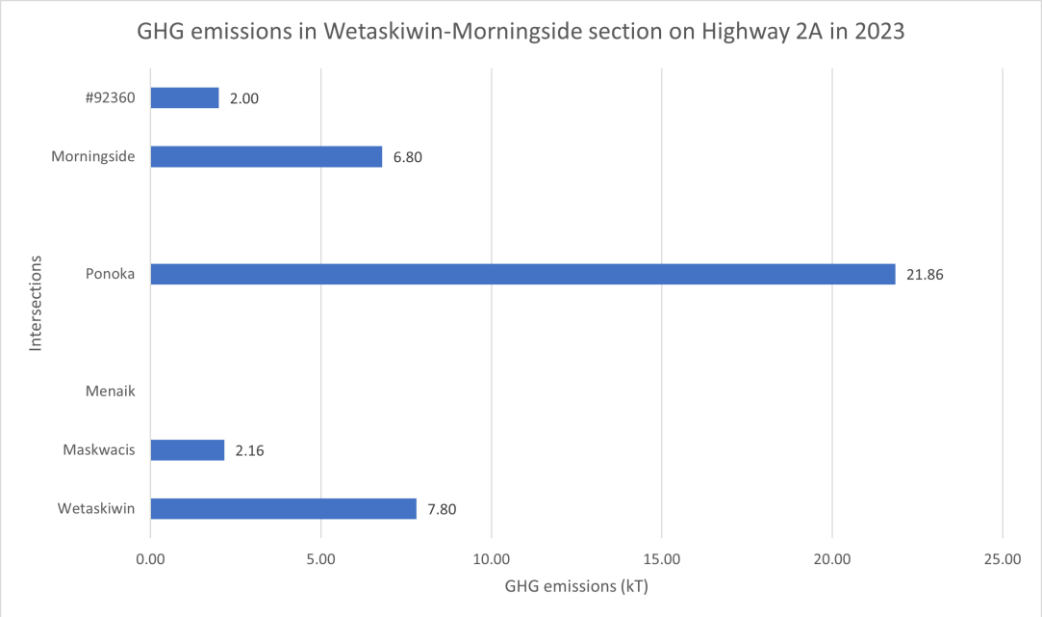


Figure 143: GHG emissions in Wetaskiwin-Morningside section on Highway 2A in 2023

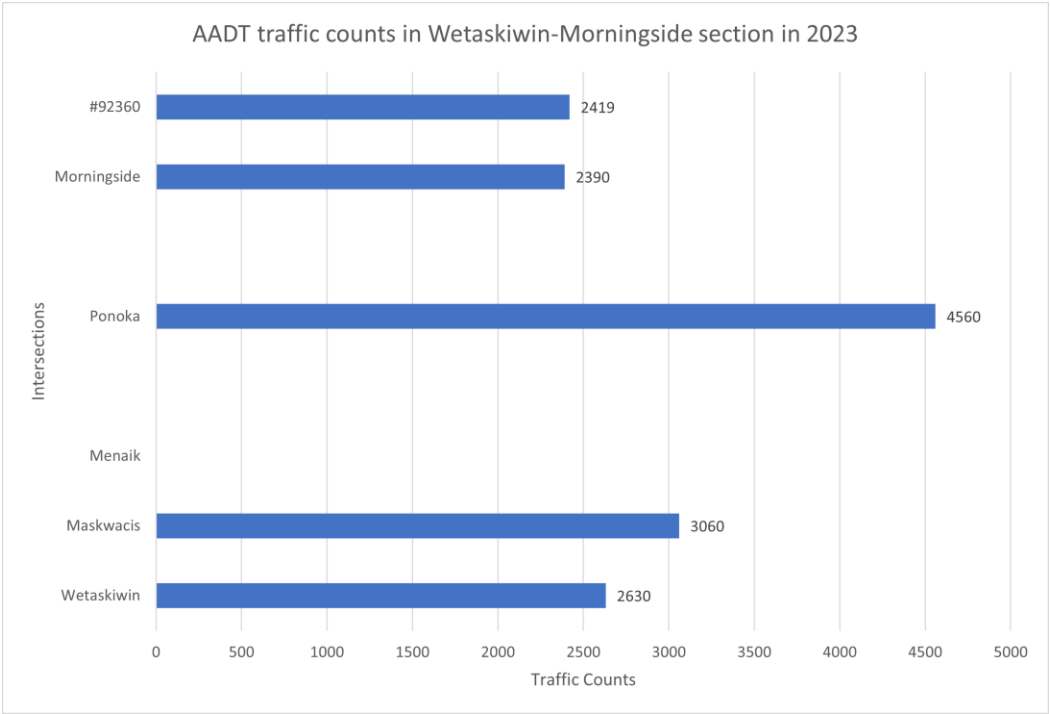


Figure 144: AADT traffic counts in Wetaskiwin-Morningside section in 2023

Lacombe-Labuma Section

In the Lacombe-Labuma section, Blackfalds generated twice the GHG emissions compared to intersection #70000004 on Highway 2A, heading from North to South, as shown in Figure 145. To assess emissions in the Lacombe-Labuma section, we selected the first and last traffic recorders along the route. We analyzed vehicle types, segment length, and traffic counts to identify the key factors contributing to GHG emissions.

The intersections showed only minor differences regarding vehicle types. According to data from September 23-29 along Highway 2A (Edmonton to Calgary), PV accounted for 93.7% and 96.8% of all vehicles, with 5.1% and 2.5% for SUT and TTC, 0.5% and 0.2% for BUS, and 0.7% and 0.4% for RV at Blackfalds and intersection #70000004, respectively.

Regarding traffic counts (as shown in Figure 146), Blackfalds saw an increase of 3,100 vehicles compared to intersection #70000004 within the Lacombe-Labuma section. The total route was divided in half, with both intersections spanning 4.6 miles each.

Despite a higher proportion of diesel vehicles at intersection #70000004, Blackfalds's significantly larger vehicle count led to considerably higher GHG emissions.

