

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/>

Author: HAI-HAN SUN

Table of Contents

Abstract	6
Introduction	6
Methodology	7
Results	10
Traffic Counts	10
Highway 2.....	10
Highway 2A.....	13
GHG Emissions in Alberta in 2019-2022	15
Highway 2.....	16
Highway 2A.....	53
Discussions	75
Traffic counts, vehicle types & the impact of COVID-19	75
Highway 2.....	75
Highway 2A.....	76
GHG emissions	79
Highway 2.....	79
Highway 2A.....	83
Conclusions.....	100
Passenger Rail Connection.....	100
Calgary-Red Deer Railway.....	101
Red Deer-Edmonton Railway.....	102
Calgary-Banff Railway.....	103
Jasper-Banff Railway	104
References.....	105

List of Figures

Figure 1: Highway 2 & 2A in Calgary-Edmonton Corridor	6
Figure 2: Highway 2 WAADT Traffic Counts in 2023	11
Figure 3: Highway 2 WAADT Total Traffic Counts & Percentages in 2019-2023	12
Figure 4: Highway 2 Vehicle Types Percentage.....	12
Figure 5: Highway 2A WAADT Traffic Counts in 2019-2023.....	13
Figure 6: Highway 2A Total WAADT Traffic Counts & Percentages in 2019-2023	14
Figure 7: Highway 2A Vehicle Types Percentage.....	14
Figure 8: GHG Emissions of Transportation in Alberta in 2019-2022	15
Figure 9: Total GHG emissions on Highway 2 from Calgary to Edmonton (S to N) from 2019 to 2023.....	16
Figure 10: Average traffic counts from each location on Highway 2 in 2023 (C-E)	18
Figure 11: Intersections from Calgary to Calgary International Airport	18
Figure 12: Average vehicle type percentages from the center of Calgary to Calgary International Airport.....	19
Figure 13: GHG emissions on Highway 2 from Calgary to Calgary International Airport in 2023	20
Figure 14: Intersections from Calgary International Airport to Balzac	20
Figure 15: Average vehicle type percentages from Calgary International Airport to Balzac	21
Figure 16: GHG emissions on Highway 2 from Calgary International Airport to Balzac in 2023	21
Figure 17: Intersections from Balzac to Airdrie	22
Figure 18: Average vehicle type percentages from Balzac to Airdrie.....	22
Figure 19: GHG emissions on Highway 2 from Balzac to Airdrie in 2023	23
Figure 20: Intersections from Airdrie to Bowden.....	24
Figure 21: Average vehicle type percentages from Airdrie to Bowden	24
Figure 22: GHG emissions on Highway 2 from Airdrie to Bowden in 2023	25
Figure 23: Intersections from Bowden to Innisfail.....	26
Figure 24: Average vehicle type percentages from Bowden to Innisfail.....	26
Figure 25: GHG emissions on Highway 2 from Bowden to Innisfail in 2023	27
Figure 26: Intersections from Innisfail to Les Trailer Park	28
Figure 27: Average vehicle type percentages from Innisfail to Les Trailer Park.....	28
Figure 28: GHG emissions on Highway 2 from Innisfail to Les Trailer Park in 2023.....	29
Figure 29: Intersections from Les Trailer Park to Brightview.....	30
Figure 30: Average vehicle type percentages from Les Trailer Park to Brightview	30
Figure 31: GHG emissions on Highway 2 from Les Trailer Park to Brightview in 2023	31
Figure 32: Intersections from Brightview to Corinthia Park	32
Figure 33: Average vehicle type percentages from Brightview to Corinthia Park.....	32
Figure 34: GHG emissions on Highway 2 from Brightview to Corinthia Park in 2023	33

Figure 35: Intersections from Corinthia Park to Leduc	34
Figure 36: Average vehicle type percentages from Corinthia Park to Leduc	35
Figure 37: GHG emissions on Highway 2 from Corinthia Park to Leduc in 2023	35
Figure 38: Intersections from Leduc to Edmonton	36
Figure 39: Average vehicle type percentages from Leduc to Edmonton.....	36
Figure 40: GHG emissions on Highway 2 from Leduc to Edmonton in 2023	37
Figure 41: Total GHG emissions of each year on Highway 2 from Edmonton to Calgary (North to South) from 2019 to 2023	39
Figure 42: Average traffic counts from each location on Highway 2 in 2023 (E-C)	41
Figure 43: Average vehicle type percentages from Edmonton to Leduc.....	42
Figure 44: GHG emissions on Highway 2 from Edmonton to Leduc in 2023	42
Figure 45: Average vehicle type percentages from Leduc to Corinthia Park.....	43
Figure 46: GHG emissions on Highway 2 from Leduc to Corinthia Park in 2023	43
Figure 47: Average vehicle type percentages from Corinthia Park to Brightview	44
Figure 48: GHG emissions on Highway 2 from Corinthia Park to Brightview in 2023	44
Figure 49: Average vehicle type percentages from Brightview to Les Trailer Park	45
Figure 50: GHG emissions on Highway 2 from Brightview to Les Trailer Park in 2023	45
Figure 51: Average vehicle type percentages from Les Trailer Park to Innisfail	46
Figure 52: GHG emissions on Highway 2 from Les Trailer Park to Innisfail in 2023.....	46
Figure 53: Average vehicle type percentages from Innisfail to Bowden.....	47
Figure 54: GHG emissions on Highway 2 from Innisfail to Bowden in 2023	47
Figure 55: Average vehicle type percentages from Bowden to Airdrie	48
Figure 56: GHG emissions on Highway 2 from Bowden to Airdrie in 2023	48
Figure 57: Average vehicle type percentages from Airdrie to Balzac.....	49
Figure 58: GHG emissions on Highway 2 from Airdrie to Balzac in 2023	49
Figure 59: Average vehicle type percentages from Balzac to Calgary International Airport	50
Figure 60: GHG emissions on Highway 2 from Balzac to Calgary International Airport in 2023	50
Figure 61: Average vehicle type percentages from Calgary International Airport to Calgary.....	51
Figure 62: GHG emissions on Highway 2 from Calgary International Airport to Calgary in 2023	51
Figure 63: Total GHG emissions of each year on Highway 2A from Calgary to Edmonton (South to North) from 2019 to 2023	53
Figure 64: Total GHG emissions of each year in Crossfield-Bowden section (South to North)..	54
Figure 65: Intersections from Crossfield to Bowden.....	55
Figure 66: Total GHG emissions of each year in Innisfail-Red Deer section (South to North)...	56
Figure 67: Intersections from Innisfail to Red Deer	57
Figure 68: Total GHG emissions of each year in Labuma-Lacombe section (South to North) ...	58
Figure 69: Intersections from Labuma to Lacombe.....	59

Figure 70: Total GHG emissions of each year in Morningside-Wetaskiwin section (South to North).....	60
Figure 71: Intersections from Morningside to Wetaskiwin	61
Figure 72: Total GHG emissions of each year in Wetaskiwin-Leduc section (South to North) ..	62
Figure 73: Intersections from Wetaskiwin to Leduc.....	62
Figure 74: Total GHG emissions of each year on Highway 2A (North to South).....	63
Figure 75: Total GHG emissions of each year in Leduc-Wetaskiwin section (North to South) ..	65
Figure 76: Total GHG emissions of each year in Wetaskiwin-Morningside section (North to South).....	67
Figure 77: Total GHG emissions of each year in Lacombe-Labuma section (North to South) ...	69
Figure 78: Total GHG emissions of each year in Red Deer-Innisfail section (North to South)...	71
Figure 79: Total GHG emissions of each year in Bowden-Crossfield section (North to South) ..	73
Figure 80: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (C-E).....	80
Figure 81: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (E-C).....	81
Figure 82: Segment Length (miles) on Highway 2 based on locations	82
Figure 83: GHG emissions in Crossfield-Bowden section on Highway 2A in 2023	83
Figure 84: Segment length in Crossfield-Bowden section on Highway 2A	84
Figure 85: AADT traffic counts in Crossfield-Bowden section on Highway 2A in 2023	84
Figure 86: GHG emissions in Innisfail-Red Deer section on Highway 2A in 2023.....	85
Figure 87: Segment length in Innisfail-Red Deer section on Highway 2A	86
Figure 88: AADT traffic counts in Innisfail-Red Deer section in 2023	86
Figure 89: GHG emissions in Labuma-Lacombe section on Highway 2A in 2023	87
Figure 90: GHG emissions in Morningside-Wetaskiwin section on Highway 2A in 2023.....	88
Figure 91: Segment length in Morningside-Wetaskiwin section on Highway 2A	89
Figure 92: AADT traffic counts in Morningside-Wetaskiwin section in 2023	89
Figure 93: GHG emissions in Wetaskiwin-Leduc section on Highway 2A in 2023	90
Figure 94: Segment length in Wetaskiwin-Leduc section on Highway 2A.....	91
Figure 95: AADT traffic counts in Wetaskiwin-Leduc section in 2023.....	91
Figure 96: GHG emissions in Leduc-Wetaskiwin section on Highway 2A in 2023	92
Figure 97: AADT traffic counts in Leduc-Wetaskiwin section in 2023.....	93
Figure 98: GHG emissions in Wetaskiwin-Morningside section on Highway 2A in 2023.....	94
Figure 99: AADT traffic counts in Wetaskiwin-Morningside section in 2023	94
Figure 100: GHG emissions in Lacombe-Labuma section on Highway 2A in 2023	95
Figure 101: AADT traffic counts in Lacombe-Labuma section in 2023.....	96
Figure 102: GHG emissions in Red Deer-Innisfail section on Highway 2A in 2023.....	97
Figure 103: AADT traffic counts in Red Deer-Innisfail section in 2023	97
Figure 104: GHG emissions in Bowden-Crossfield section on Highway 2A in 2023	99
Figure 105: AADT traffic counts in Bowden-Crossfield section in 2023	99
Figure 106: Temperature Difference at Calgary, Red Deer, Edmonton, Jasper, and Banff	100
Figure 107: Topographic map from Calgary to Red Deer.....	101

Figure 108: Topographic map from Red Deer to Edmonton.....	102
Figure 109: Topographic map from Calgary to Banff.....	103
Figure 110: Topographic map from Jasper to Banff.....	104

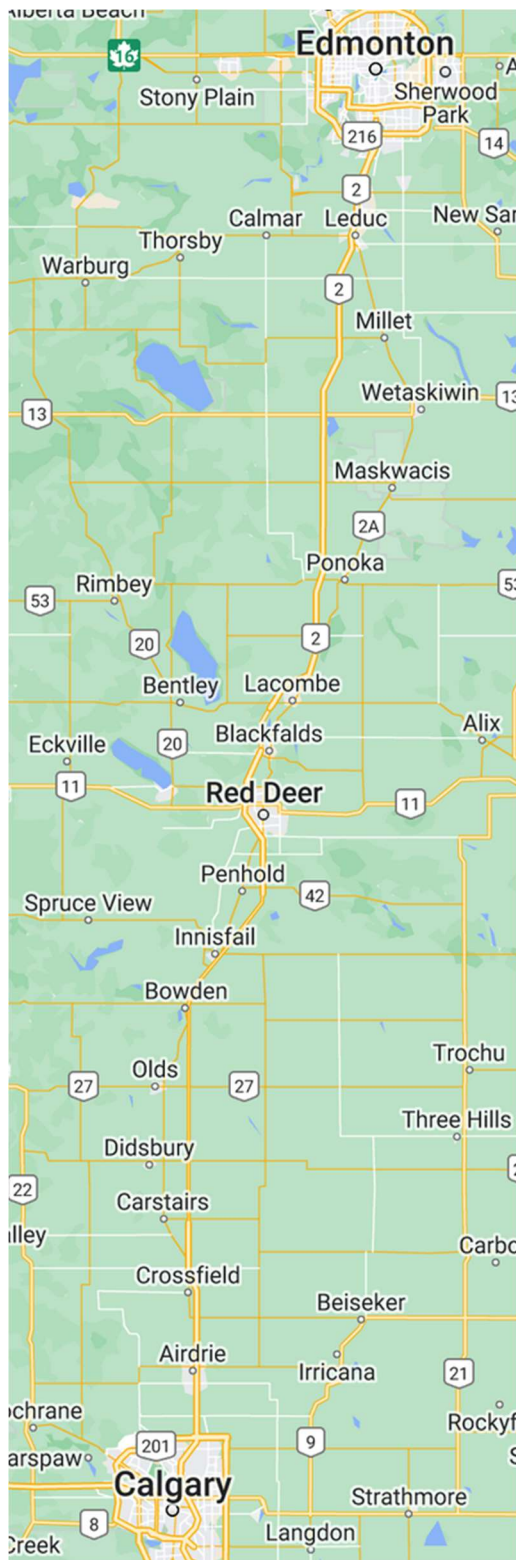


Figure 1: Highway 2 & 2A in Calgary-Edmonton Corridor

Abstract

The Rail for All project from Integrated Travel Company aims to save on highway costs and bring more benefits to Calgary-Edmonton corridors. 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

After collecting all the data, possible recommendations for reducing GHG emissions, decreasing the cost of maintaining the highway, prioritizing the railway arrangement in Aldersyde, Calgary, Foothills County, and Edmonton cities, and arranging transportation for fluent traffic flow will be developed.

Introduction

The research will consider transportation between the Calgary-Edmonton corridor, airports, railways, buses, and highways. Highways 2 and 2A will be considered for improving transportation. Calgary's financial center and Edmonton's government hub are crucial midpoints for connecting within Alberta—the Calgary-Edmonton connection links with numerous small communities, businesses, and services. The Calgary-Edmonton corridor runs through the major cities from South to North: Edmonton, Red Middle, and Calgary.

Highway 2 is a major route connecting to the National Highway System of Canada, including Fort Macleod to Edmonton and Donnelly to Grimshaw. In winter, accidents commonly occur because of rapid

and unpredictable weather conditions between the Calgary and Edmonton corridor. In the route between Fort Macleod and Edmonton, highway 2 is largely freeway, improving 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 cities. Because of the indirect route arrangement and less land, Highway 2A is the second option for commuting from Calgary to Edmonton. Although the traffic load 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 will cause breathing difficulties and loss of taste and smell. Besides, according to the National Library of Medicine report, 44% of people are 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. With the policy being implemented, transportation selection changed during COVID-19 in Canada, concerning infection-related factors rather than traditional factors, increasing the number of personal vehicles used. ^{iv}

Railway construction in the Calgary-Edmonton corridor is the main purpose of this project. Integrated Travel is dedicated to building railways to benefit the economy in Alberta, developing a complete railway system to increase the demand for trains from several aspects, such as saving time, satisfying the customer's demand, and looking for improvement in the service, for achieving a sustainability goal which reduces GHG emissions from the vehicles and the cost on maintaining the highways.

In order to achieve the goal successfully and bring values to Calgary-Edmonton corridor, the steps will be following in this project. 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 explosion was inspected to understand the transportation selections from the people and to examine the differences in GHG emissions. Lastly, we will use SOLIDWORKS on the at-graded track, embedded track, and direct-fixation track to visualize each type of track assembly.

Methodology

This project uses the online datasets of Weighted Annual Average Daily Traffic (WAADT) from the Government of Alberta ^v to traffic counts and collects total AADT data for analyzing the GHG emissions and traffic patterns on Highway 2 and 2A in 2019-2023. The Highway 2 calculation is from 2 & MEMORIAL DR IN CALGARY (10000007), passing through Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, Les Trailer Park, Lochinvar, Leduc,

and finally arrive 2 & ELLERSLIE R (70000577) in Edmonton. The Highway 2A calculation separates into five intersections: 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 HOBBERMA NJ (99380) in Wetaskiwin, 2A & 13 N OF WETASKIWIN NJ (100390) to 2A & TWP RD 492, S OF LEDUC (90420). The first intersection starts from Crossfield, passing through Carstairs, Olds, and Netook, and ends on Bowden. The second intersection passes through Innisfail, Penhold, and Red Deer. The third intersection passes through Laburnum, Blackfalds, and Lacombe. The fourth intersection starts from Morningside, passing through Ponoka, Menaik, and Maskwacis, and ends on Navarre. The last intersection passes through Wetaskiwin, Milet, and Leduc.