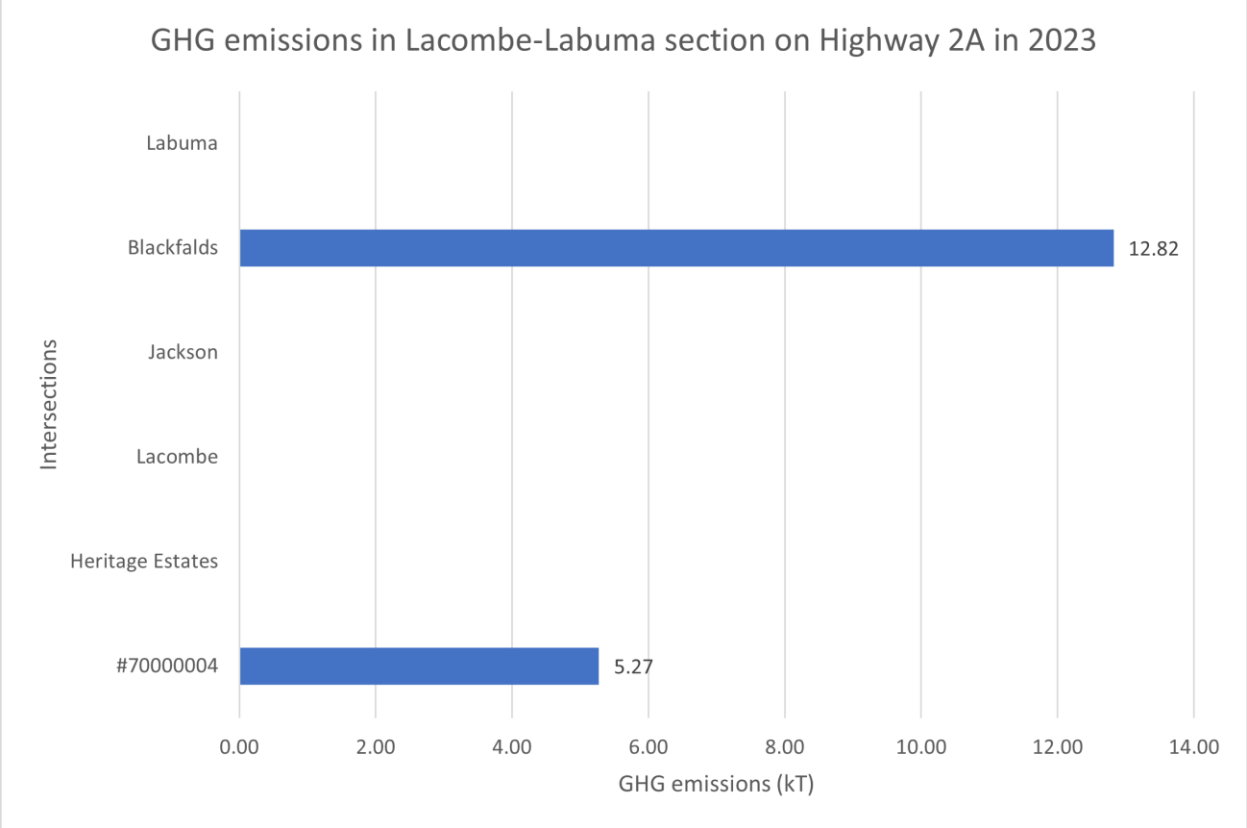


Figure 145: GHG emissions in Lacombe-Labuma section on Highway 2A in 2023

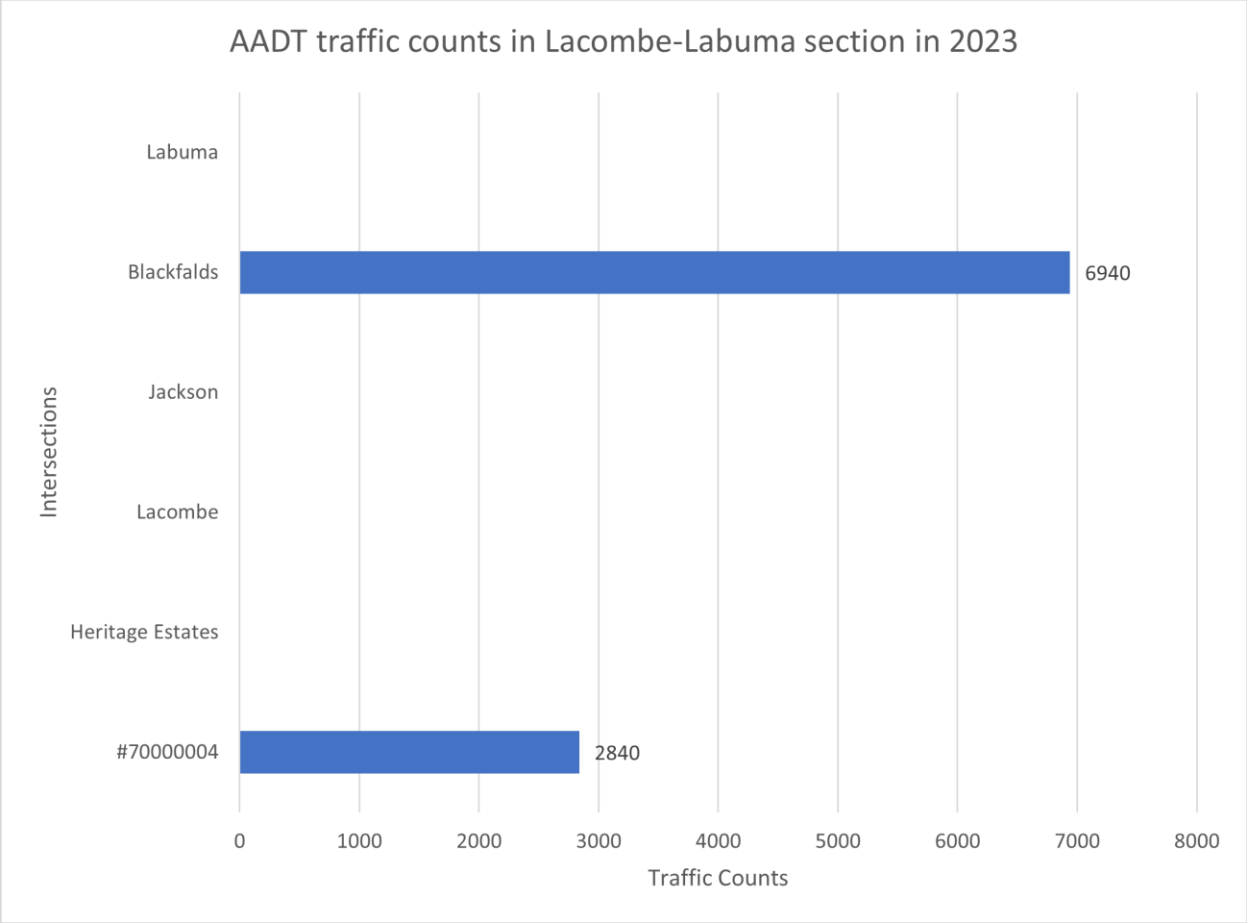


Figure 146: AADT traffic counts in Lacombe-Labuma section in 2023

Red Deer-Innisfail Section

In the Red Deer-Innisfail section, Innisfail and Red Deer produced twice the GHG emissions compared to Penhold on Highway 2A, heading from north to south, as illustrated in Figure 147. To evaluate emissions in this section, we examined vehicle types, segment length, and traffic counts to identify the main factors contributing to GHG emissions.

The vehicle types at Red Deer and Penhold were quite similar, with Innisfail showing a higher proportion of diesel vehicles. According to data from September 23-29 along Highway 2A (Edmonton to Calgary), vehicle types at Red Deer and Penhold had identical percentages, while Innisfail recorded 90% for PV, 9.4% for TTC, SUT, and BUS, and 0.6% for RV. In comparison, Red Deer and Penhold had 6.6% more gasoline vehicles than Innisfail, but Innisfail had 6.5% more diesel vehicles, resulting in more significant GHG emissions from Innisfail due to the vehicle types and emissions factors.

Regarding traffic counts (Figure 148), Red Deer had 2,900 more vehicles than Innisfail and Penhold combined. In segment length, as shown in Figure 132, Innisfail was the longest at 8.52 miles, followed by Penhold at 6.76 miles and Red Deer at 4.01 miles. Consequently, Innisfail significantly impacted GHG emissions in the Red Deer-Innisfail section.

Despite Red Deer having higher traffic counts, Innisfail's greater segment length and higher proportion of diesel vehicles resulted in significantly higher GHG emissions.

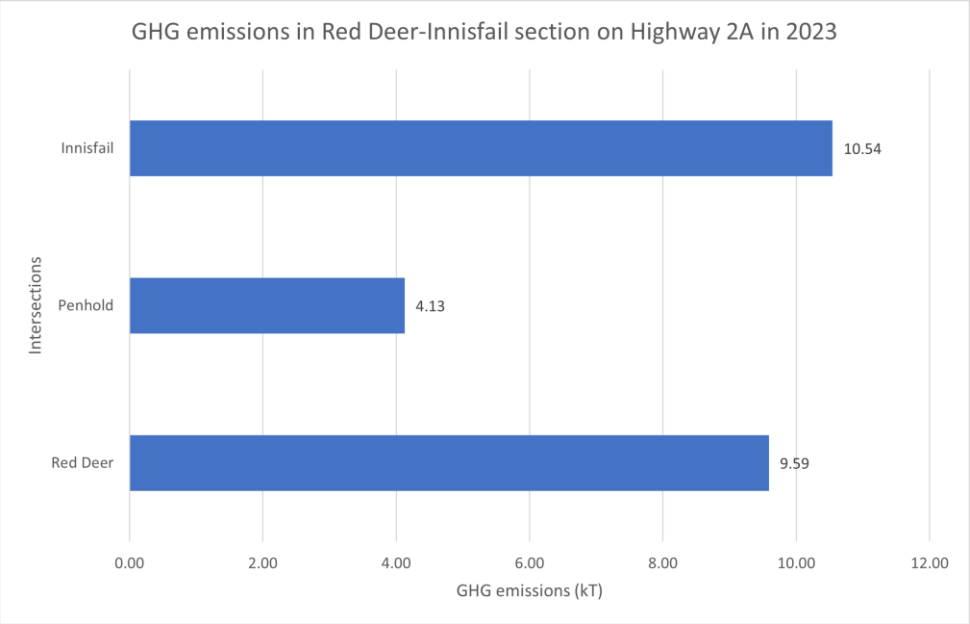


Figure 147: GHG emissions in Red Deer-Innisfail section on Highway 2A in 2023

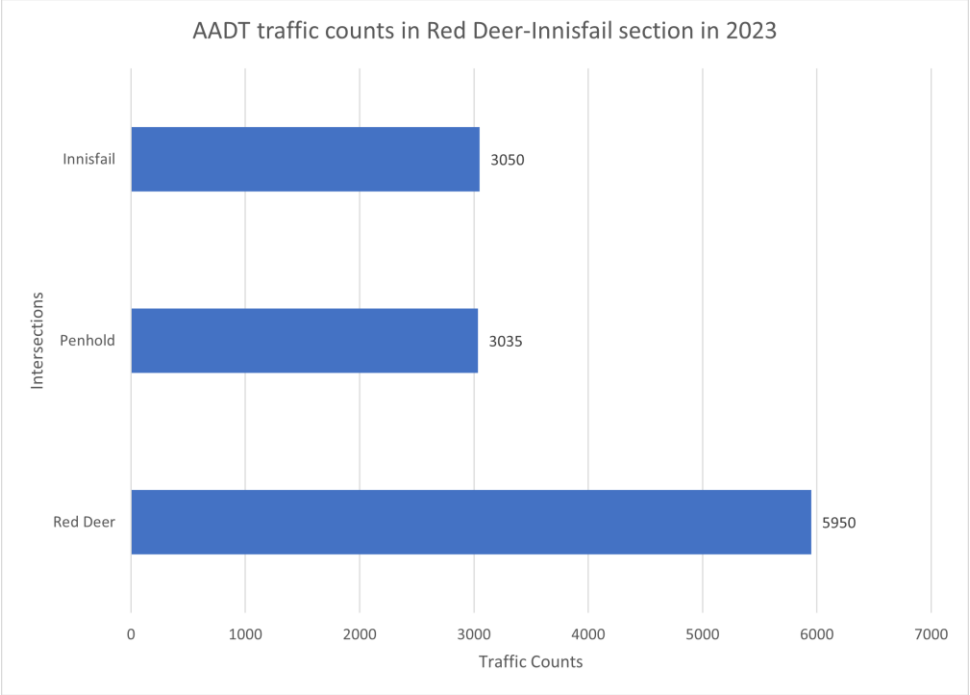


Figure 148: AADT traffic counts in Red Deer-Innisfail section in 2023

Bowden-Crossfield Section

In the Bowden-Crossfield section, Olds recorded the highest GHG emissions among all intersections on Highway 2A, heading from north to south, as shown in Figure 149. We analyzed vehicle types, segment length, and traffic counts to assess emissions in this section and determine the key factors influencing GHG emissions.

The vehicle types across all intersections were quite similar. According to data from September 23-29 along Highway 2A (Edmonton to Calgary), the average distribution of vehicle types was 91.38% for PV, 7.57% for TTC, SUT, and BUS, and 1.06% for RV. Bowden and intersection #78280 had the highest percentages of diesel vehicles compared to other intersections, while Olds showed only slight differences in vehicle type distribution except when compared to Bowden and intersection #78280.

In terms of traffic counts (Figure 150), intersection #75230 had the highest traffic volume in the Bowden-Crossfield section, followed by Carstairs, Olds, Didsbury, intersection #70000526, intersection #79250, Crossfield, Bowden, and lastly, intersection #78280. Based on the AADT dataset, the traffic counts ranged from 810 to 2,790 vehicles, presenting a relatively average comparison to the Leduc-Wetaskiwin section.

Regarding segment length (Figure 129), Olds had the most extended segment among all intersections, followed by Crossfield, Didsbury, intersection #70000526, intersection #75230, intersection #79250, Bowden, intersection #78280, and Carstairs.

While intersection #75230 had the highest traffic count, Olds' longer segment length had a more significant impact on GHG emissions. As a result, Olds generated the highest GHG emissions in the Bowden-Crossfield section due to its extended segment length combined with sufficient traffic volumes.

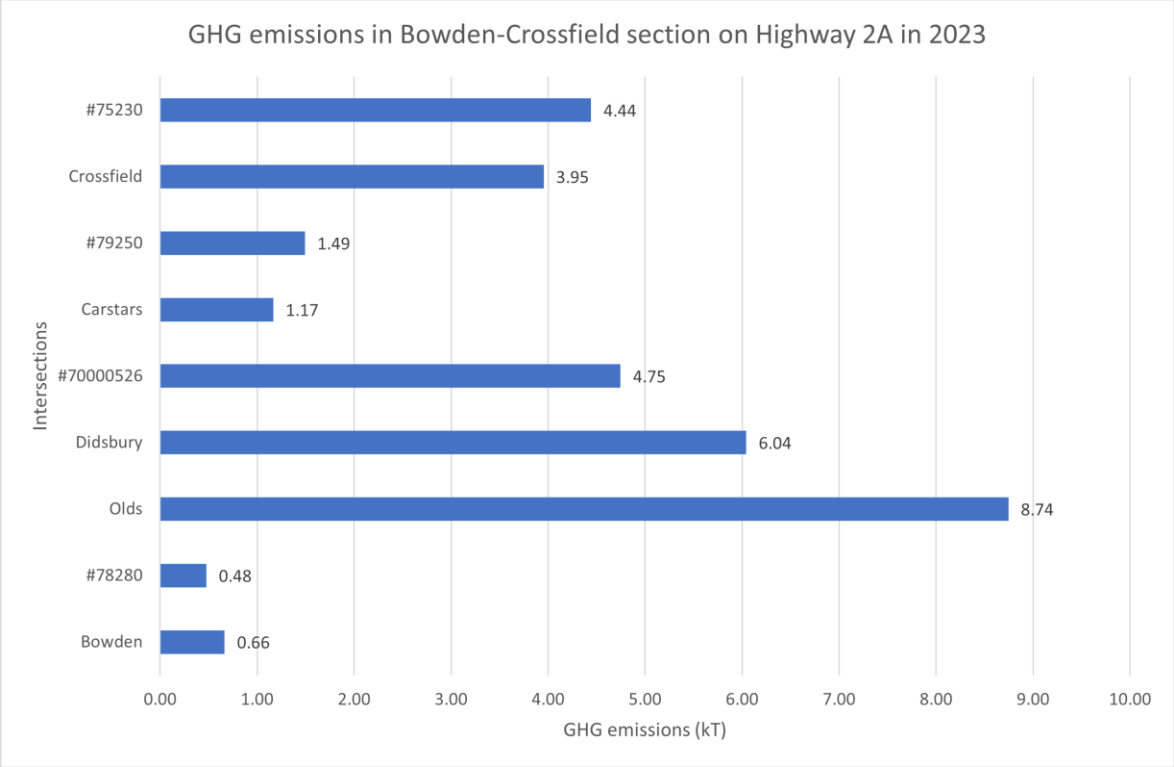


Figure 149: GHG emissions in Bowden-Crossfield section on Highway 2A in 2023

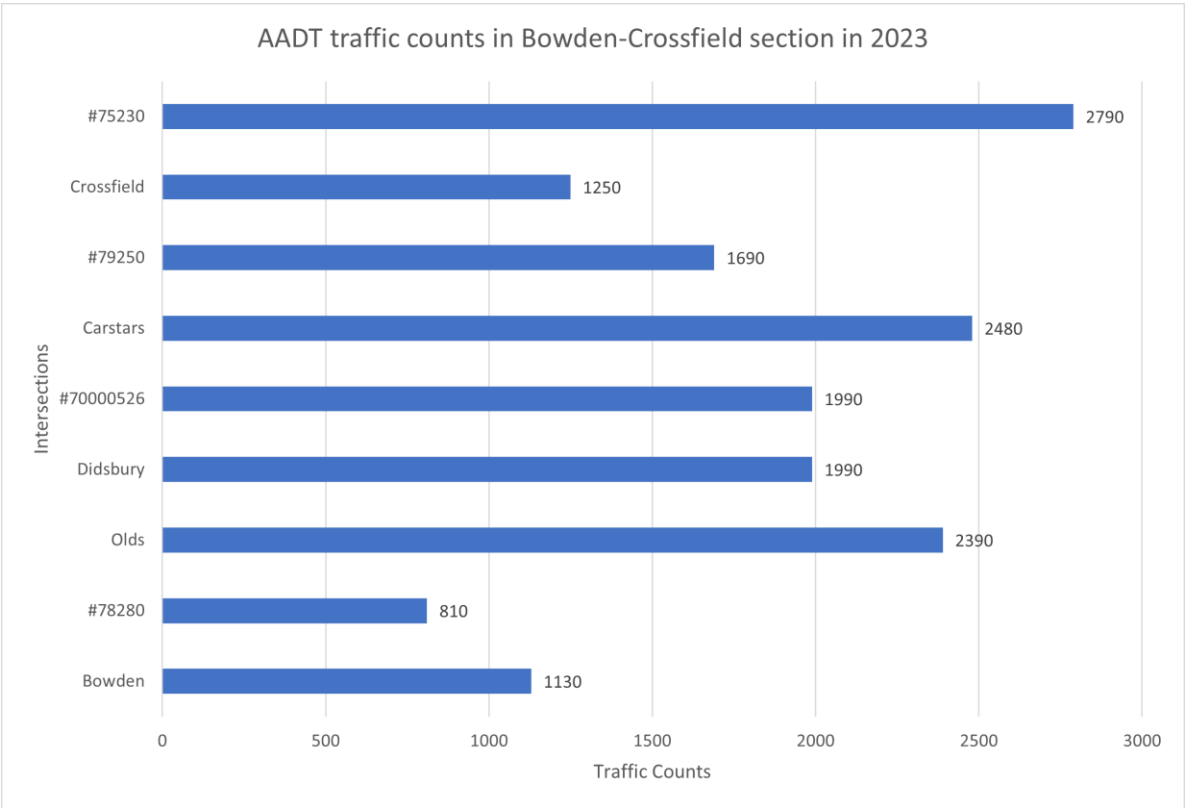


Figure 150: AADT traffic counts in Bowden-Crossfield section in 2023

Future Vision

Deerfoot Trail Improvements on Highway 2

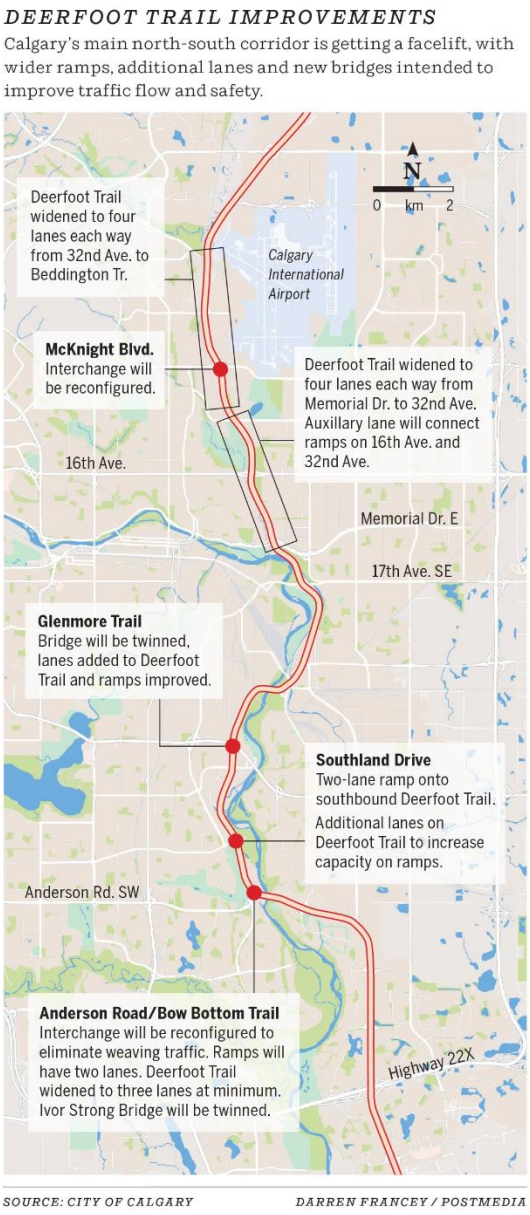


Figure 151: Deerfoot Trail Improvements (Calgary on Highway 2)

Based on the results and discussions of traffic counts and GHG emissions, the province should focus on intersections between the center of Calgary and Calgary International Airport. According to a report in the Calgary Herald posted on Sep 2 2024 [ix], Calgary was improving Highway 2 to alleviate the traffic load in the future since traffic volumes have continued to increase. According to the province, the traffic volumes will reduce by 22 percent of commute time after the reconstruction. The reconstruction included five main points. First, more connectivity at Beddington Trail and 11th Street should be added to provide full moments for the drivers to get on northbound Deerfoot. Second, the signal and ramp configuration at McKnight Boulevard must be changed. Also, adding a fourth continuous lane in each direction from 32 Ave. N.E. to Beddington Trail. Third, planning to improve the Memorial Drive and Deerfoot Trail interchange in the future. Fourth, a lane on Glenmore Trail should be added to carry northbound and southbound traffic. Fifth, redistribute the Southland, Anderson Road, and Bow Bottom Trail to improve safety and traffic flow on these roads. Also, a lane from Northbound Deerfoot will be added to Anderson and Bow Bottom. Details and more information are shown in Figure 151.