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

$$\Delta \text{ emissions} = \text{AADT} * \text{Vehicle Percentage} * \text{Segment Length} * \text{EF}$$

The $\Delta \text{ emissions}$ 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

CO₂ emissions from a gallon of gasoline: 8887 grams CO₂/gallon, and
CO₂ emissions from a gallon of diesel: 10180 grams CO₂/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 *CO₂ emissions*:

$$\text{CO}_2 \text{ emissions per mile} = \frac{\text{CO}_2 \text{ per gallon}}{\text{MPG}} = \frac{8887}{22.2} = 400 \text{ grams}$$

After the calculation, the average gasoline vehicle when driving one mile has tailpipe *CO₂ 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 *CO₂ 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 center of Calgary and go to the entry on the south side of Edmonton. Since the AADT are different from Calgary to Edmonton and Edmonton to Calgary, we calculate two routes for both directions. Based on the intersection data on the traffic data mapping website, 2 & MEMORIAL DR IN CALGARY (10000007) will be the start point

and endpoint in Calgary, and 2 & 216 S OF EDMONTON (20000013) will be the start point and endpoint in Edmonton.

After receiving the WAADT datasets of traffic counts and GHG emissions, we will analyze the impact of COVID-19 between 2019-2020, check the differences between traffic counts and GHG emissions, and visualize traffic patterns before and after the pandemic explosion.

For the transportation arrangement, we will use SOLIDWORKS 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

The traffic counts in Figure 2 show the total WAADT from 2 & MEMORIAL DR IN CALGARY (10000007) ¹ 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 Les Trailer Park, the vehicle number is approximately 35250 in 2023. The vehicle number from Les Trailer Park to Leduc is approximately 29877 in 2023. From Leduc to Edmonton, the vehicle number is approximately 64490 in 2023. The red sections in Figure 2 are the following locations: Calgary, Calgary International Airport, Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, Les Trailer Park, Lochinvar, Leduc, Edmonton, showing that the

¹ 2 & MEMORIAL DR IN CALGARY (10000007): Intersection of 2 & MEMORIAL DR IN CALGARY and the reference number is 10000007

transportation arrangement should focus on Between Calgary and Airdrie, Gasoline Alley and Lochinvar, Leduc and Edmonton sections.

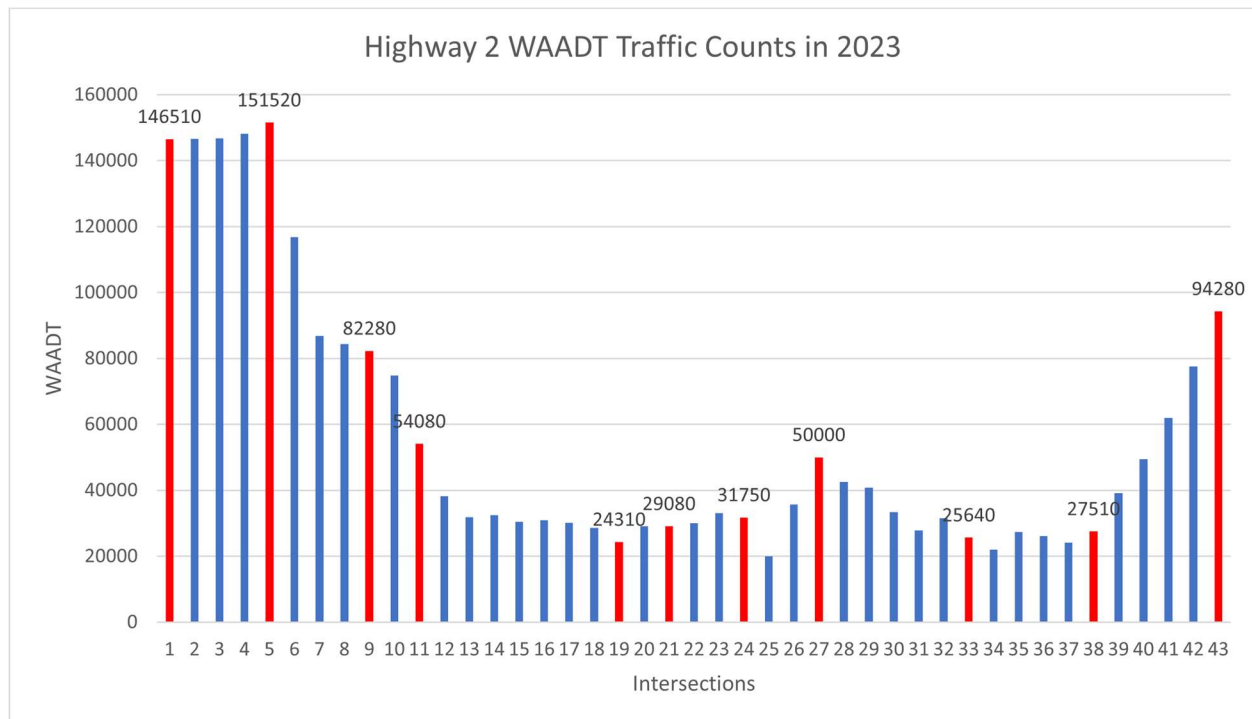


Figure 2: Highway 2 WAADT Traffic Counts in 2023

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: Les Trailer Park; Intersection 33: Lochinvar

Intersection 38: Leduc; Intersection 43: Edmonton

Impact of COVID-19 on the traffic counts

Figure 3 shows 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 469,399 vehicles (3.97%) disappeared within a year. After vaccines are invented, the number of vehicles will be approximately 229,307 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.

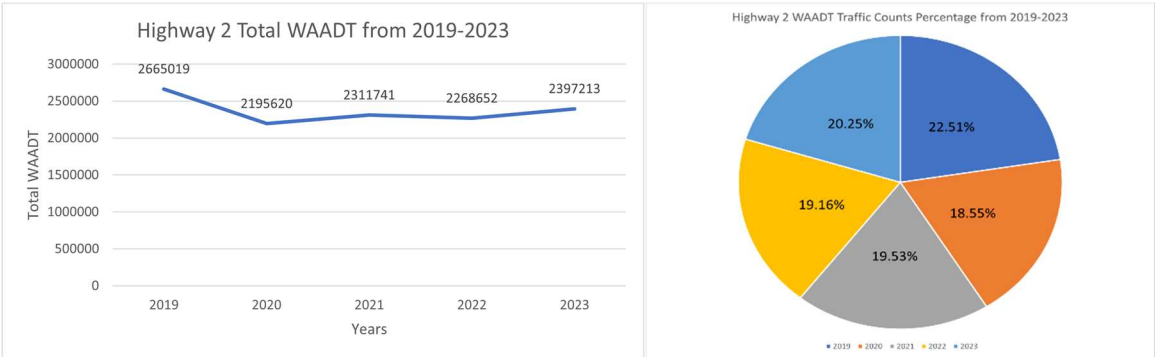


Figure 3: Highway 2 WAADT Total Traffic Counts & Percentages in 2019-2023

Vehicle Types

From the dataset of vehicle types on the Government of Alberta in Figure 4, 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%).

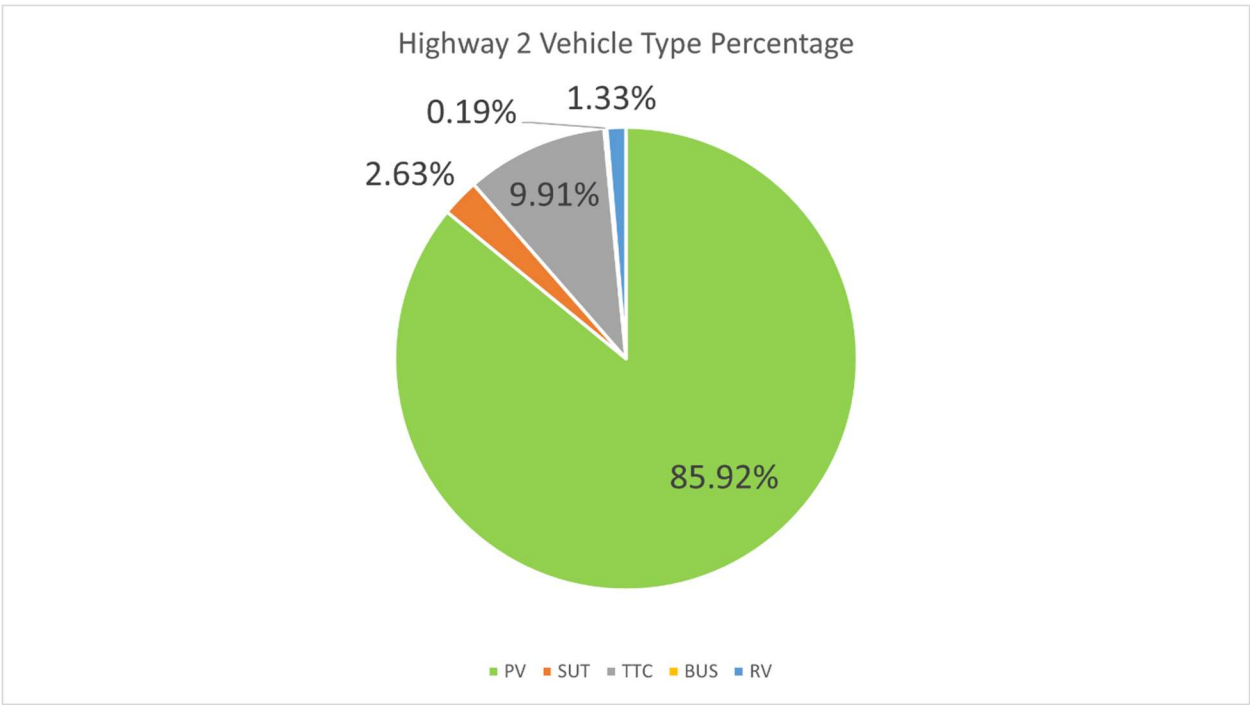


Figure 4: Highway 2 Vehicle Types Percentage

Highway 2A

WAADT Traffic Counts

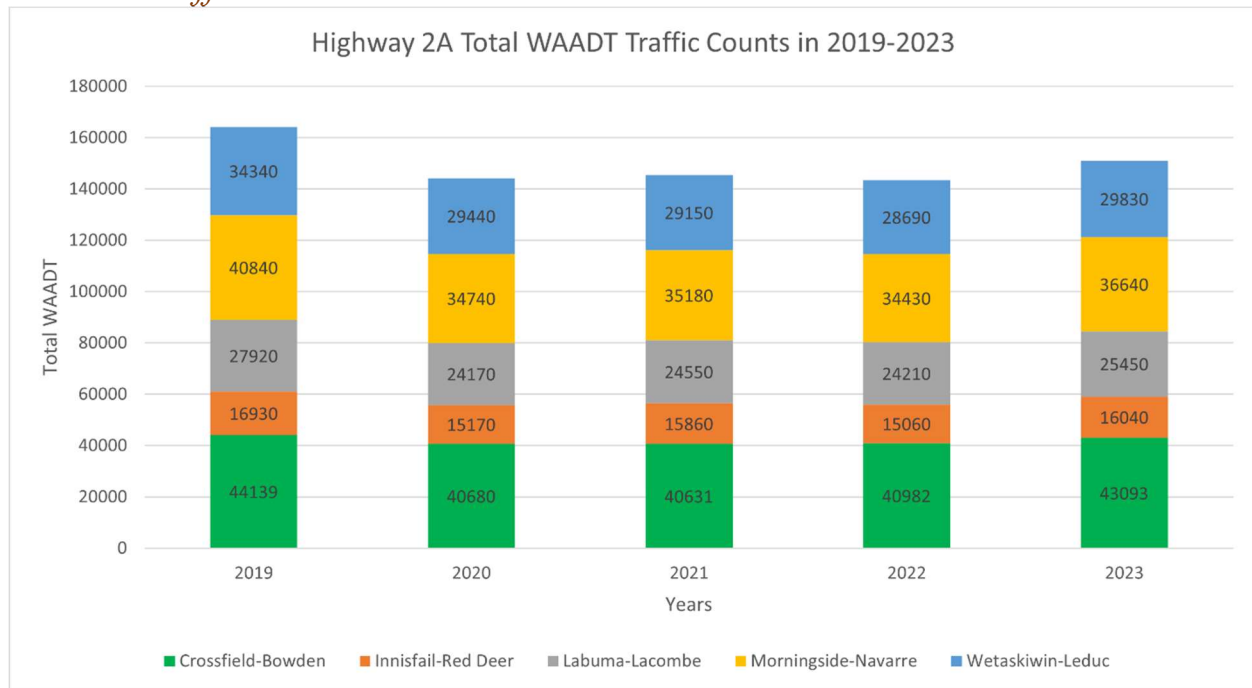


Figure 5: Highway 2A WAADT Traffic Counts in 2019-2023

The traffic counts in Figure 5 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 5 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 6, 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 2023.

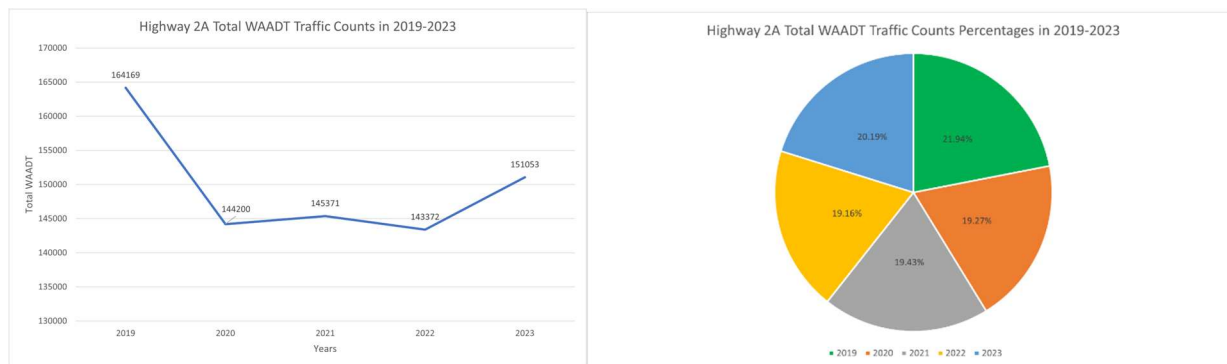


Figure 6: Highway 2A Total WAADT Traffic Counts & Percentages in 2019-2023

Vehicle Types

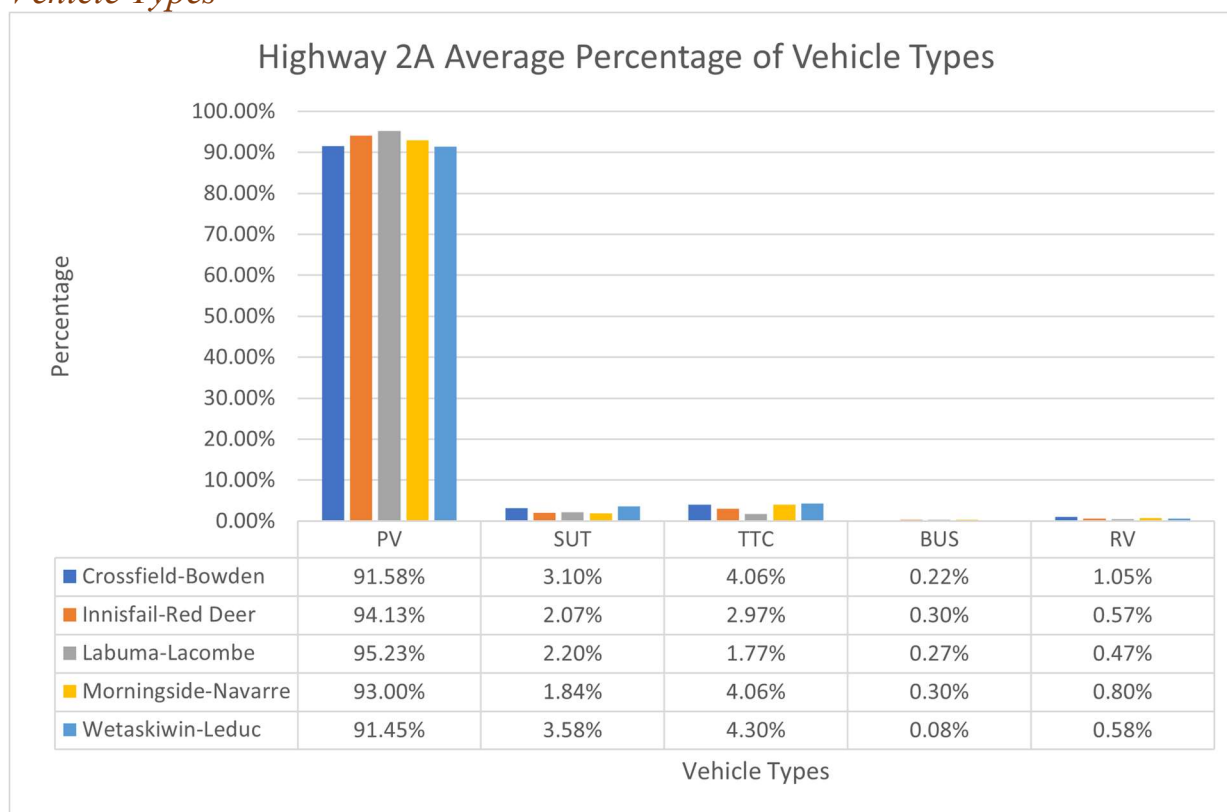


Figure 7: Highway 2A Vehicle Types Percentage

The dataset in Figure 7 shows that the primary 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 7. However, the ratio of the Bus was the lowest within these five intersections.