Edmonton - Calgary High Speed Rail Line

TransPod Inc. [x], announced its intention in 2023 to build an ultra-high-speed connection between Edmonton International Airport (YEG) and downtown Edmonton. They hoped to secure financing to enable operations from Edmonton-to-Edmonton International Airport (YEG) by 2027. This was to be the first leg of the project. This project aimed to save travel time for the residents and travelers between Calgary and Edmonton, reducing GHG emissions and congestion from the vehicles on Highway 2, bringing more safety benefits to avoid car accidents, and creating more job opportunities for Canadians.

TransPod's system will include five sections:

- Calgary to Edmonton
- Calgary to Red Deer
- Edmonton to Red Deer
- Downtown Calgary to Calgary International Airport
- Downtown Edmonton to Edmonton International Airport

Compared with existing transportation options from Calgary to Edmonton, as shown in Figure 152, TransPod's high-speed technology will create additional benefits for residents of Alberta. TransPod will:

- Save travel time,
- Increase safety compared to passenger vehicles,
- Lessen the risk of trip cancellations.

Although the break-even rate for each trip and the design capacity of the vehicles are drawbacks for the TransPod, system, the benefits of TransPod may attract people to commute to Calgary, Edmonton, and adjacent cities more regularly.

Air transportation provides convenience to Calgary and Edmonton cities; however, Red Deer's airport in Penhold is underused. Highway 2 is the main transportation method from Calgary to Edmonton, directly connecting both cities. However, most vehicles are passenger vehicles and trucks carrying freight. and the bus service is not sufficient in this region. Rail transportation between Calgary and Edmonton is not offered. Specifically, the rail tracks in the region are reserved for freight to transport heavy goods. A study has considered a passenger rail service from Calgary to Banff.

Highway 2 transportation accounts for the majority of travel within the Calgary-Red Deer-Edmonton corridor. Planes and buses are less attractive options for commuting and traveling. As a result, high-speed rail may be a viable option for the resident of Calgary, Red Deer, and Edmonton.

	Passenger Flights	Car	Bus	TransPod
Length of Trip (door-to-door)	Estimated travel time: 3hr 28min	Estimated travel time: 3hr 15min	Estimated travel time: 4hr 2min	Estimated travel time: 1hr 2min
Cost of Trip	High $162	Low $37	Medium $61	Medium $90
Frequency of Departures	Medium Hourly	High On demand	Low ~6 per day	High Every 2 min
Capacity of Vehicle	High 50-215 passengers	Low 4-8 passengers	Medium 50 passengers	Medium 50 passengers

Likelihood of Trip Cancellation	Moderate (Due to weather, particularly in the winter)	Medium (Due to weather, particularly in the winter)	Medium (Due to weather, particularly in the winter)	Low Protected tube environment
Safety	High Accidents are very rare	Medium Winter conditions can be challenging	Medium Winter conditions can be challenging	High Protected tube environment

Figure 152: Comparison of the types of transportation (C-E)

Suggestions for Passenger Railway Construction

Based on the recent research on transportation system between Calgary and Edmonton, the passenger railway system will require to consider the following issues:

1. Cost

In the research of passenger rail in the Calgary-Edmonton corridor [xi], the history of passenger rail in the Calgary-Edmonton corridor did not work well from 1891 to 1985. Due to the rise of airlines, highways, and automobiles, the population declined, resulting in an arduous situation in maintaining the railway and including safety concerns. Since then, the rail service ended in 1985. In 2004, the Van Horne Institute suggested a high-speed rail study to the Alberta government [xii]. The government committed to studying the possibility of high-speed rail (HSR), finishing the study in February 2008 and releasing it to the public in 2009. Based on research conducted in 2004, the Calgary-Edmonton corridor is one of Canada's fastest-growing urban regions, housing 72% of Alberta's population. New methods are required to be implemented to address the increasing population and road congestion and sustain economic growth. While one billion was planned for highway improvement, rail investment was lacking. Economists warned that over-reliance on highways could cause economic efficiency.

HSR has two options for constructing routes between Calgary and Edmonton. The first one is to upgrade the existing Canadian Pacific Railway corridor, which is called CPR alignment, and the second one is to construct Greenfield alignment, a new dedicated HSR corridor parallel to Highway 2. Both options were feasible and provided travel time of less than 2 hours from Calgary to Edmonton.

The cost estimation for CPR was 1.71 billion dollars, and there are two options in the Greenfield alignment. The first one is the non-electric vehicle, which requires 2.61 billion for construction, and the second one is the electric vehicle, which requires 3.41 billion for construction. Each alignment is estimated to cost 71 to 97 million dollars each year to operate.

We suggest the HSR with CPR option between Calgary and Edmonton. The population is estimated to reach 1.7 to 2 million passengers annually, with 22 to 28% of the market share of total intercity trips; recovery capital costs are expected within 30 years. In addition to the recovery, total benefits such as job creation, tax revenue, and travel savings are estimated to reach 3.7 to 6.1 billion dollars. GHG emission was expected to reduce by 1.8 to 3.1 million metric tons, and 25500 to 52000 jobs created in construction and rail operations.

2. Connections

Based on the announcement from the Government of Alberta in April 2024 [xiii], passenger rail service will separate into three parts: Commuter rail, Regional rail, and Light-rail transit (LRT). Table 1 indicates the difference between each rail types.

Feature	Commuter Rail	Regional Rail	Light Rail Transit (LRT)
Purpose	Suburban to City Travel	Intercity Travel	Inner-city Travel
Speed	80-160 km/h	100-200 km/h	30-80 km/h
Distance	20-100 km	50-500 km	5-30 km
Service Frequency	Peak hours (morning/evening)	Less frequent (hourly/daily)	Frequent (every few minutes)
Stops	Fewer, at major suburban hubs	Stops at major cities	Frequent stops, urban areas
Tracks	Often shared with freight trains	Dedicated or shared tracks	Dedicated tracks or street-level
Train Type	Heavy rail (diesel/electric)	Medium/Heavy rail	Light rail vehicles
Best For	Daily commuters from suburbs	Longer regional travel and tourism	City-wide public transit

Table 1: Types of passenger rail in Alberta

We recommend:

- Connecting Calgary with Balzac and Airdrie to alleviate the traffic loads from the north of Calgary. Traffic counts in Figure 3 show that Balzac and Airdrie have high traffic volume along Highway 2 and efforts must be made to reduce traffic volume on Highway 2 in the future.
- Connecting the Edmonton with Leduc to reduce the pressure on Highway 2 to the south of Edmonton. Since the Edmonton International Airport is located between Edmonton and Leduc, the priority should be to prioritize a connection from Leduc to Edmonton to reduce traffic counts,

- In this order, construction should start:
    1. From Calgary to Balzac and Airdrie,
    2. From Edmonton to Leduc,
    3. From Red Deer to Penhold (Red Deer Airport) to Lacombe.

3. Sustainability

Based on a Calgary transit [xiv], study. several projects are proposed to reduce GHG emissions from 2022 to 2050. Calgary Transit's target is to reduce 60 percent of GHG emissions below 2005 levels by 2030 and achieve zero GHG emissions by 2050. The following lists include mitigation plans and program pathways:

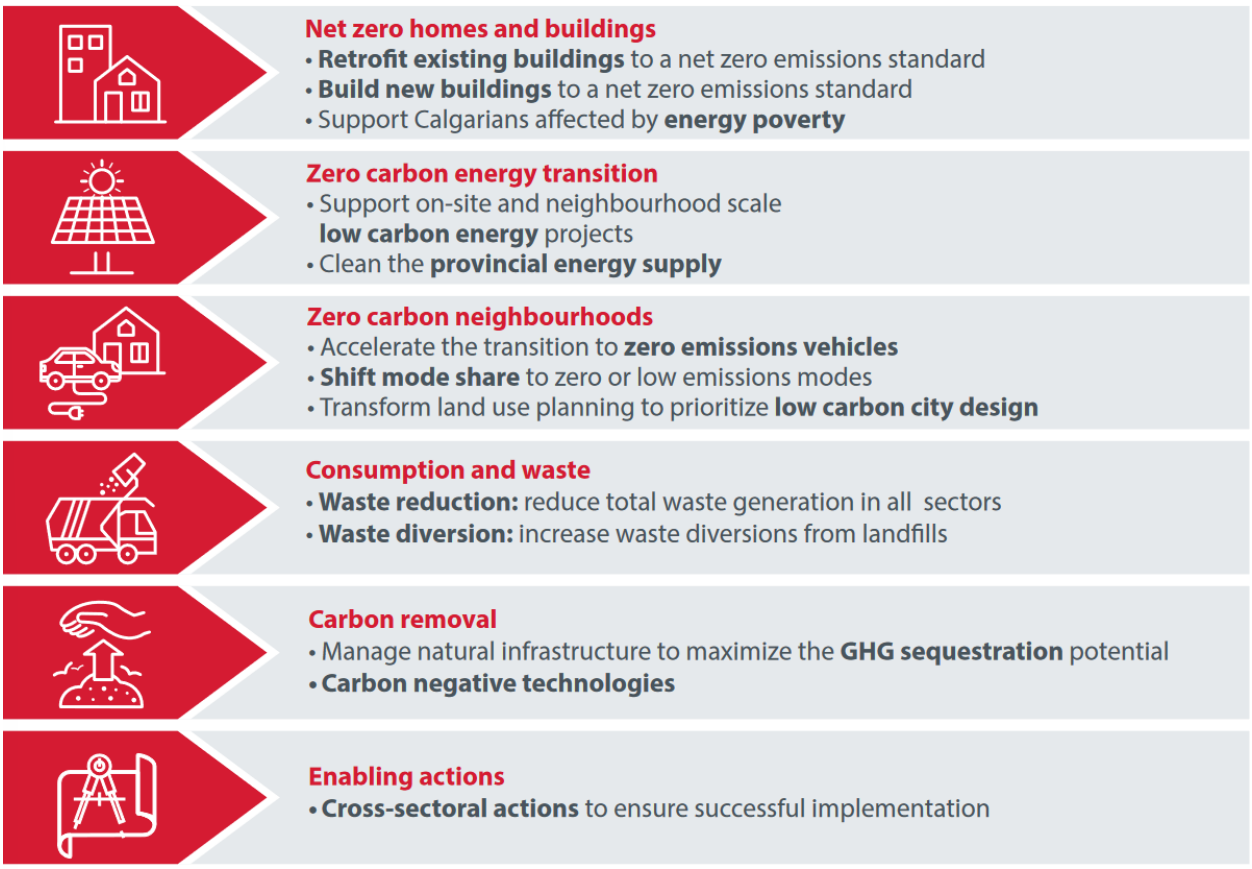


Figure 153: Plans and programs to reduce GHG emissions from Calgary transit

Shown in Figure 154, the Calgary Transit report compared transportation with other emission origins. It showed that residential areas account for lower GHG emissions, however, residential emissions are almost equal to the GHG emissions from transportation. GHG emissions from commercial activities account for a quarter of total GHG emissions, followed by almost 10% from industrial activities. As a result, research into emission reduction must focus on transportation as it accounts for a large % of GHG emissions in Alberta.

Transportation improvement in Calgary and Edmonton

Based on the study of zero-carbon neighborhoods, Calgary Transit has worked on implementing Level 2 and Level 3 fast charging stations for local and regional electric vehicles to prepare the zero GHG emissions goals. It has also implemented road pricing tools such as the duration of time, location, type of vehicle, and level of congestion to calculate a reasonably priced price for the customers.

At the same time, Edmonton also tested the hydrogen bus last winter. According to the Alberta Zero Emission Hydrogen Transit (AZEHT) announcement [xv], Edmonton Transit tested a hydrogen bus in the winter of 2023. The bus traveled over 400 kilometers in temperatures below -20 degrees Celsius.

Road improvements will help Calgary reduce GHG emissions. Calgary Transit research focused on changing transportation patterns in Calgary, such as sidewalks, wheeling infrastructure, and carpooling networks, concentrating more on reinvesting in infrastructure, prioritizing maintenance, and providing convenient transit service to achieve sustainability from the arrangement of roads in the city.

Land use will be Calgary's last consideration in achieving a zero-emissions mission. Since the rapid development of the suburban area in Calgary, the loss of natural and agricultural resources will impact maintenance of the ecosystems. To achieve social equity between transportation and land use, Calgary made several plans to face the challenges of the impact of climate change and tried to tailor plans and policies to develop for existing and future neighborhoods.

Calgary Transit and the City of Calgary have incorporated net zero emissions targets and have followed the plan's recommended actions. It proposes amendments to local area plans to support development while ensuring alignment with the climate strategy and support industry plans to reduce GHG emissions and prevent further environmental impact to industrial areas.

Calgary is growing rapidly and should leverage data modeling to achieve net zero targets between 2030 and 2050. The application of appropriate policies and prioritization of energy efficiency projects will lower the impact to the environment.

Calgary should implement and develop net-zero emissions and climate-resilient design guidelines for new and existing communities. The government should align new communities with active mobility infrastructure and transit services to prioritize transit-oriented development. Additionally, climate mitigation and adaptation should be a priority in the review of outline plan applications, considering available options for innovative solutions.

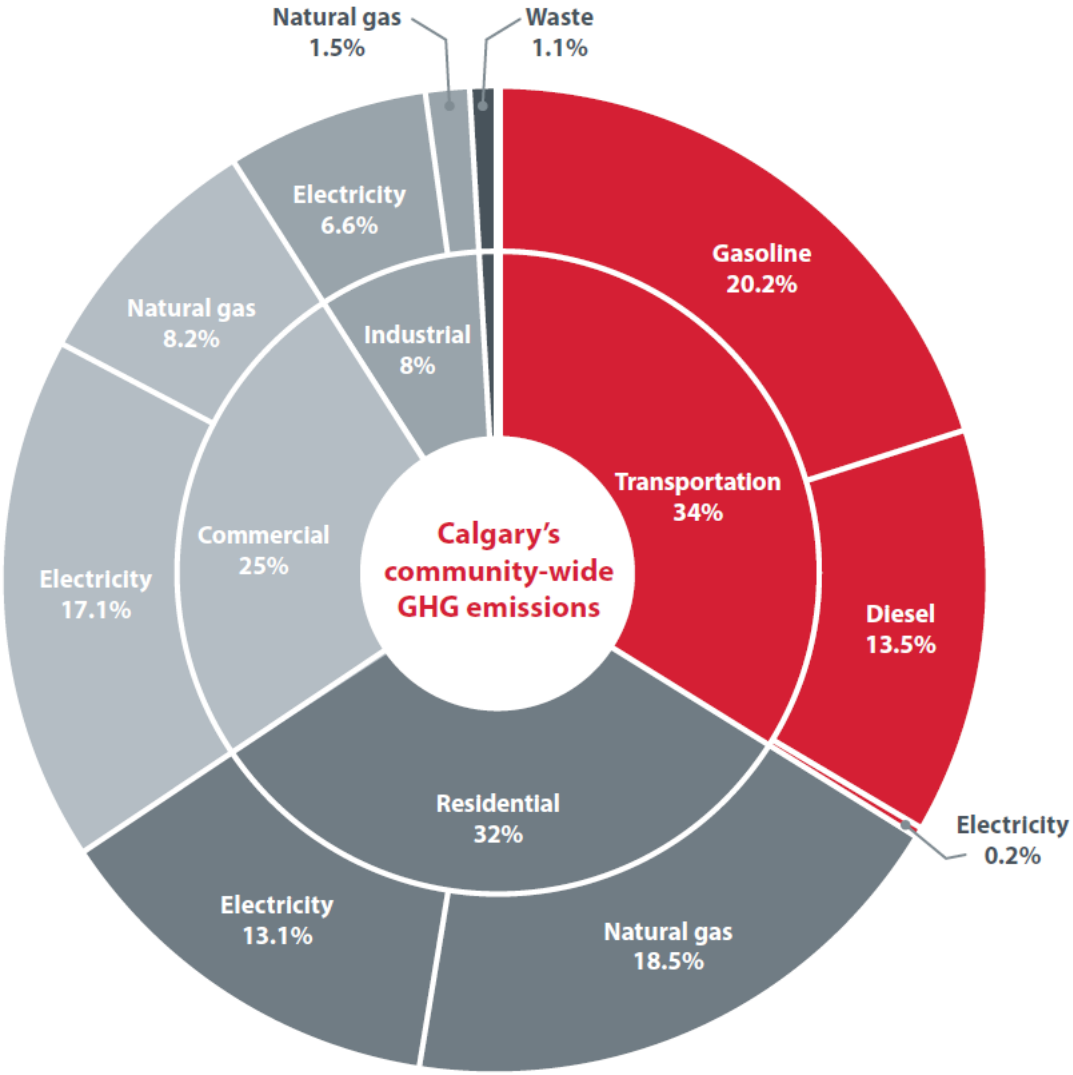


Figure 154: GHG emissions in Calgary with percentages

Carbon removal

Nature plays a crucial role in cooling the environment in summer, recovering heat in the winter, and reducing carbon dioxide emissions. Long-term strategies are needed to focus on future development considering the need for conservation, protection of natural areas, and infrastructure.

Calgary Climate Strategy Pathways to 2050, planned to improve technologies and monitor research to achieve carbon-negative goals. Several actions will apply to the project:

- Estimate the cost and start the plan in the scope of the city to reduce carbon accumulation
- Improve GHG modelling and tools to increase the accuracy of GHG emissions
- Collect more detailed datasets and improve the scope of GHG emissions tracking and reporting each year

- Integrate policies and plans, such as mitigation plans and climate adaptation, to brainstorm ideas for future revisions
- Collaborate with high education institutions, non-profit organizations, and private businesses to innovate solutions.
- Implement the final plan to achieve a hospitable environment

Carbon-negative goals require deep thinking and consideration of impacts on communities and societies: Effort must be made to determine potential risks and prevent negative results. A Carbon-Negative goal requires society to brainstorm and identify the best route between Calgary and Edmonton.