GHG Emissions in Alberta in 2019-2022

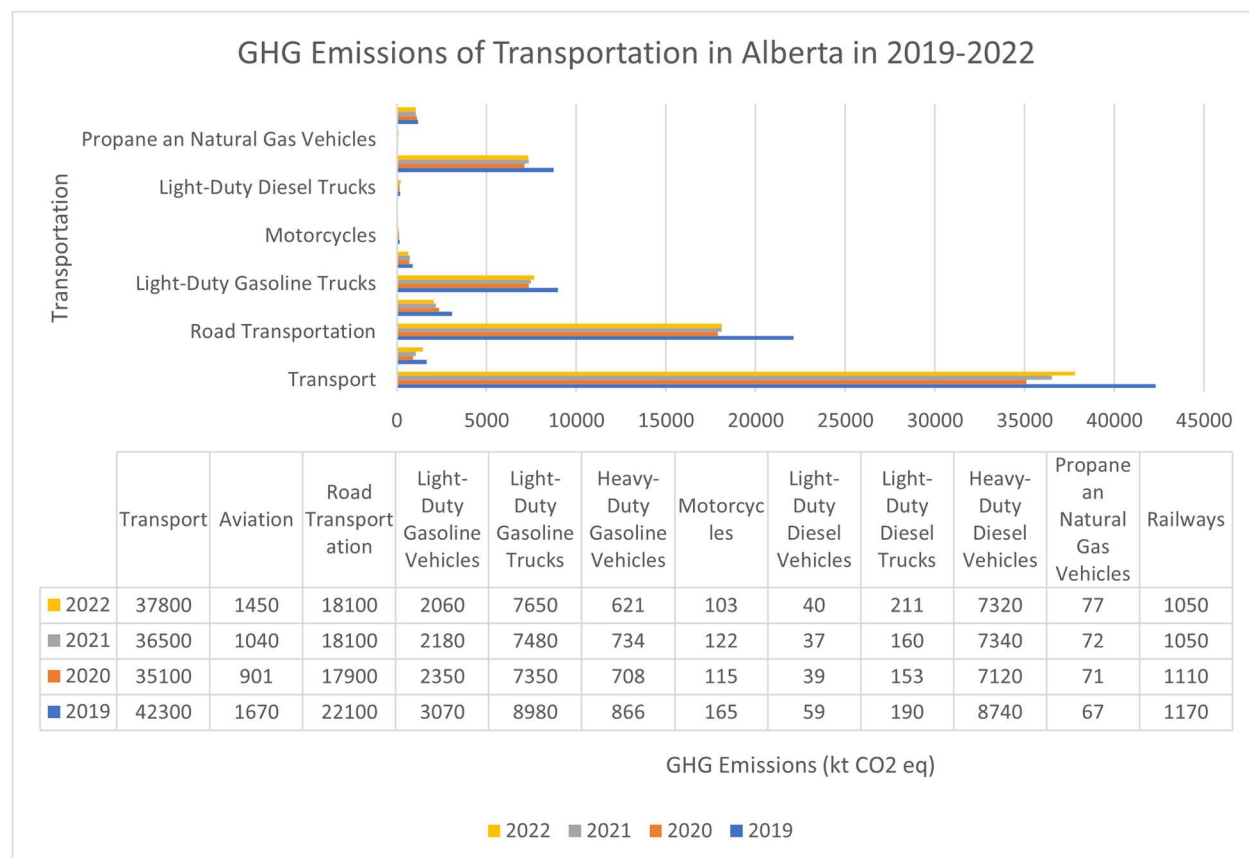


Figure 8: GHG Emissions of Transportation in Alberta in 2019-2022

The dataset in Figure 8 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 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)

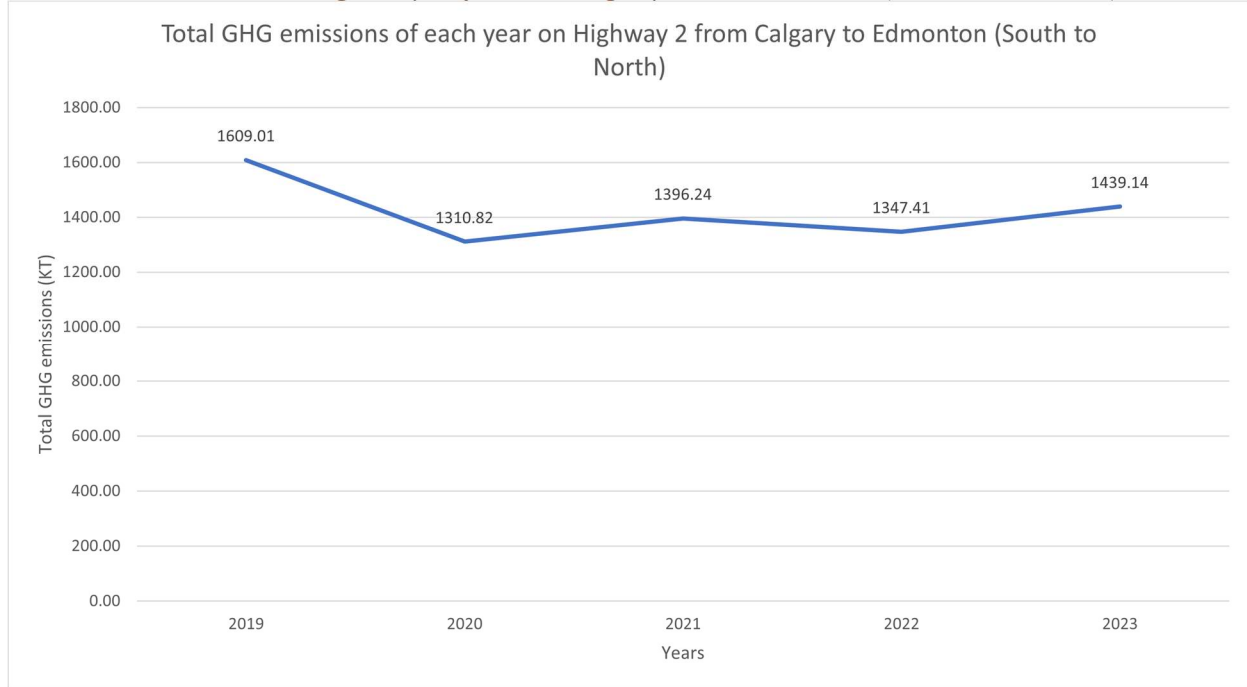


Figure 9: Total GHG emissions on Highway 2 from Calgary to Edmonton (S to N) from 2019 to 2023

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. Start point in the center of Calgary, going through Calgary International Airport, Balzac, Airdrie, Bowden, Innisfail, Gasoline Alley, West Park Extension, Les Trailer Park, Brightview, Corinthia Park, Leduc, and endpoint in Edmonton. From Figure 9, 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 Les Trailer Park, the vehicle counts dropped from 25160 to 19040 in 2023. From Les Trailer Park to Brightview, the vehicle counts dropped from 19040 to 11960 in 2023. From Brightview to Corinthia Park, the vehicle counts increased from 11960 to 19570 in 2023. From Corinthia Park 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 Les Trailer Park and Brightview. 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)

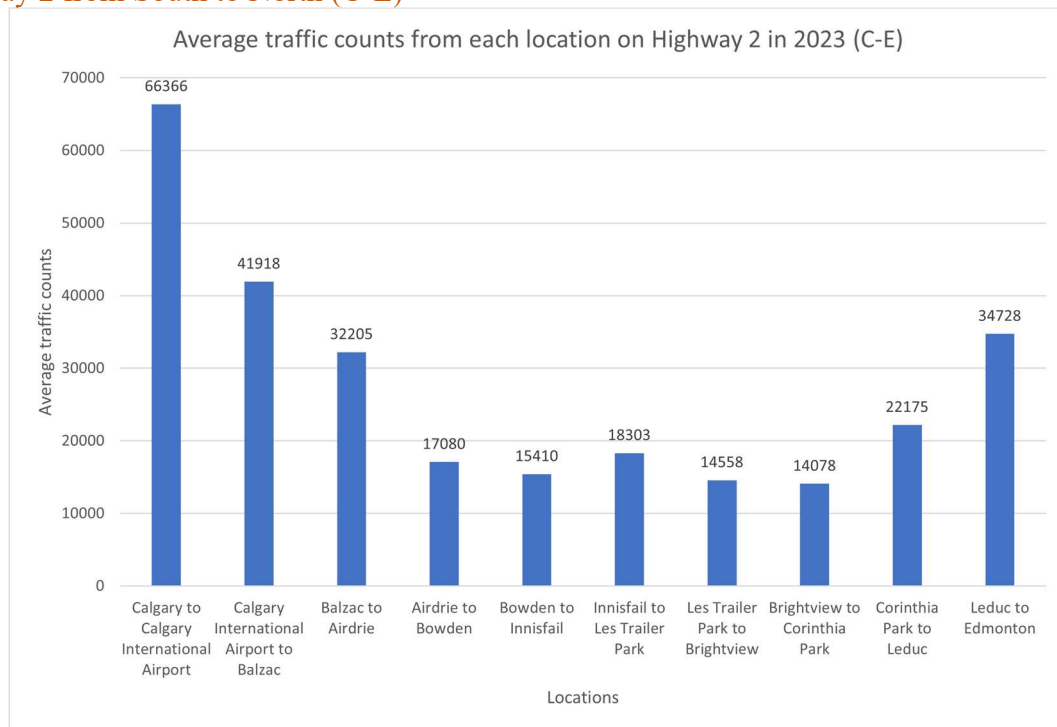


Figure 10: Average traffic counts from each location on Highway 2 in 2023 (C-E)

Calgary to Calgary International Airport

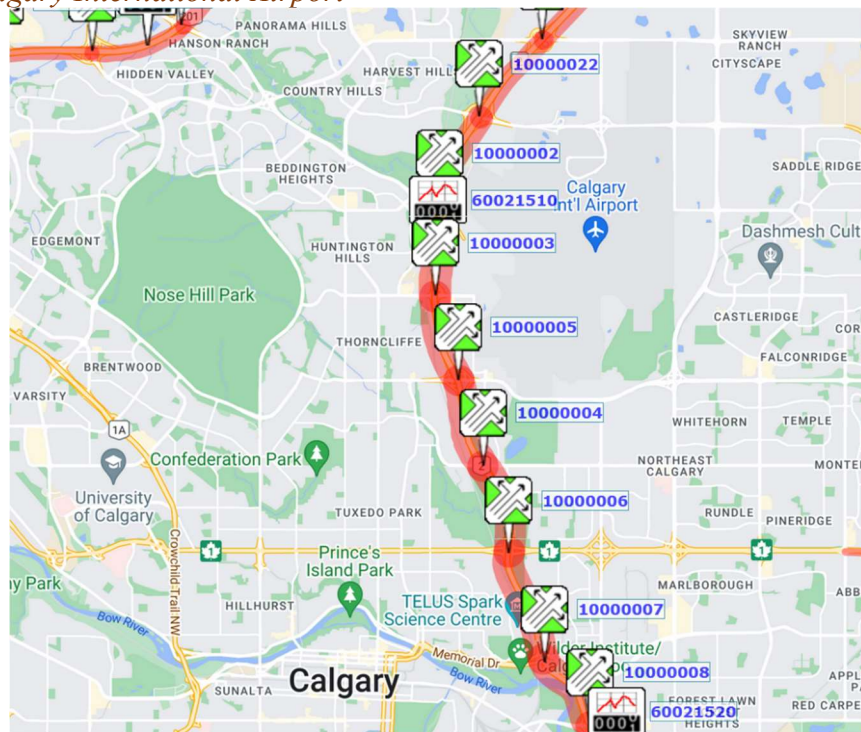


Figure 11: Intersections from Calgary to Calgary International Airport

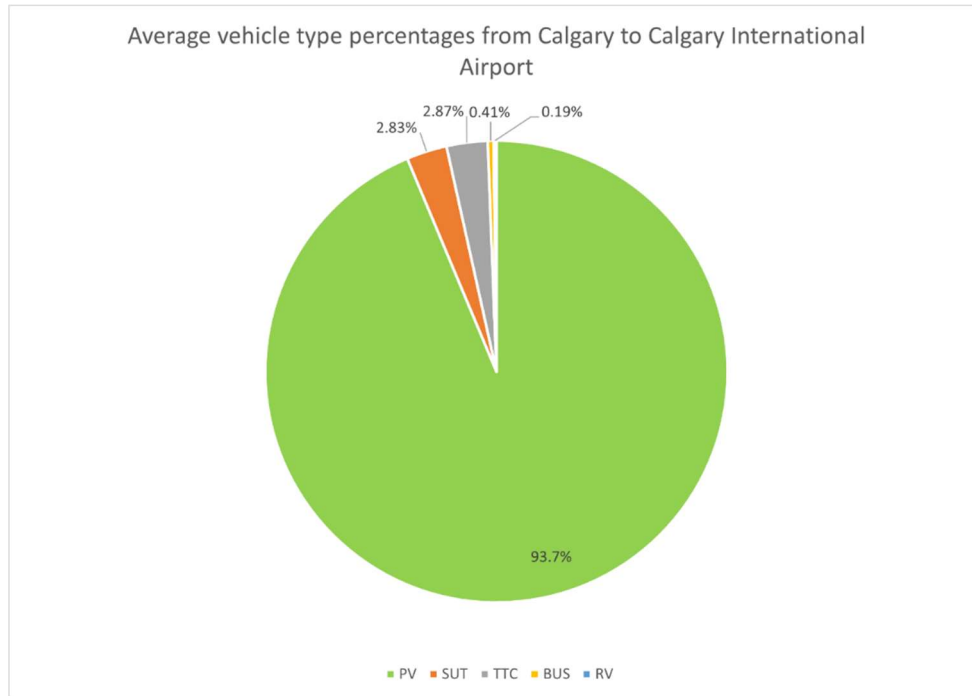


Figure 12: Average vehicle type percentages from the center of Calgary to Calgary International Airport

The first one is Calgary (#10000007) to Calgary International Airport (#10000022), shown in Figure 11. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Calgary to Calgary International Airport are shown in Figure 12.

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 13, 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%.

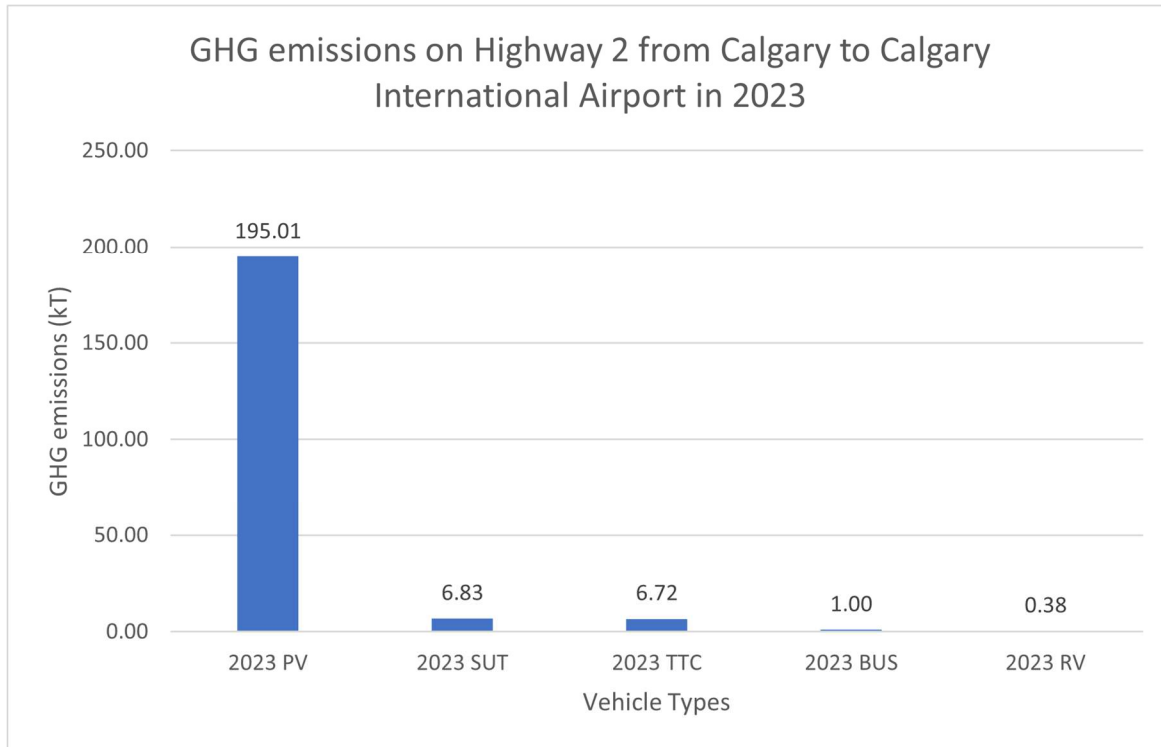


Figure 13: GHG emissions on Highway 2 from Calgary to Calgary International Airport in 2023

Calgary International Airport to Balzac

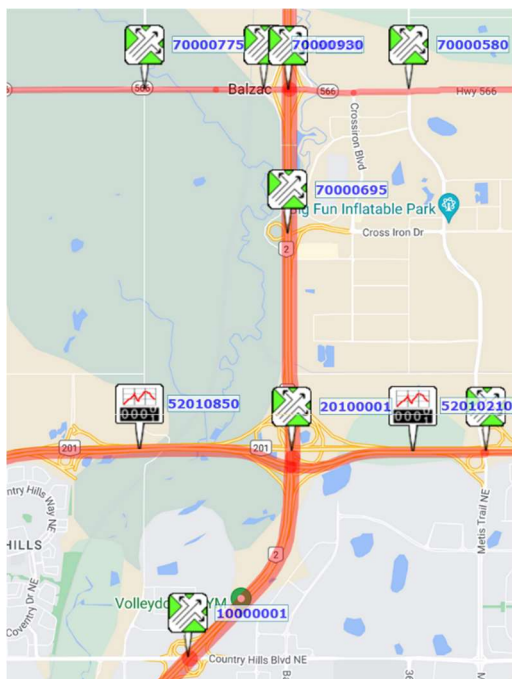


Figure 14: Intersections from Calgary International Airport to Balzac

The second one is Calgary International Airport (#10000022) to Balzac (#80210), shown in Figure 14. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Calgary International Airport to Balzac are shown in Figure 15.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 91.1% of the total vehicle types. The BUS only occupied 0.18% of all vehicle types for public transportation. 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 16, 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%.

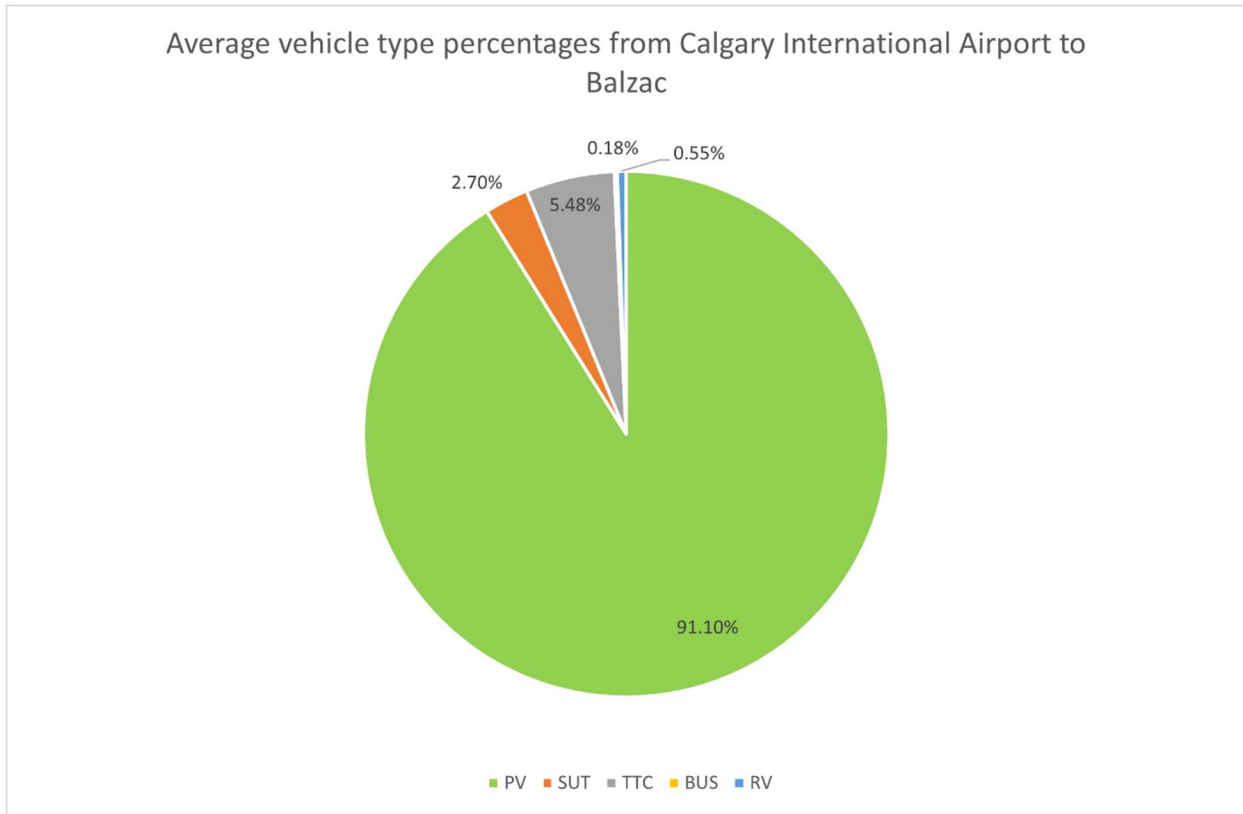


Figure 15: Average vehicle type percentages from Calgary International Airport to Balzac

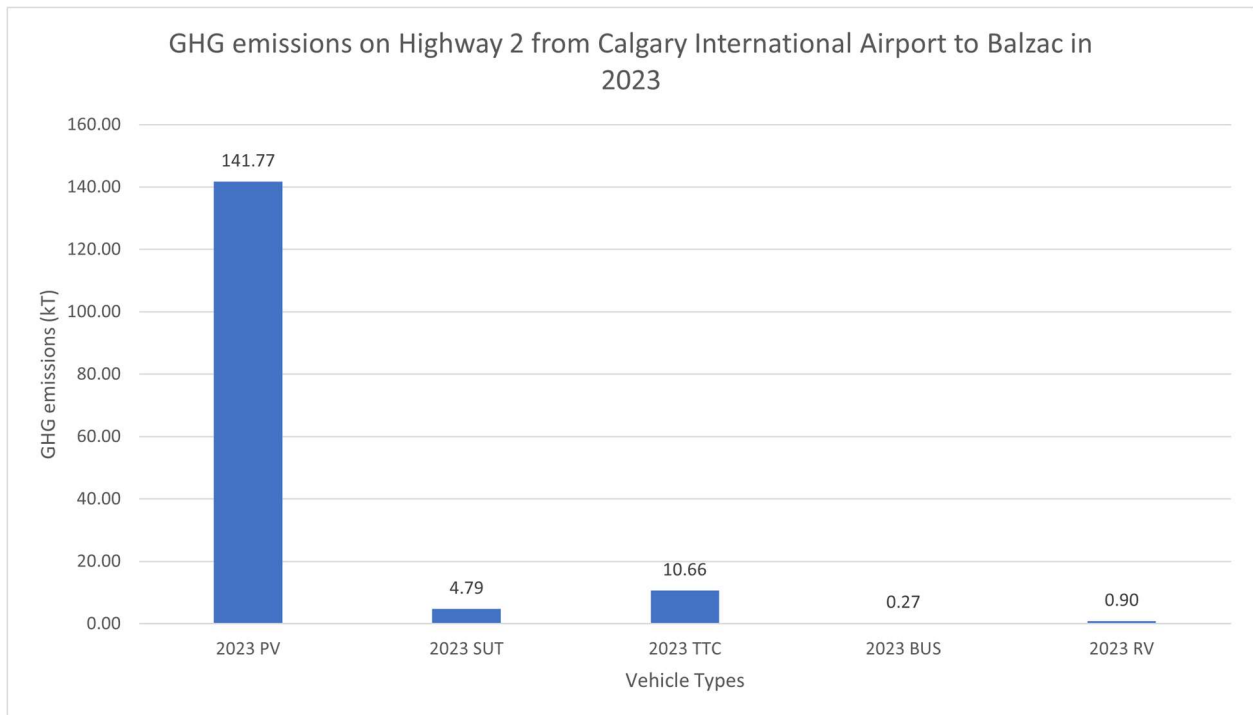


Figure 16: GHG emissions on Highway 2 from Calgary International Airport to Balzac in 2023

Balzac to Airdrie

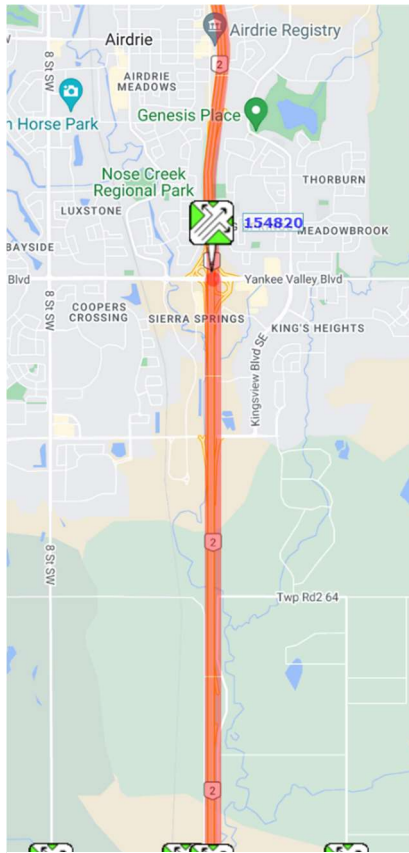


Figure 17: Intersections from Balzac to Airdrie

The third one is Balzac (#80210) to Airdrie (#154820), shown in Figure 17. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Balzac to Airdrie are shown in Figure 18.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 88.8% of the total vehicle types. The BUS only occupied 0.1% of all vehicle types for public transportation. 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 19, 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%.