4. Tourism

The Tourism Calgary map [xvi] shows that most activities for visitors and residents are located in Calgary and Edmonton. However, natural assets between Calgary and Edmonton are often overlooked and have great economy value. These locations will attract more business if the transportation system is convenient and less time consuming for visitors and residents.

We suggest to connect National and Provincial parks by rail and offer passenger rail funding to improve transportation options to achieve a more sustainable outcome.

Banff National Park is one of the most famous parks in the world and is close to Calgary. The Report of Railway Technology (November 2023 [xvii]), recommends that a new railway passenger service between Banff National Park and Calgary will create employment and economic benefits to the region. The project planned to apply a hydrogen-powered passenger rail service to reach its net-zero goal. The train service will have stops between Calgary International Airport and Banff. The project will bring in more business from residents and visitors and enhance tourism opportunities.

Jasper Fitzhugh reported in May 2024 [xviii] , that Jasper National Park in the Canadian Rockies attracted 2.4 million visitors in 2023. The Park is located to the West of Edmonton. Current transportation options to visit Jasper National Park is to take a bus or to drive a PV from Calgary or take the infrequent VIA rail service, a bus or PV from Edmonton. The Alberta government is planning to connect the International Airports in Calgary and Edmonton with Jasper and Banff National Parks by the re-introduction of a tourism train along CPKC or CN Right of Ways. Wildlife mortality needs to be addressed – however – is of much lower impact that wildlife kills caused by thousands of PVs that travel through the National Parks daily.

Conclusions

After we analyzed transportation trends, GHG emissions, and the impact of COVID-19 on traffic using AADT methodologies along the Calgary-Edmonton corridor, several key findings and recommendations are mentioned in the following section:

Traffic Patterns on Highway 2 and 2A

Highway 2 is the primary arterial in the Calgary-Edmonton corridor and has significant traffic volumes (more than 80000 vehicles from the WAADT dataset in Figure 3) in Calgary, Balzac, and Edmonton cities. A pattern from the heaviest congestion intersection is located in the center of Calgary to Calgary International Airport. It gradually declines as vehicles move north through Balzac, Airdrie, and Bowden, reaching its lowest recorded counts near Innisfail. As vehicles approach Edmonton, traffic increases again. This pattern shows that Calgary-Edmonton has an urban-centric nature of traffic, having the potential to explore alternative transportation solutions to relieve the heavy traffic volumes in cities.

Highway 2A is an alternative highway connecting towns and rural communities between Calgary and Edmonton. Based on the traffic volume analysis, the highest traffic volume was recorded between Crossfield and Bowden, with 43093 vehicles in 2023. Traffic then declines significantly in the Innisfail to Red Deer segment, where vehicle counts drop to 16040 vehicles. The Labuma to Lacombe segment has a moderate level of regional connectivity with 20450 vehicles. The Morningside to Navarre section is another high-traffic area with 36640 vehicles. The Wetaskiwin to Leduc section shows a steadier flow as it approaches Edmonton with 29830 vehicles. Highway 2A is a secondary highway corridor for local travel and freight movement.

Impact of COVID-19 on Highway 2 and 2A

The COVID-19 had a substantial impact on transportation trends on Highway 2 and 2A. According to research on Highway 2, traffic volumes had a sharp decline in 2020 due to lockdowns, travel restrictions, and increased remote work, which decreased by 3.97% compared to 2019. From 2021 to 2023, introducing vaccines and lifting restrictions will help traffic volumes recover. However, the urban areas experienced faster rebounds than rural sections in terms of traffic growth. Although people have passed through challenging situations during the pandemic, more people continue to work remotely, reducing long-distance commuting, and e-commerce and logistics have increased freight and goods transportation.

The impact of COVID-19 on Highway 2A was similar to that of Highway 2 but with some differences. In 2020, traffic on Highway 2A dropped by 2.67%; the recovery period was slower than that on Highway 2 due to low commuter reliance and rural nature. Traffic trends indicate that local travel demand remained more stable since Highway 2A relies on PV to serve small communities. Highway 2A did not experience the same rapid rebound as Highway 2 after post-pandemic. On the contrary, Highway 2A has a more permanent shift in travel behavior. A

long-term decline in traffic demand on Highway 2A might be influenced by increasing urban migration and improving infrastructure on Highway 2.

GHG Emissions and Environmental Impact

The discussion highlights how vehicle emissions on Highway 2 and 2A are closely linked to traffic patterns. From the research on Highway 2, although PV, with 85.6% of total traffic, contributed the highest GHG emissions, TTC also dedicated a crucial amount of GHG emissions on Highway 2 due to their fuel consumption. Urban sections contributed the highest emissions due to heavy traffic congestion. During COVID-19, Highway 2 has had notable reductions due to fewer traffic counts. Freight transport and passenger rail are lower-emission methods that are an alternative to truck transport. The Calgary and Edmonton governments plan some mitigation strategies. For example, using electric or hydrogen-powered freight trucks to reduce emissions from commercial transport, expanding public transportation options to encourage commuters to use buses or rail instead of PV, and implementing green infrastructure, such as highway electrification and more charging stations for electric vehicles.

Highway 2A has a similar problem as Highway 2. Although Highway 2A has lower emissions compared to Highway 2, emissions remain a high percentage of freight vehicles produce a higher number of emissions. PV dominated the Highway 2A traffic with 93.08%, but a notable share of traffic is commercial freight, particularly in sections closer to Calgary and Edmonton. Heavy-duty vehicles contribute more emissions relative to their traffic share, especially in Wetaskiwin-Leduc and Labuma-Lacombe sections. The GHG emissions dropped sharply in 2020 due to COVID-19, but post-pandemic emission recovery has been slower than Highway 2. Mitigation strategies are similar to Highway 2, such as expanding freight rail alternatives to divert heavy trucks away from Highway 2A, encouraging electric vehicle adoption in rural communities by improving charging infrastructure and enforcing stricter emission regulations for freight operators using Highway 2A.

Based on traffic counts, GHG emissions, the impact of COVID-19 on Highway 2 and 2A, and the government's future vision, we recommend the construction of a passenger rail service between Calgary and Edmonton.

Infrastructure, Mobility Challenges and Solutions

Growing infrastructure challenges on Highway 2 are particularly in high-traffic sections. For instance, severe congestion during peak travel times affected efficiency in the Calgary International Airport to Airdrie section. Red Deer and surrounding areas increased traffic due to its central location between Calgary and Edmonton, requiring an infrastructure expansion. The absence of a passenger rail system places excessive dependency on road travel, leading to higher congestion and maintenance costs.

Highway infrastructure upgrades will resolve problems on Highway 2, expanding high-traffic sections to accommodate growing demand and implementing intelligent transportation

systems (ITS) to improve traffic flow and reduce bottlenecks. High-speed rail development also mitigated high traffic volumes from highways, reducing congestion and emissions and saving time for businesses and long-distance commuters.

Compared to Highway 2, Highway 2A faced several challenges that must be addressed. First, the traffic distribution on Highway 2A is inconsistent, with high congestion in Crossfield-Bowden and Morningside-Navarre. At the same time, Innisfail-Red Deer has much lower traffic, indicating that some segments need upgrades while others are underutilized. Second, heavy freight use in Wetaskiwin to Leduc affected road conditions and increased emissions. Rail freight options alleviate truck congestion on Highway 2A. Some recommended solutions on Highway 2A included:

- Improve road safety and intersection design in high-traffic areas such as Crossfield-Bowden and Morningside-Navarre
- Widen lanes in congested sections to improve freight movement
- Develop regional rail connections to reduce truck reliance on Highway 2A
- Improve public transit options to reduce PV dependence
- Introduce electric freight corridors to encourage low-emission trucking
- Expand cycling and pedestrian infrastructure in areas with growing residential communities

The research on Highway 2 emphasized the urgent need for a balanced transportation strategy to accommodate growing traffic demands and minimize environmental impact. We suggest policymakers focus on the following:

- Investing in innovative transportation technologies to manage congestion effectively
- Developing alternative modes of transport to reduce reliance on PV
- Enhancing sustainability efforts, including GHG reduction policies and green infrastructure investments

Highway 2A is also an important regional route between Calgary and Edmonton. The need for declining traffic volumes and increasing freight dependency are targets on Highway 2A. We suggest the future of Highway 2A could focus on:

- Targeted infrastructure improvements in high-traffic areas
- Freight rail integration to reduce truck congestion
- Sustainability measures to reduce emissions and improve efficiency

A multimodal approach in the Calgary-Edmonton corridor can improve efficiency, lower emissions, and enhance long-term economic viability. The integration of rail, optimized highway infrastructure, enhanced regional connectivity, and green transport policies will be crucial for sustainable growth in Alberta’s most important transportation corridor.

Passenger Rail Connection

We suggest to create a route from Calgary, passing through Calgary International Airport, Red Deer, Edmonton International Airport, Jasper National Park, and back to Calgary.

At this time, CN Rail would have to travel past Jasper to Prince George before heading south and interchange with CPKC to return to Banff National Park, and back to Calgary. Thus – we do not recommend to connect Banff and Jasper directly at this time.

We analyzed possible obstacles to railway construction, including climate and topography in Calgary, Red Deer, Edmonton, Jasper, and Banff.