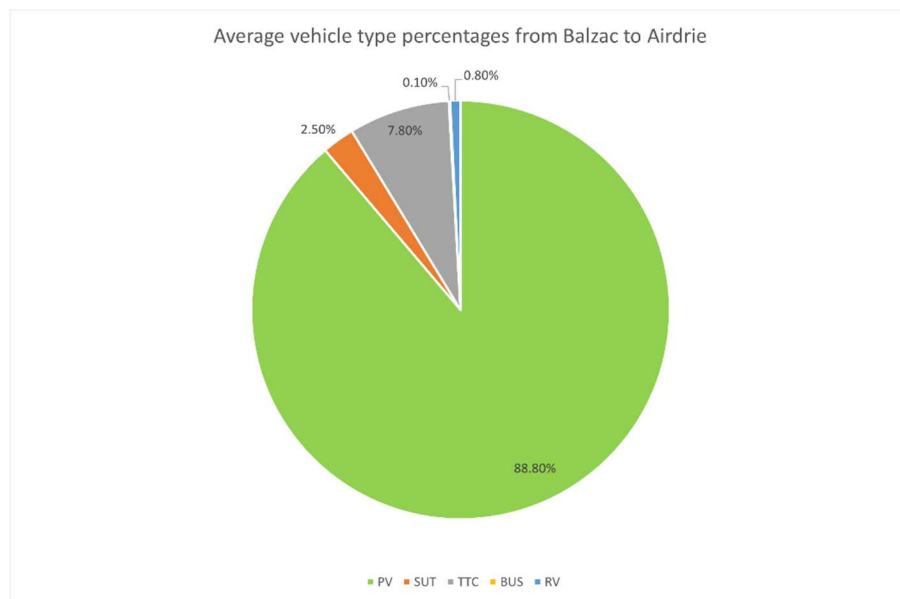


Figure 18: Average vehicle type percentages from Balzac to Airdrie

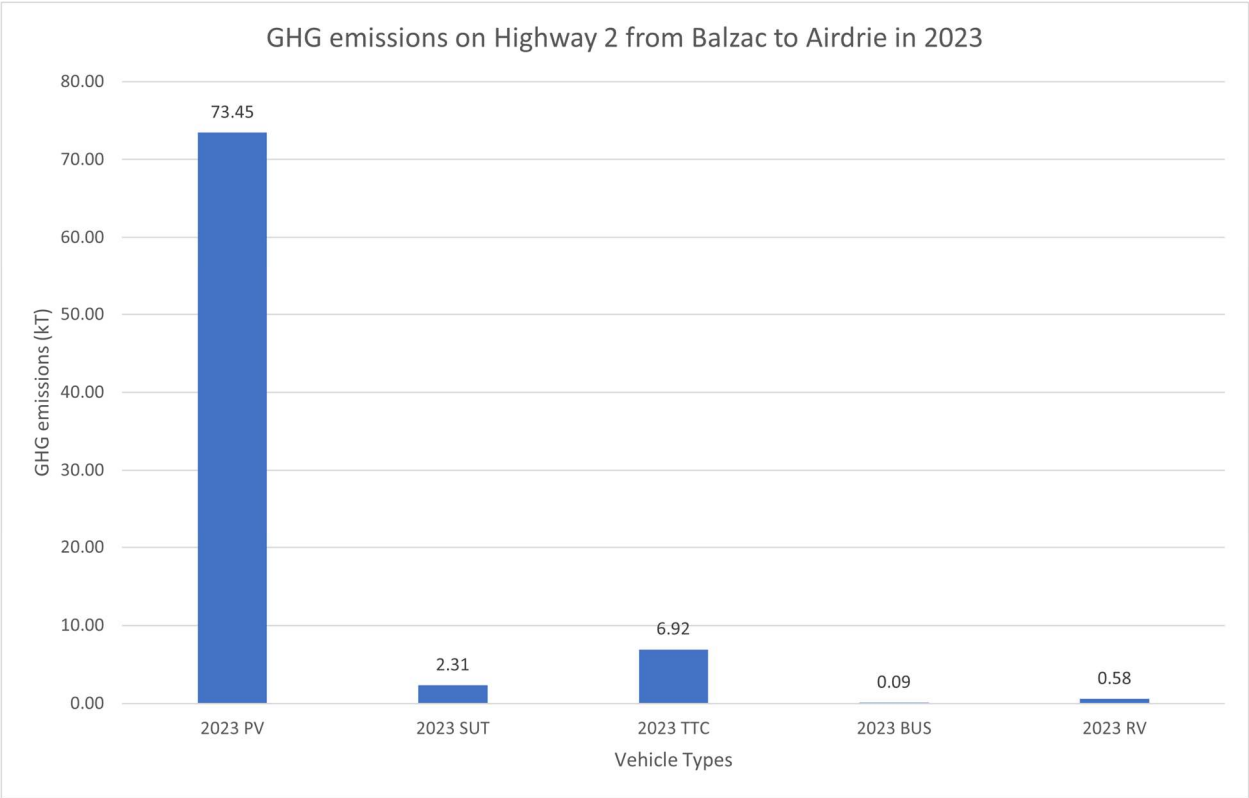


Figure 19: GHG emissions on Highway 2 from Balzac to Airdrie in 2023

Airdrie to Bowden

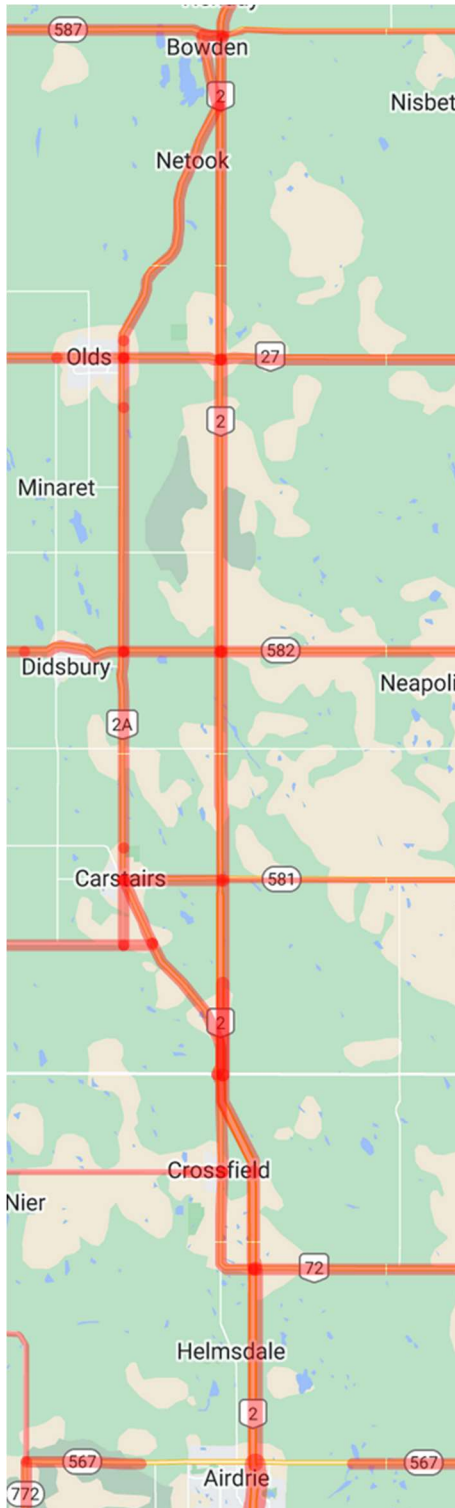


Figure 20: Intersections from Airdrie to Bowden

The fourth one is Airdrie (#154820) to Bowden (#79290), shown in Figure 20. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Airdrie to Bowden are shown in Figure 21.

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

For the GHG emissions shown in Figure 22, 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%.

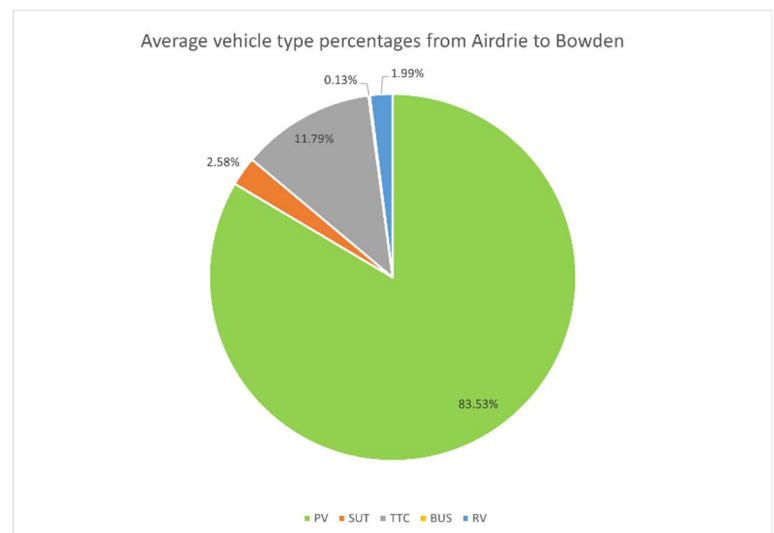


Figure 21: Average vehicle type percentages from Airdrie to Bowden

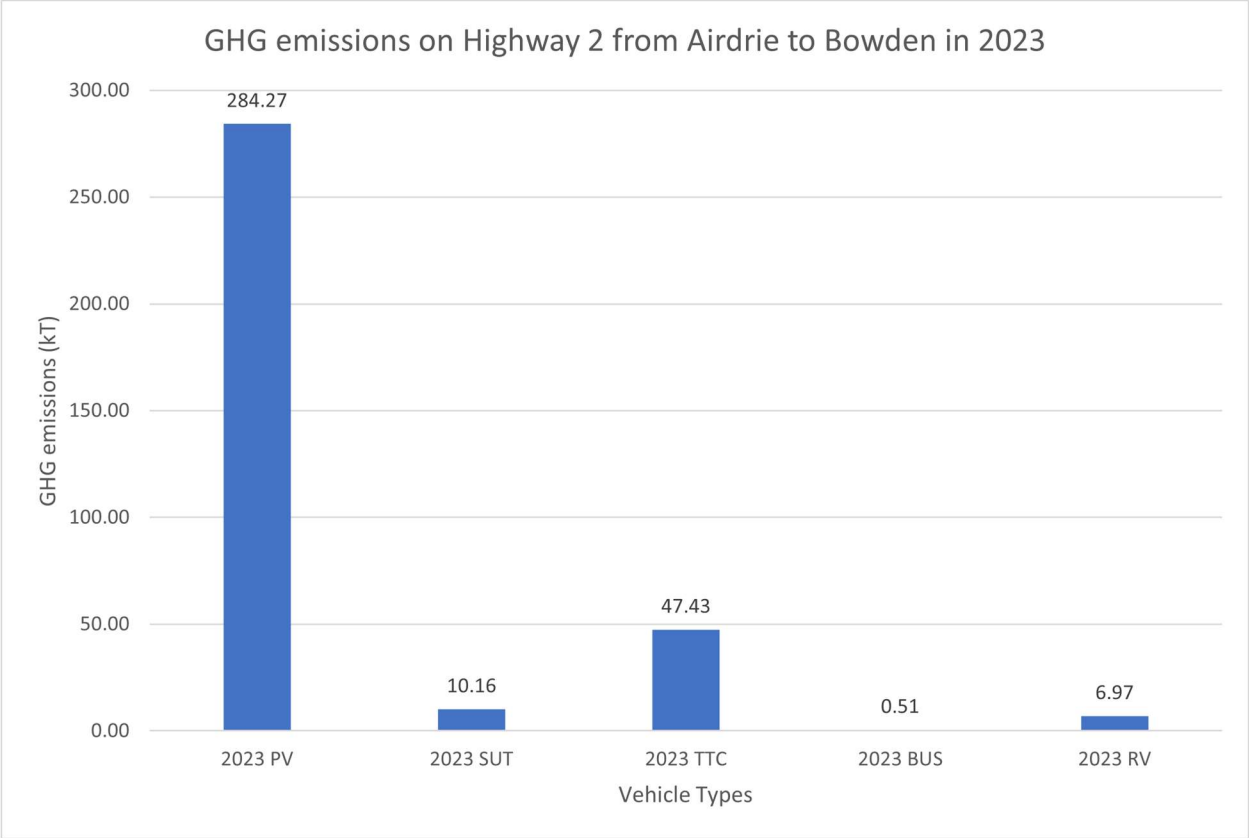


Figure 22: GHG emissions on Highway 2 from Airdrie to Bowden in 2023

Bowden to Innisfail

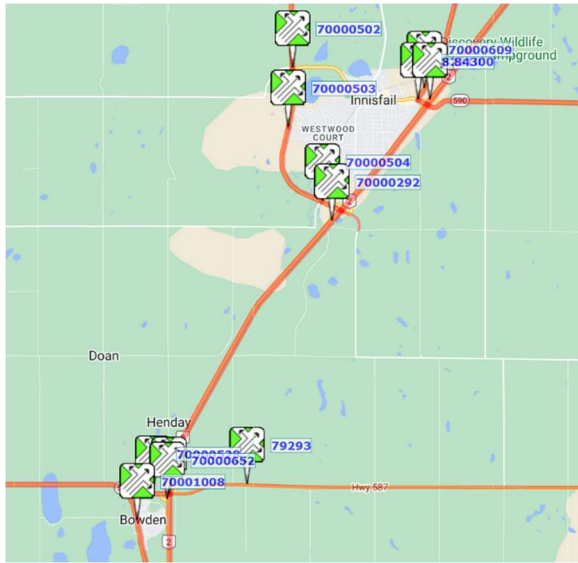


Figure 23: Intersections from Bowden to Innisfail

The fifth one is Bowden (#79290) to Innisfail (#84300), shown in Figure 23. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Bowden to Innisfail are shown in Figure 24.

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

For the GHG emissions shown in Figure 25, 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%.

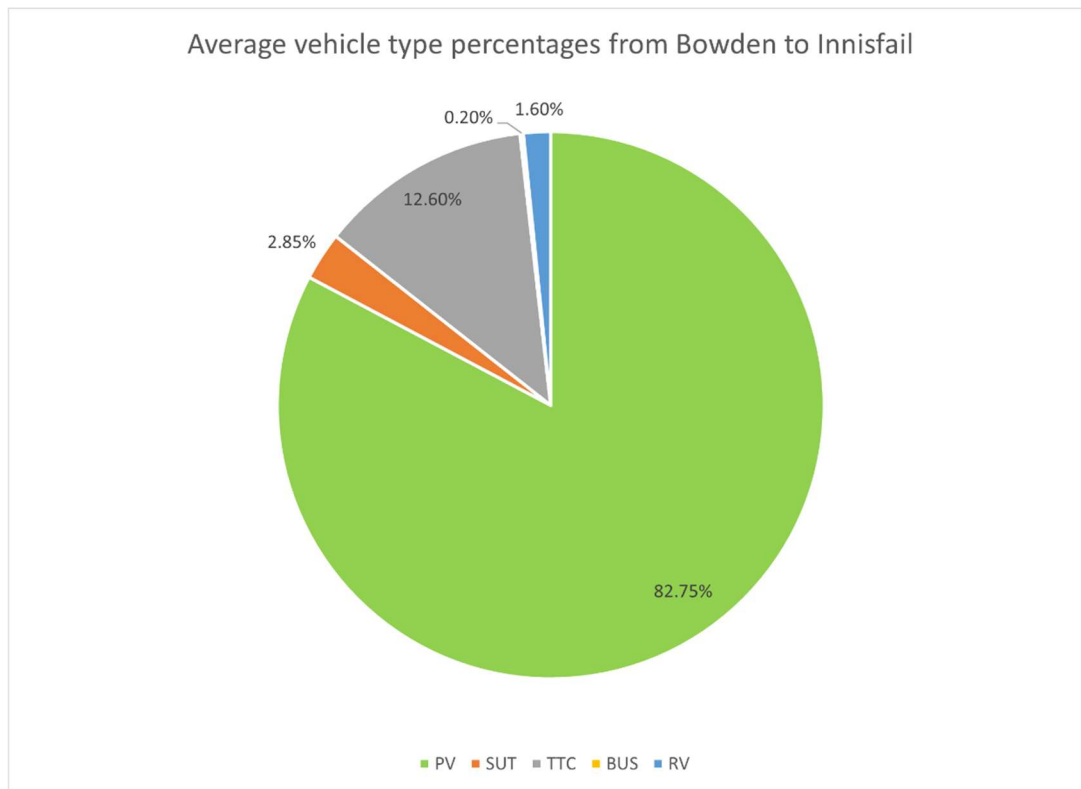


Figure 24: Average vehicle type percentages from Bowden to Innisfail

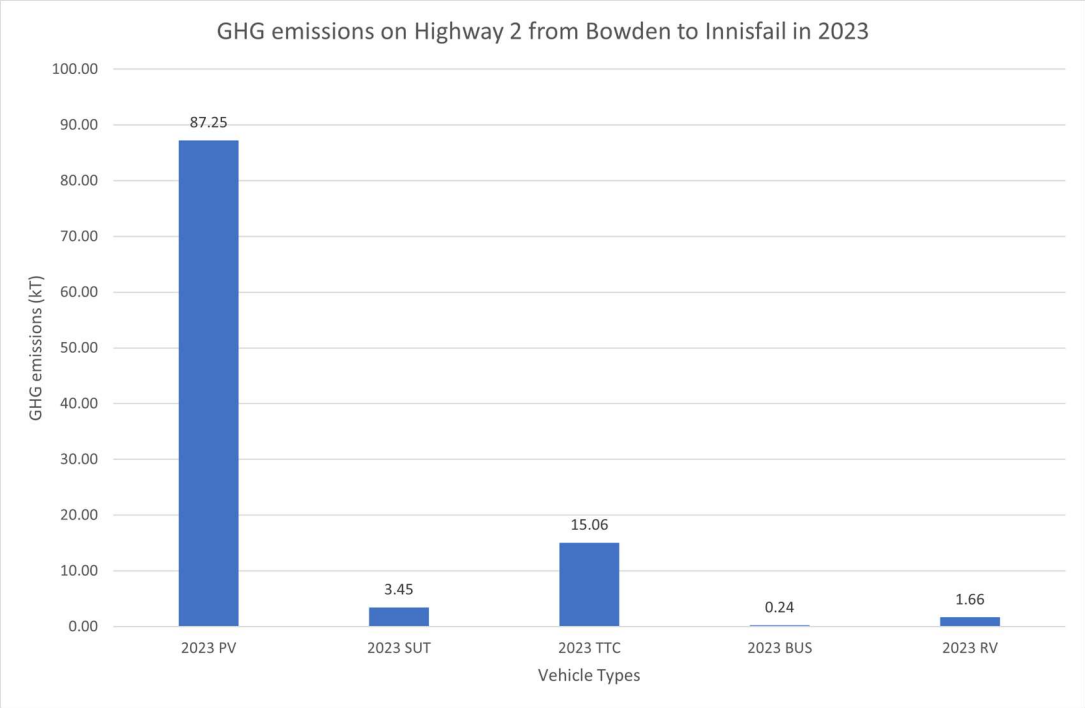


Figure 25: GHG emissions on Highway 2 from Bowden to Innisfail in 2023

Innisfail to Les Trailer Park

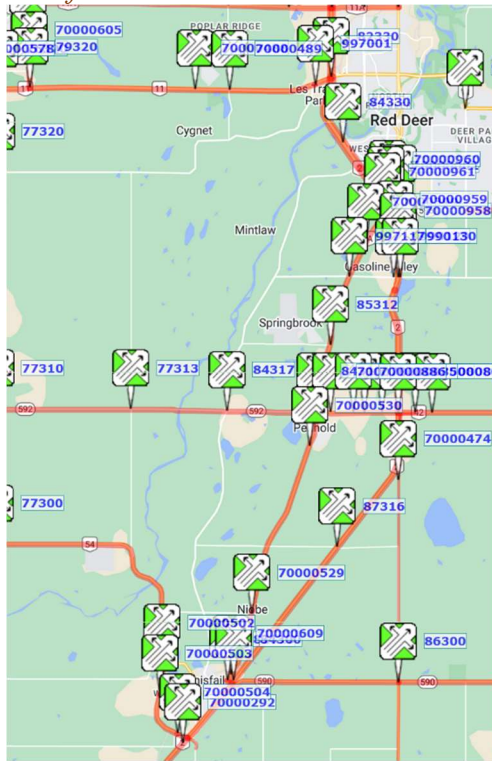


Figure 26: Intersections from Innisfail to Les Trailer Park

The sixth one is Innisfail (#84300) to Les Trailer Park (#82330), shown in Figure 26. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Innisfail to Les Trailer Park are shown in Figure 27.

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

For the GHG emissions shown in Figure 28, 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%.

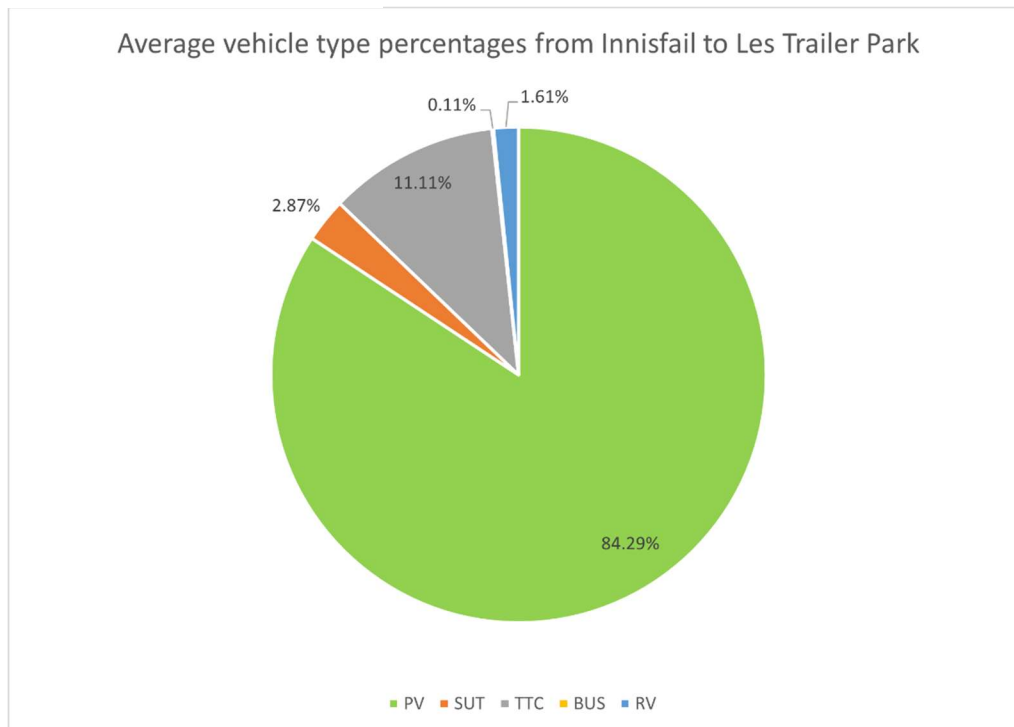


Figure 27: Average vehicle type percentages from Innisfail to Les Trailer Park

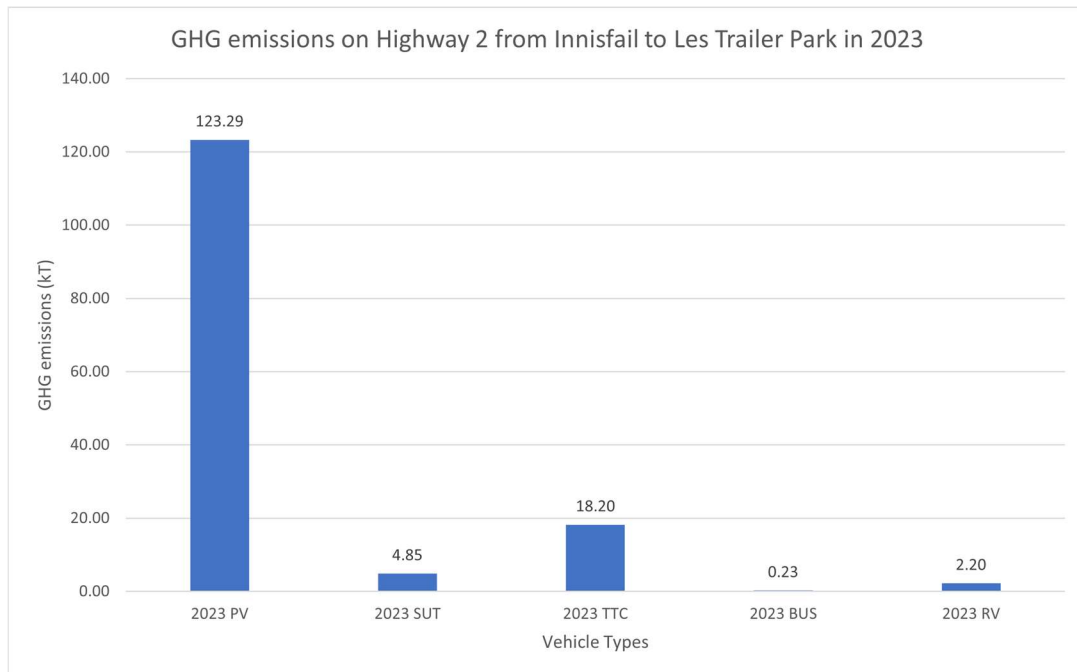


Figure 28: GHG emissions on Highway 2 from Innisfail to Les Trailer Park in 2023

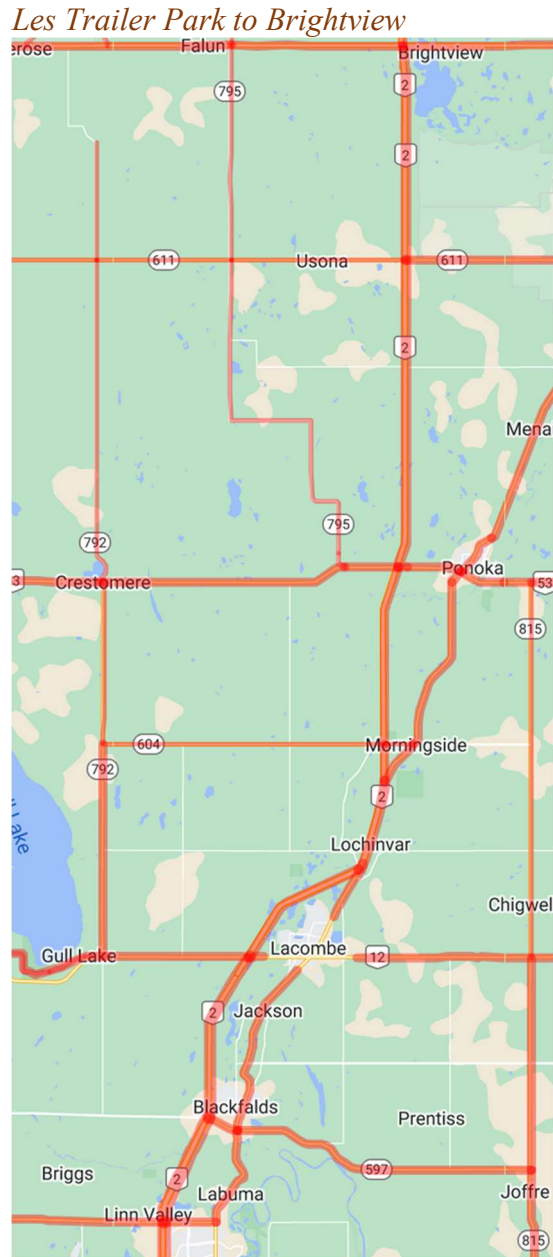


Figure 29: Intersections from Les Trailer Park to Brightview

The seventh one is Les Trailer Park (#82330) to Brightview (#94390), shown in Figure 29. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Les Trailer Park to Brightview are shown in Figure 30.

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

For the GHG emissions shown in Figure 31, 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%.

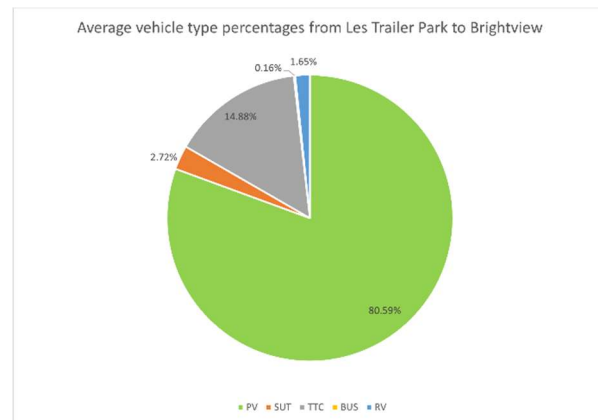


Figure 30: Average vehicle type percentages from Les Trailer Park to Brightview

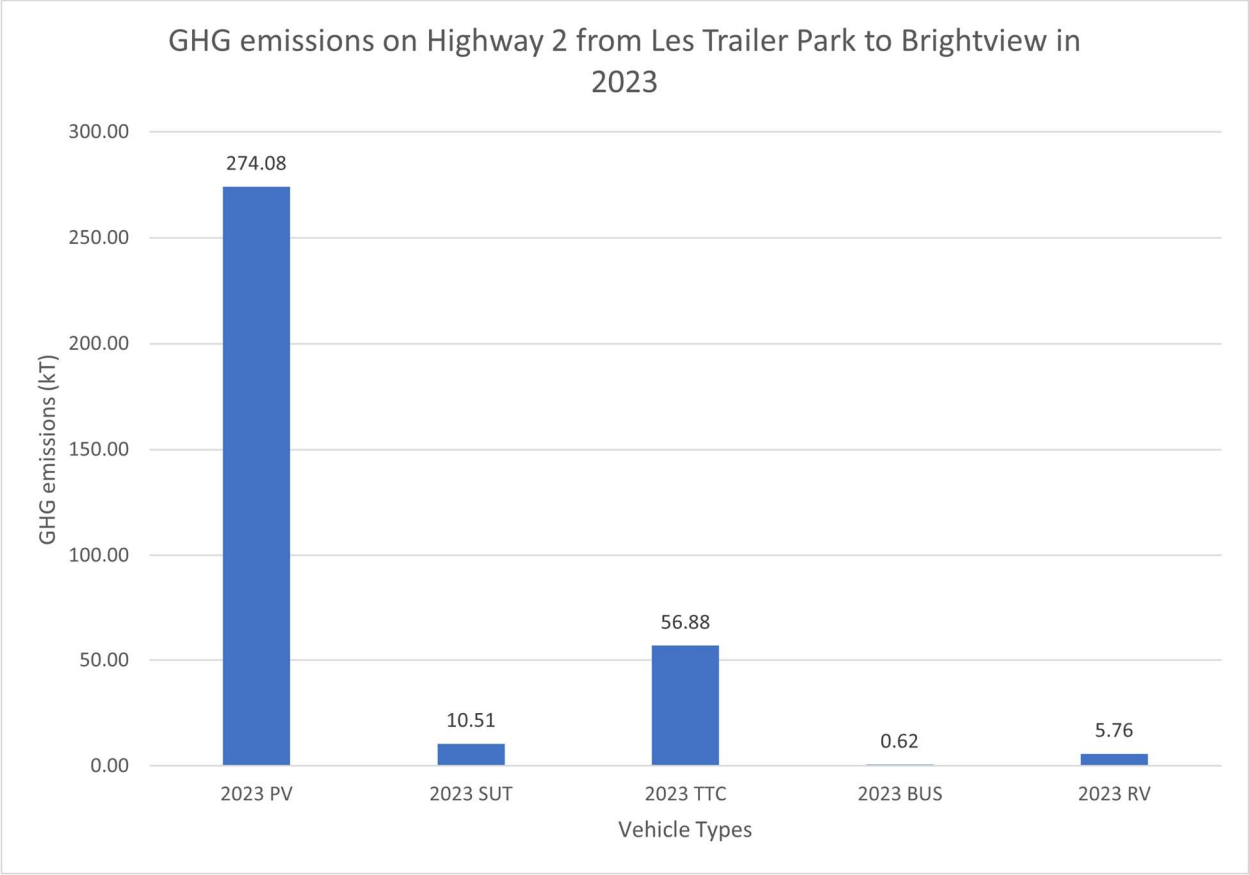


Figure 31: GHG emissions on Highway 2 from Les Trailer Park to Brightview in 2023

Brightview to Corinthia Park

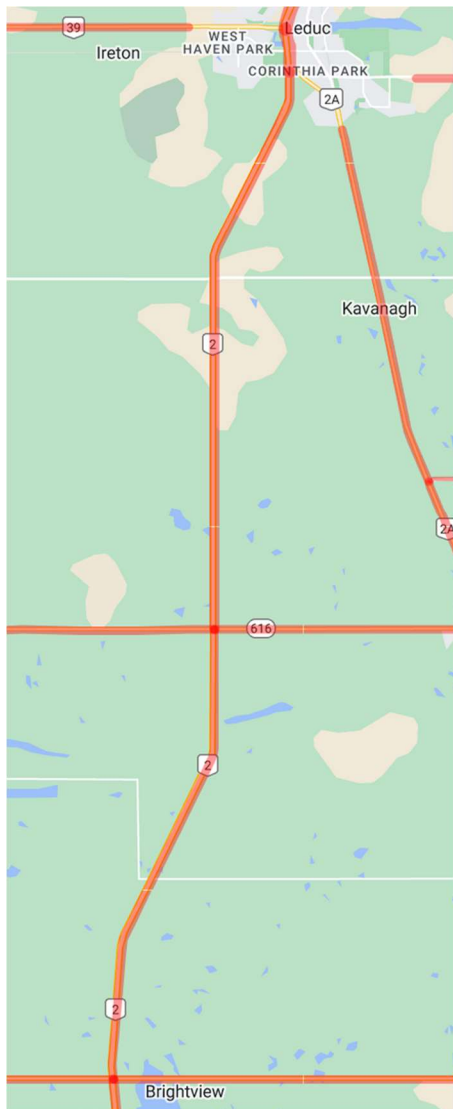


Figure 32: Intersections from Brightview to Corinthia Park

The eighth one is Brightview (#94390) to Corinthia Park (#87450), shown in Figure 32. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Brightview to Corinthia Park are shown in Figure 33.

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

For the GHG emissions shown in Figure 34, 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%.

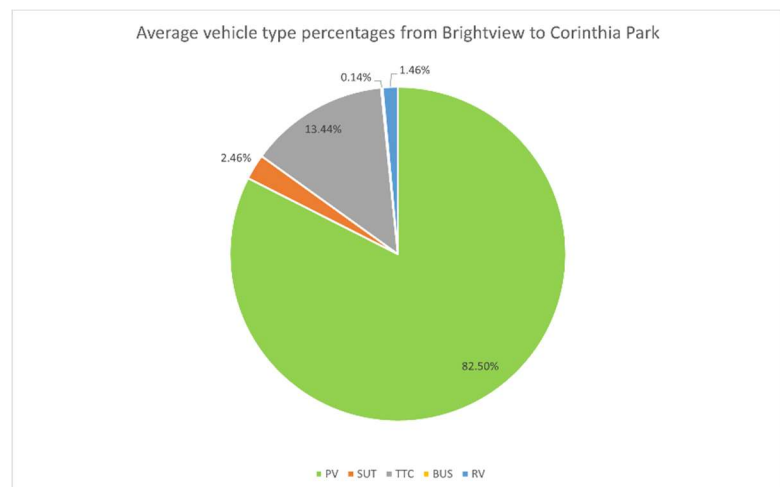


Figure 33: Average vehicle type percentages from Brightview to Corinthia Park

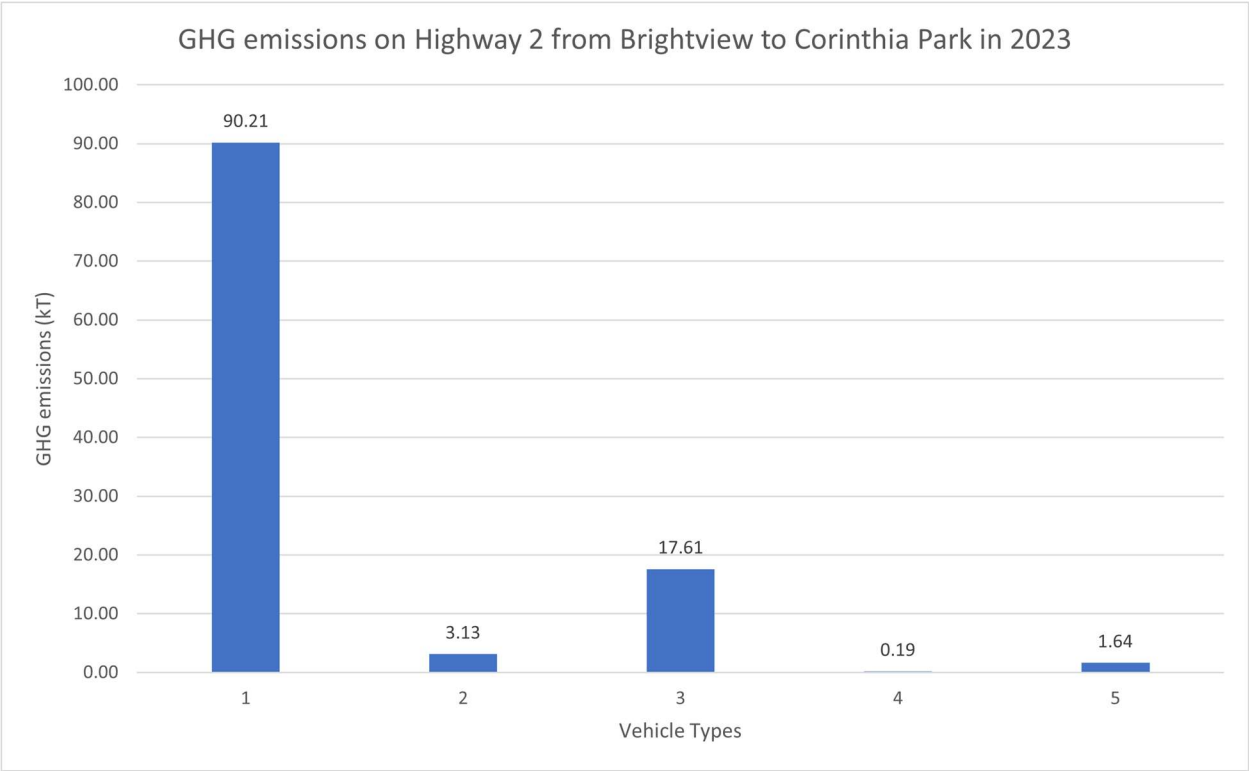


Figure 34: GHG emissions on Highway 2 from Brightview to Corinthia Park in 2023

Corinthia Park to Leduc

The ninth one is Corinthia Park (#87450) to Leduc (#88450), shown in Figure 35. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Corinthia Park to Leduc are shown in Figure 36.