Based on data from Topographic Map [xix] and weather from Weather Spark [xx], we suggest to build the rail service in stages:

1. Calgary-Red Deer
2. Red Deer-Edmonton
3. Calgary-Banff
4. Banff-Jasper via Prince George, Kamloops, Salmon Arm, Revelstoke and Golden BC

High	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Edmonton	-6°C	-3°C	3°C	12°C	18°C	21°C	23°C	22°C	18°C	10°C	0°C	-5°C
Calgary	-1°C	1°C	5°C	12°C	17°C	20°C	23°C	23°C	18°C	12°C	4°C	-1°C
Red Deer	-5°C	-3°C	3°C	11°C	17°C	20°C	23°C	22°C	18°C	11°C	1°C	-5°C
Jasper National Park of Canada	-8°C	-5°C	-0°C	5°C	10°C	14°C	17°C	17°C	11°C	4°C	-5°C	-9°C
Banff National Park of Canada	-4°C	-1°C	3°C	8°C	13°C	17°C	20°C	20°C	15°C	8°C	-0°C	-5°C

Low	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Edmonton	-14°C	-12°C	-7°C	0°C	6°C	10°C	13°C	11°C	6°C	1°C	-7°C	-13°C
Calgary	-11°C	-9°C	-5°C	-0°C	5°C	9°C	11°C	10°C	6°C	1°C	-6°C	-10°C
Red Deer	-15°C	-13°C	-8°C	-1°C	4°C	8°C	10°C	9°C	4°C	-1°C	-9°C	-14°C
Jasper National Park of Canada	-20°C	-18°C	-14°C	-9°C	-5°C	-0°C	1°C	0°C	-3°C	-8°C	-15°C	-20°C
Banff National Park of Canada	-11°C	-10°C	-7°C	-2°C	3°C	6°C	9°C	9°C	5°C	-0°C	-7°C	-12°C

Figure 155: Temperature Difference at Calgary, Red Deer, Edmonton, Jasper, and Banff

Calgary-Red Deer Railway

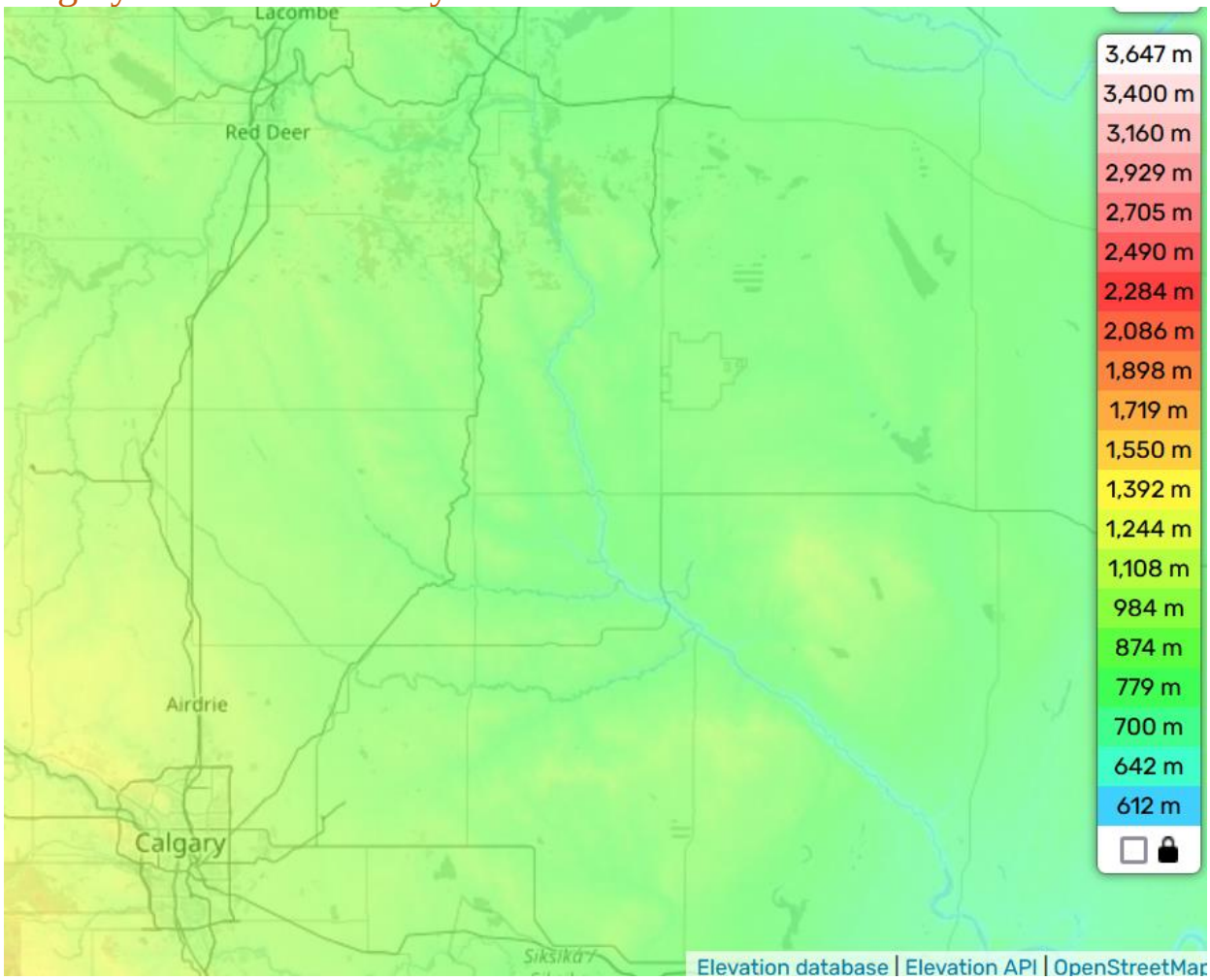


Figure 156: Topographic map from Calgary to Red Deer

The map in Figure 156, show the topography between Calgary and Red Deer does not differ greatly, in a range of 1108 to 1392 meters over 150 km. The weather in Figure 155 is above zero degrees Celsius from April to October. The topography will allow for year-round railroad construction. In the winter, snow and ice will slow down railroad construction from time to time but will not significantly delay construction schedules as long as the work plan accommodates for changes in weather.

Red Deer-Edmonton Railway

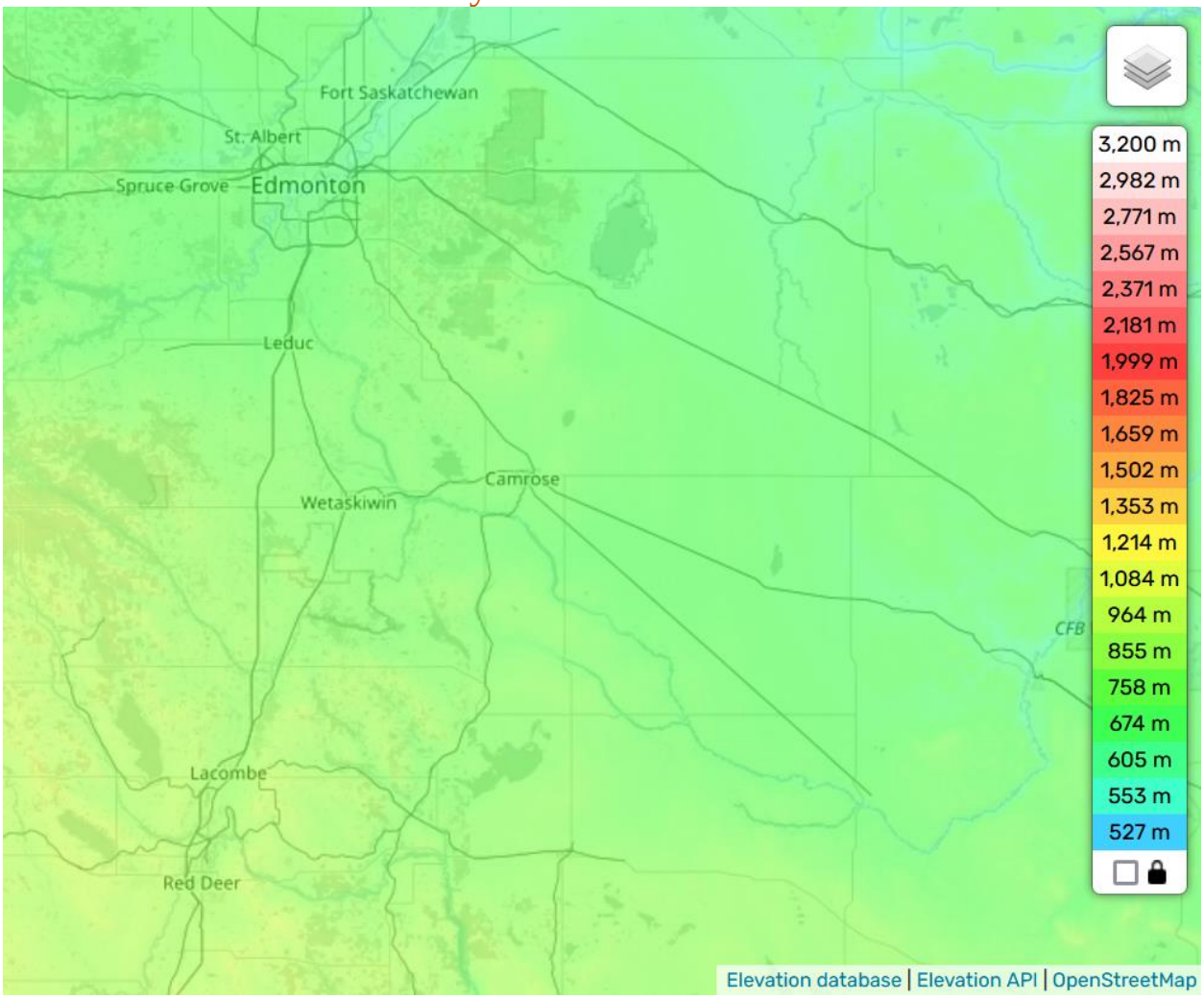


Figure 157: Topographic map from Red Deer to Edmonton

Figure 157, confirms that the topography between Red Deer and Edmonton is similar to Calgary to Red Deer, in a range of 1214 to 855 meters over 150 km. The weather in Figure 155 is above zero degrees Celsius from March to October. Due to the topography, the weather will not be too severe in winter to continue the railroad construction as from Calgary to Red Deer. CPKC and CN maintain and construct their Right of Ways during this period.