PV dominated the traffic type on Highway 2 from Corinthia Park to Leduc, with 87.5% of the total vehicle types. The BUS only occupied 0.1% of all vehicle types for public transportation. 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 37, 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%.

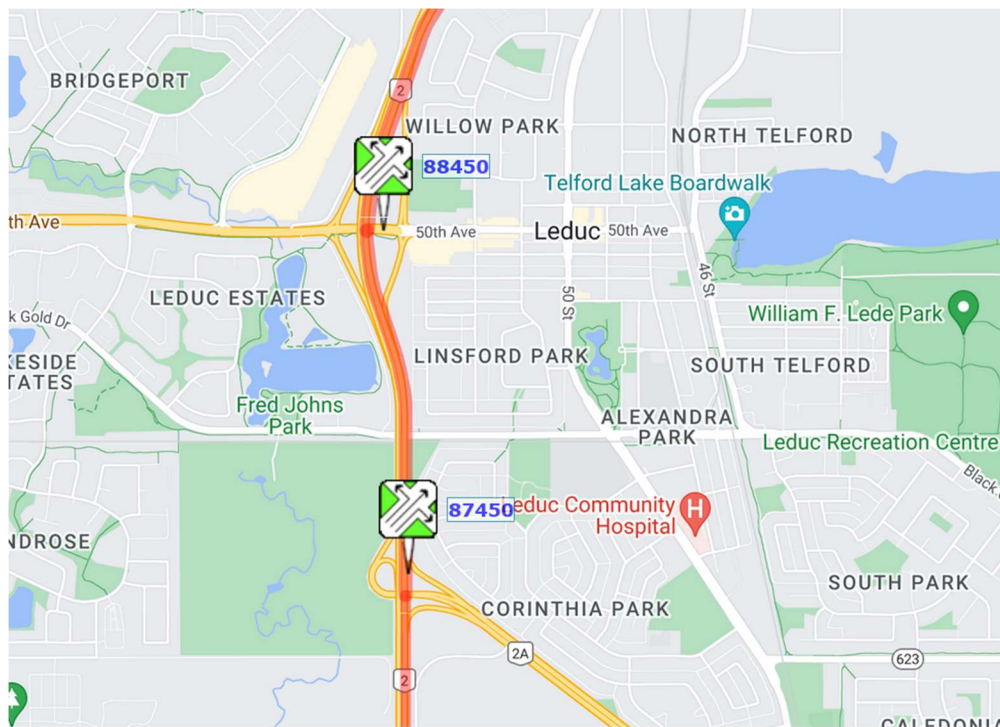


Figure 35: Intersections from Corinthia Park to Leduc

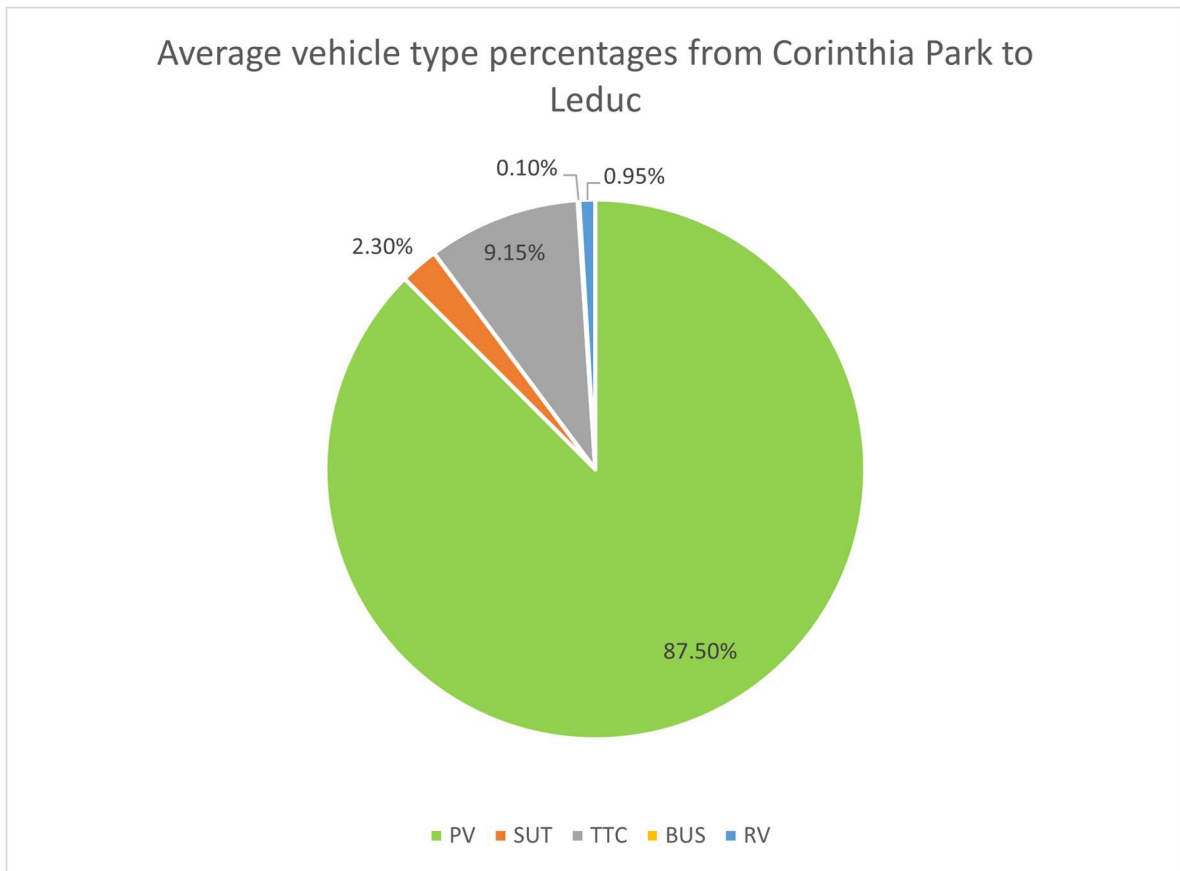


Figure 36: Average vehicle type percentages from Corinthia Park to Leduc

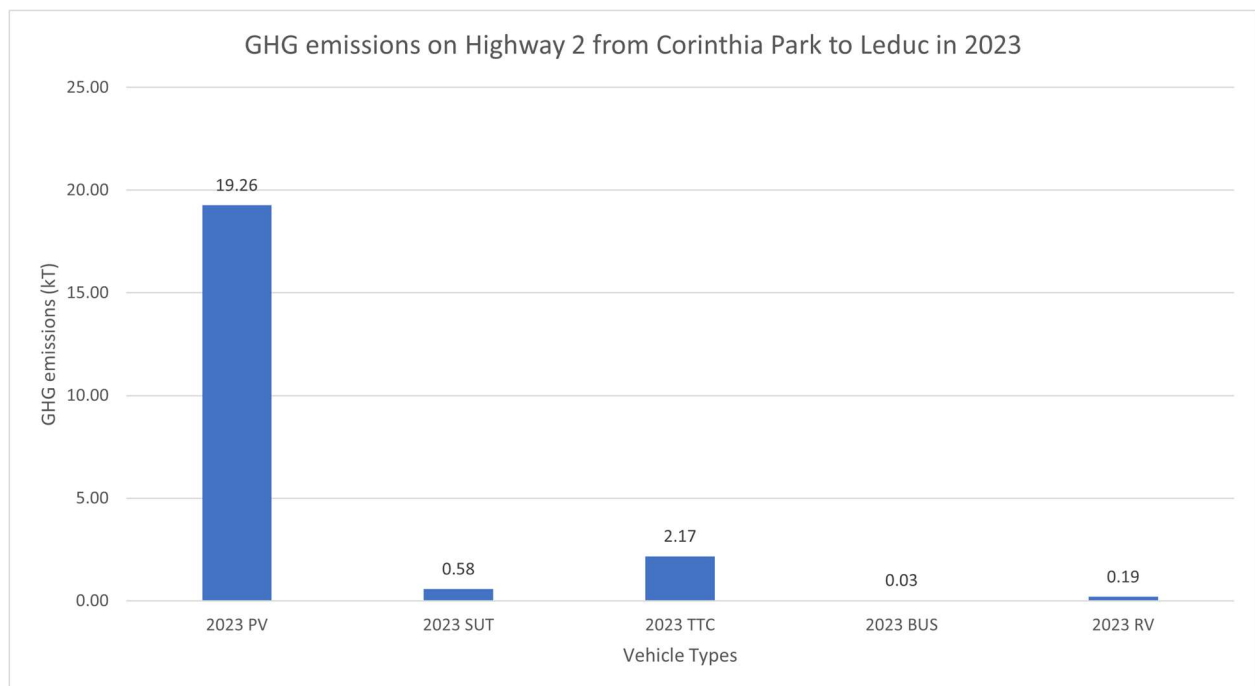


Figure 37: GHG emissions on Highway 2 from Corinthia Park to Leduc in 2023

Leduc to Edmonton

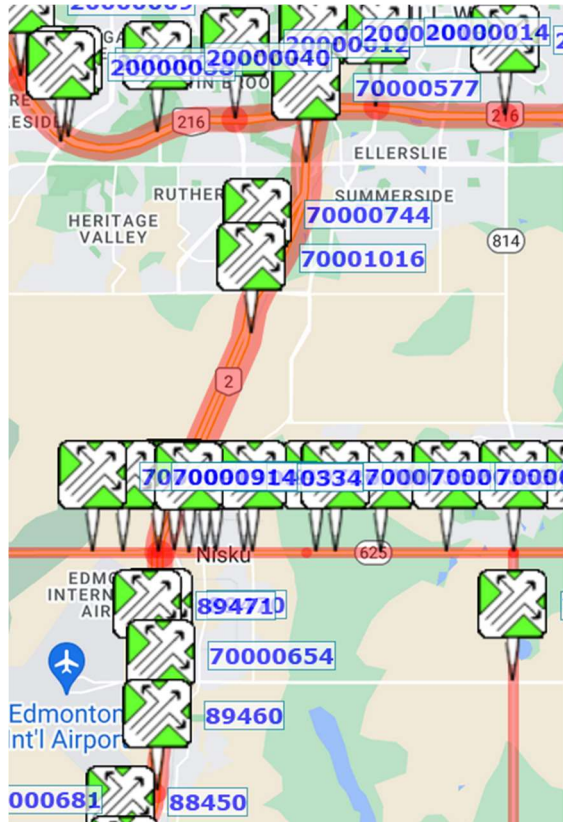


Figure 38: Intersections from Leduc to Edmonton

The last one is Leduc (#88450) to Edmonton (#20000013), shown in Figure 38. Based on the dataset in GHG emissions based on locations (C-E), vehicle types from Leduc to Edmonton are shown in Figure 39.

PV dominated the traffic type on Highway 2 from Calgary International Airport to Balzac, with 89.76% of the total vehicle types. The BUS only occupied 0.16% of all vehicle types for public transportation. 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 40, 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%.

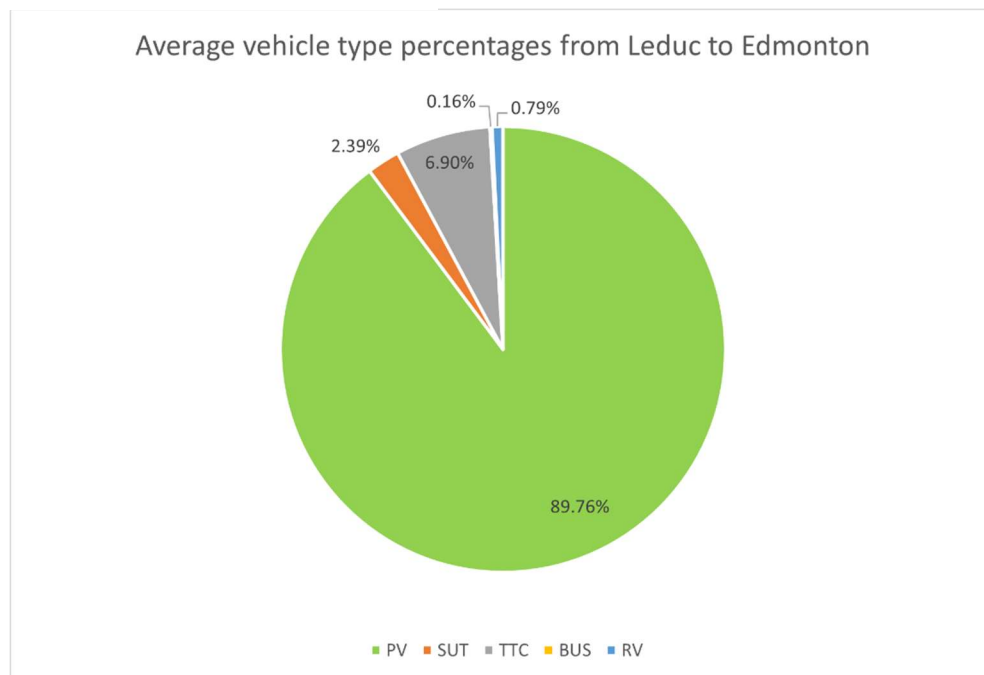


Figure 39: Average vehicle type percentages from Leduc to Edmonton

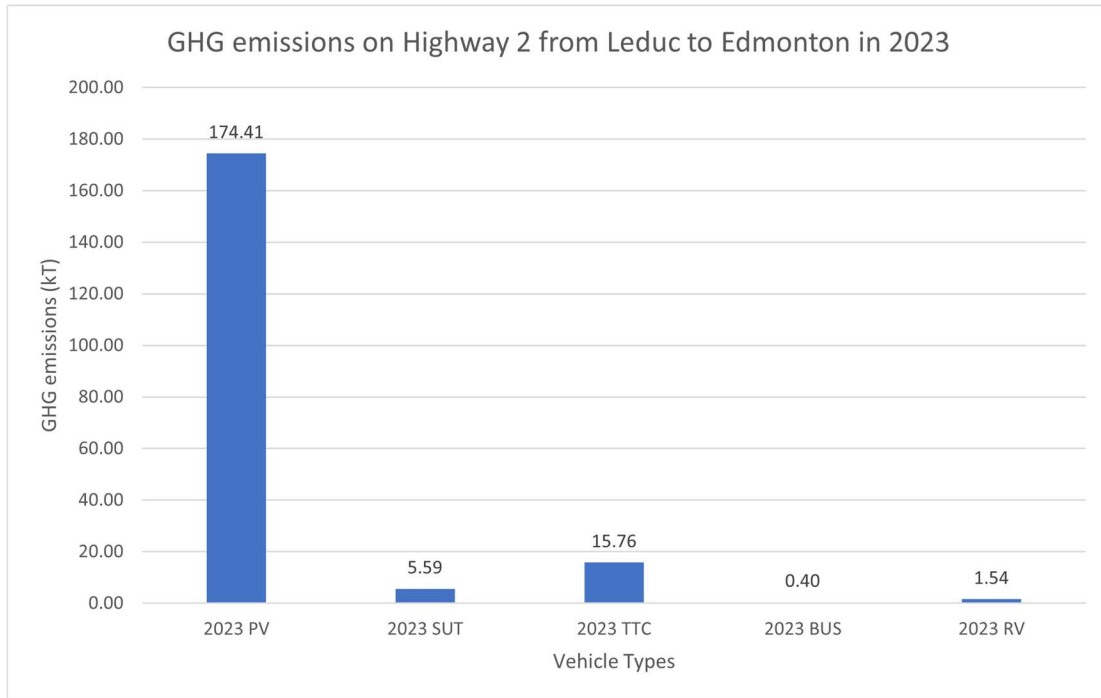


Figure 40: GHG emissions on Highway 2 from Leduc to Edmonton in 2023

Impact of COVID-19 to GHG emissions

When the COVID-19 exploded, the GHG emission dropped 298.18 kT from 2019 to 2020. Specifically, 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, GHG emissions gradually increased and slightly decreased from 2020 to 2023. From 2020 to 2021, the GHG emission increased to 85.41 kT. From 2021 to 2022, the GHG emission decreased 48.83 kT. From 2022 to 2023, the GHG emission increased to 91.73 kT.