Calgary-Banff Railway

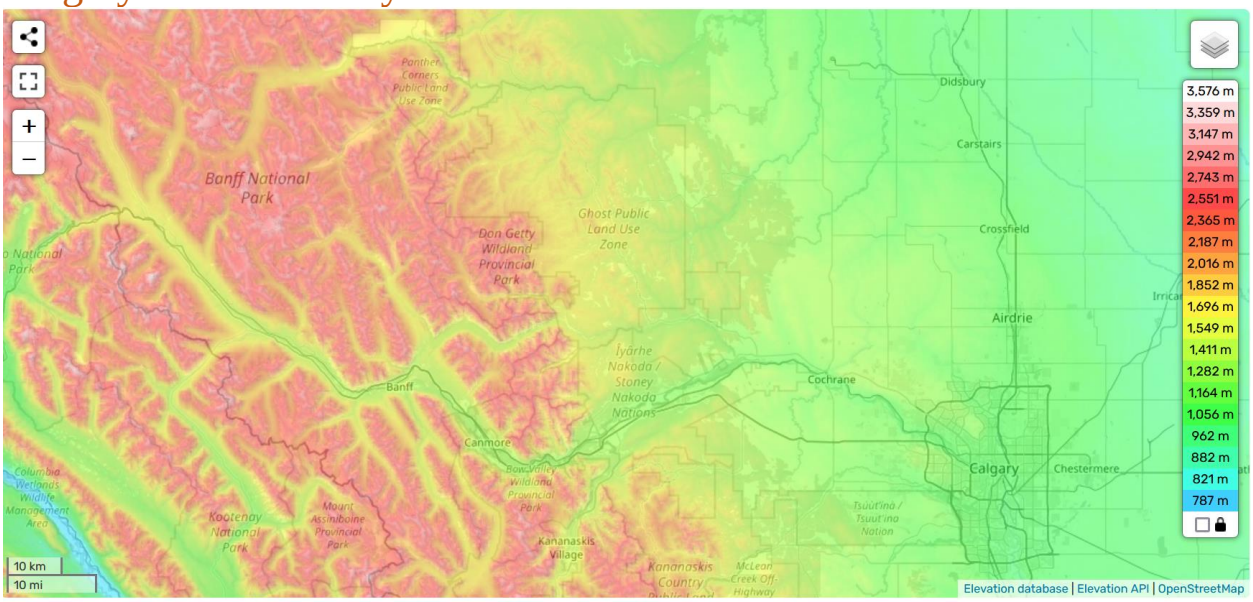


Figure 158: Topographic map from Calgary to Banff

Reinstatement of rail services will offer an alternative to travel to Banff National Park. Railroad construction requires slope stability. CPKC chose the Bow Valley Corridor as it is the only pass though the Rockies with suitable grade. High-altitude terrain required the spiral tunnel and several bridges to be constructed to allow for safe passage of freight trains. The terrain from Calgary to Banff is relatively flat. The costs to proceed west of Banff are far greater and will be impacted by many environmental assessments and public consultation.

Canadian Pacific Railway was constructed from Toronto to Vancouver in only 4 years from 1881 until 1885. The “Las Spike” was hammered in place on November 7, 1885 in Craigellachie, British Columbia. Given that this engineering and construction feat was completed over a length of 4400 kilometers – we are confident that it is possible for an extension of service along this corridor may take 1 year or less.

Jasper-Banff Railway

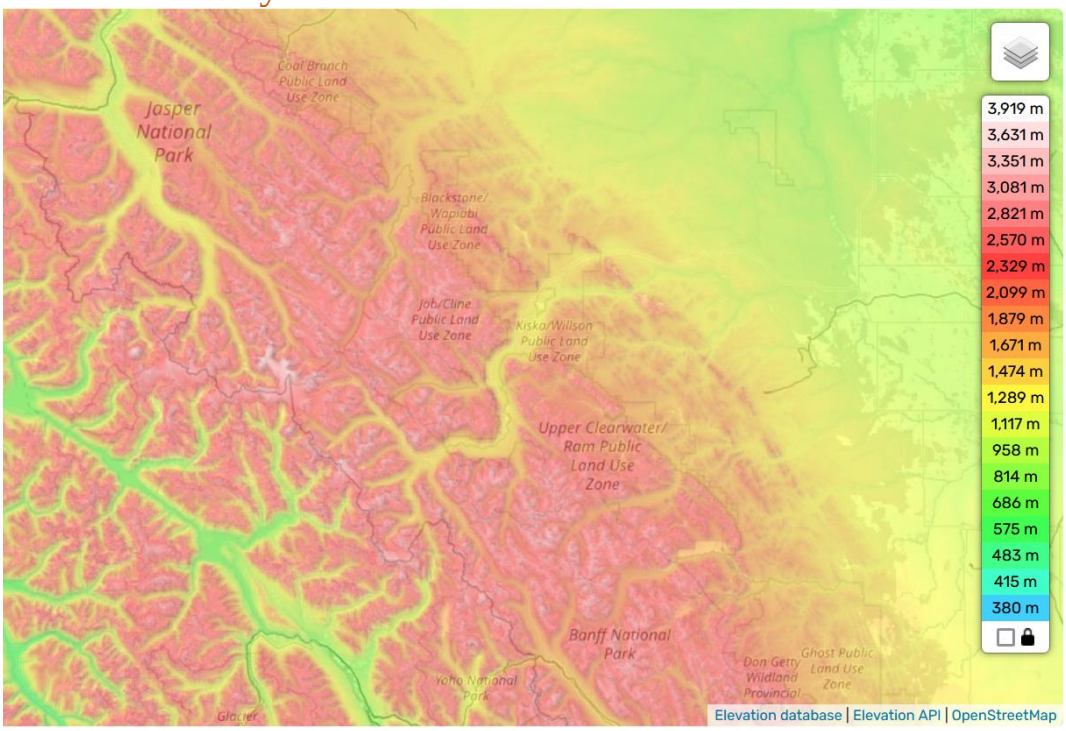
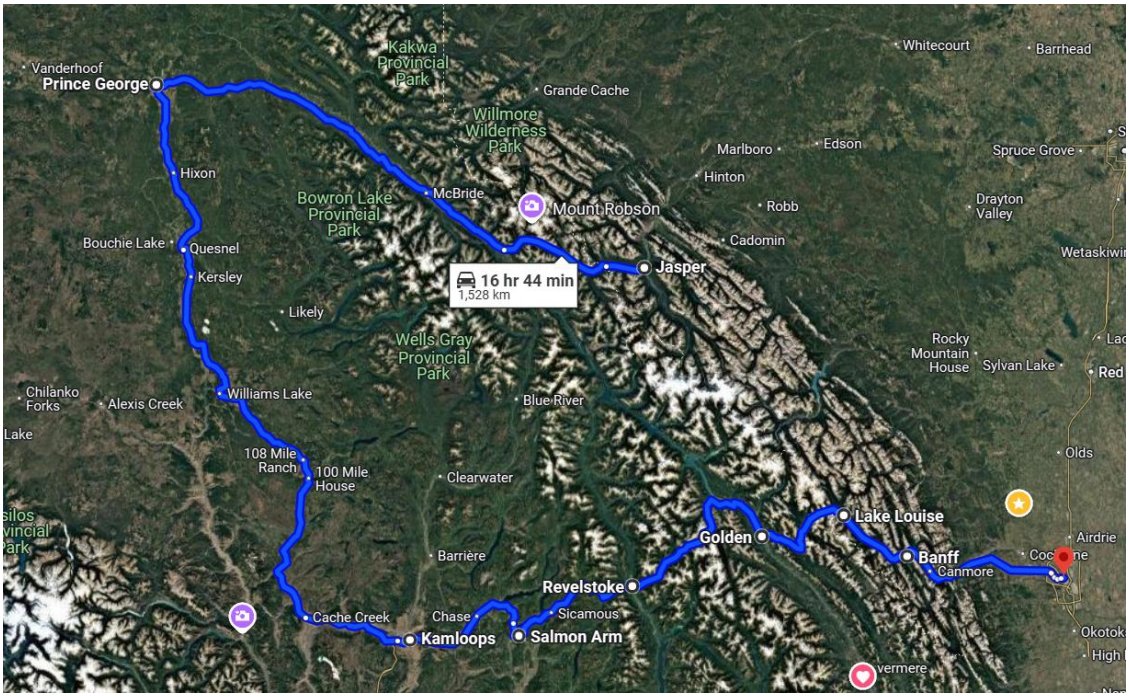


Figure 159: Topographic map from Jasper to Banff

A direct service from Jasper to Banff will leverage existing right of ways running through British Columbia. The tourism route is over 1500 km long and will require hotel accommodation and or sleeper accommodation.



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