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

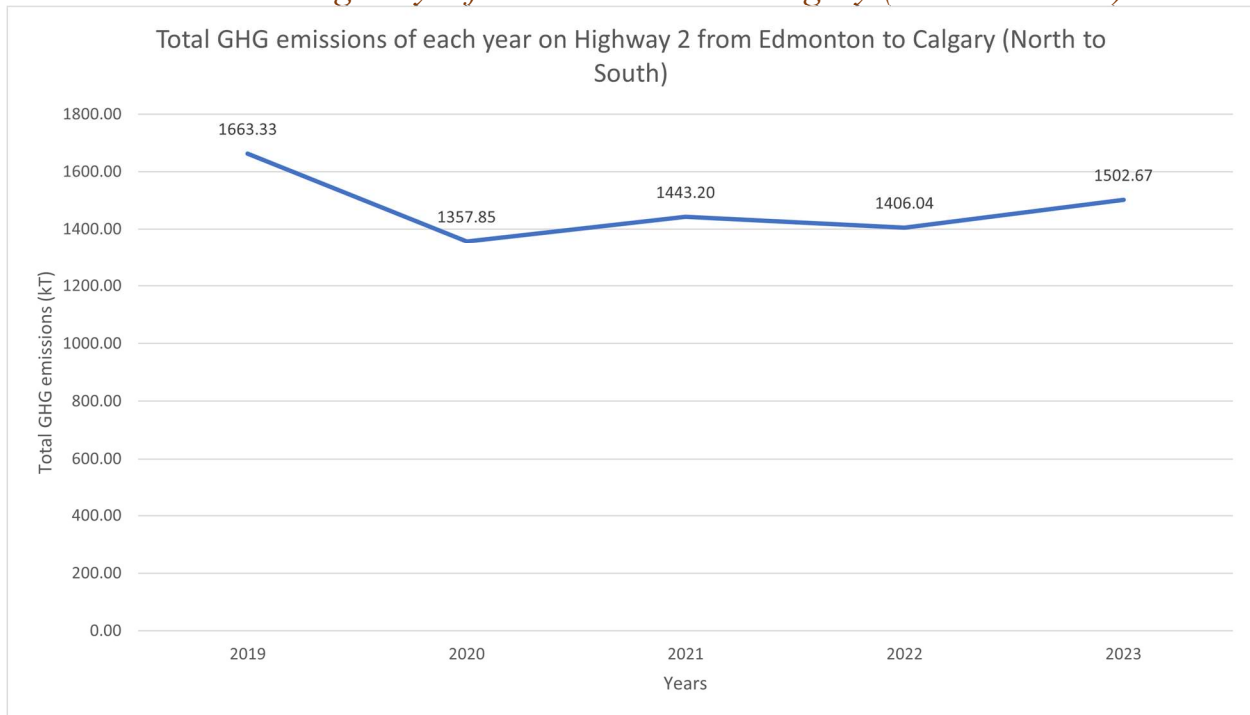


Figure 41: Total GHG emissions of each year on Highway 2 from Edmonton to Calgary (North to South) from 2019 to 2023

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. The start point is in the South of Edmonton, going through Leduc, Corinthia Park, Brightview, Les Trailer Park, West Park Extension, Gasoline Alley, Innisfail, Bowden, Airdrie, Balzac, Calgary International Airport, and endpoint in Calgary. From Figure 41, 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), from Edmonton to Leduc, the traffic counts gradually decreased, from 48610 dropped to 19560 vehicles in 2023. From Leduc to Corinthia Park, the vehicle counts dropped from 19560 to 13200 in 2023. From Corinthia Park to Brightview, the vehicle counts dropped from 13200 to 12820 in 2023. From Brightview to Les Trailer Park, the vehicle counts increased from 12820 to 24130 in 2023. From Les Trailer Park 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 Les Trailer Park and Brightview. 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. From the center of Edmonton, pass through Leduc, Corinthia Park, Brightview, Les Trailer Park, Innisfail, Bowden, Airdrie, Balzac, and Calgary International Airport, and arrive at Calgary. Based on the result from Figure 42, 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, Les Trailer Park to Innisfail, Leduc to Corinthia Park, Brightview to Les Trailer Park, Innisfail to Bowden, and finally Corinthia Park to Brightview.

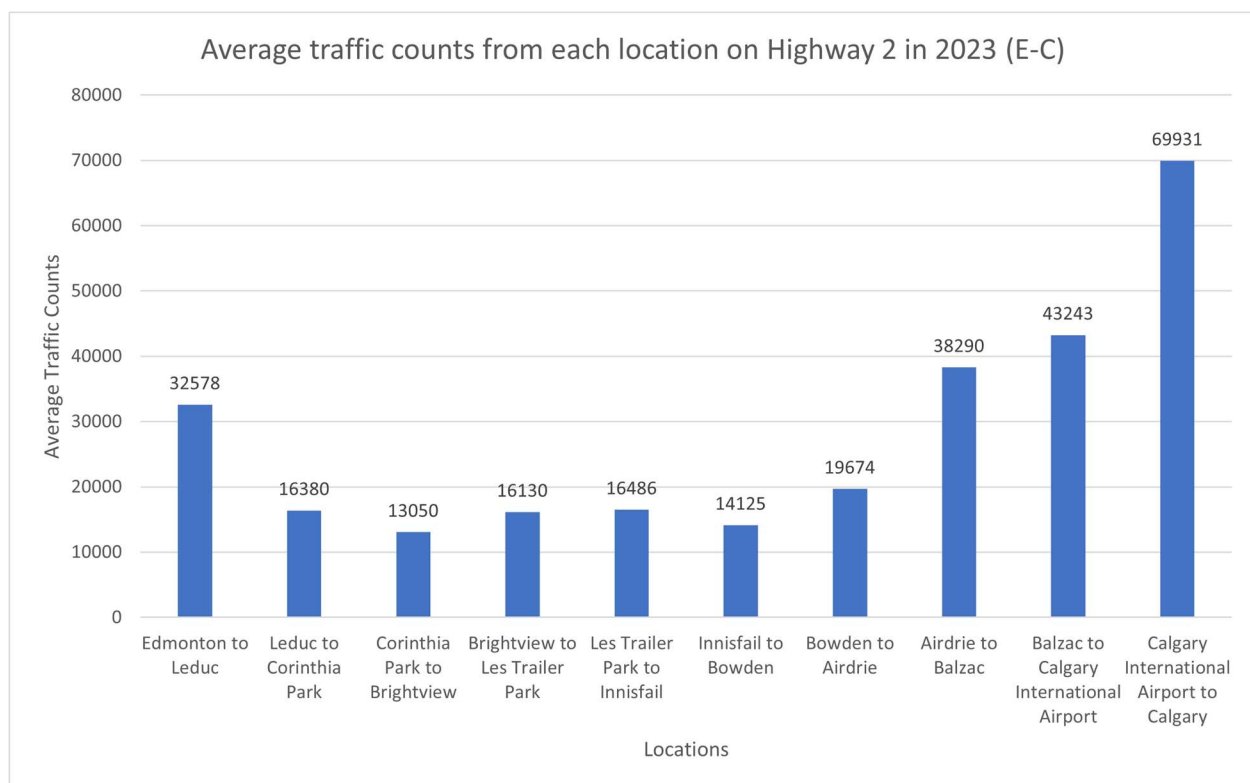


Figure 42: Average traffic counts from each location on Highway 2 in 2023 (E-C)

Edmonton to Leduc

The first is Edmonton (#20000013) to Leduc (#88450). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Edmonton to Leduc are shown in Figure 43.

PV dominated the traffic type on Highway 2 from Edmonton to Leduc, with 89.76% of all vehicle types. The BUS only occupied 0.16% of all vehicle types for public transportation. 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 44, 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%.

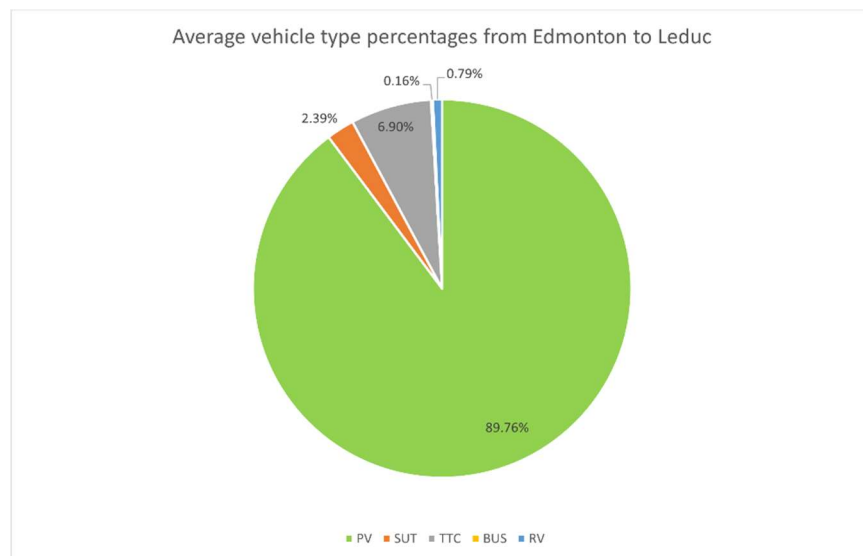


Figure 43: Average vehicle type percentages from Edmonton to Leduc

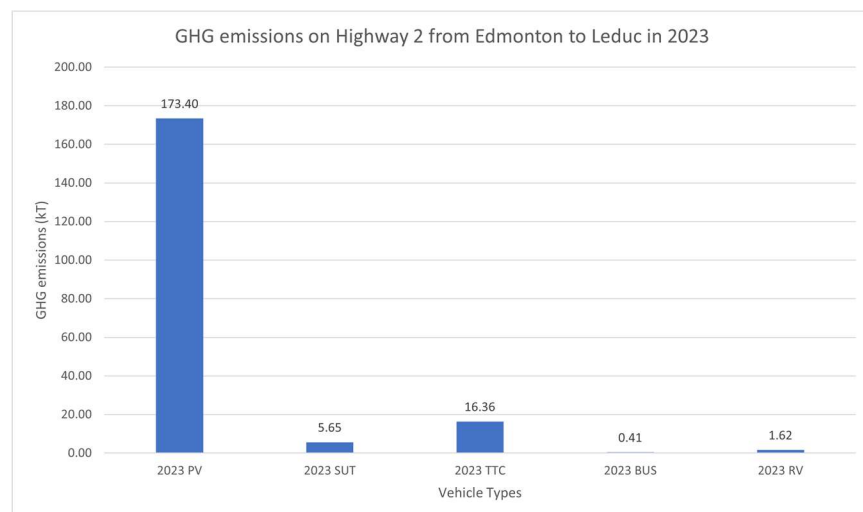


Figure 44: GHG emissions on Highway 2 from Edmonton to Leduc in 2023

Leduc to Corinthia Park

The second is Leduc (#88450) to Corinthia Park (#87450). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Leduc to Corinthia Park are shown in Figure 45.

PV dominated the traffic type on Highway 2 from Leduc to Corinthia Park, 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%.

For the GHG emissions shown in Figure 46, 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%.

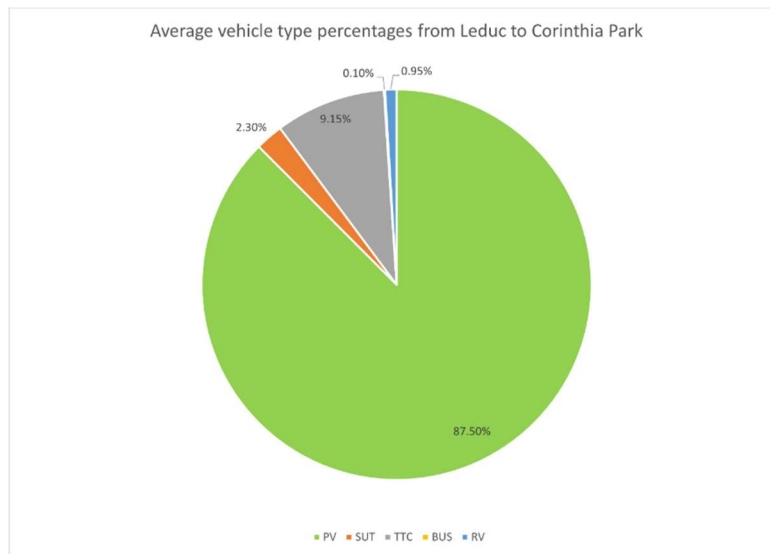


Figure 45: Average vehicle type percentages from Leduc to Corinthia Park

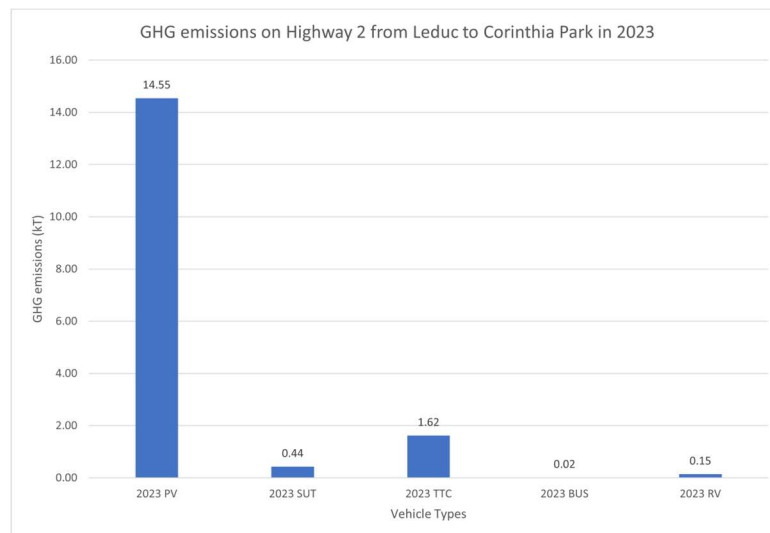


Figure 46: GHG emissions on Highway 2 from Leduc to Corinthia Park in 2023

Corinthia Park to Brightview

The third one is from Corinthia Park (#87450) to Brightview (#94390). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Corinthia Park to Brightview are shown in Figure 47.

PV dominated the traffic type on Highway 2 from Corinthia Park to Brightview, with 82.5% of all vehicle types. The BUS only occupied 0.14% of all vehicle types for public transportation. 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 48, 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%.

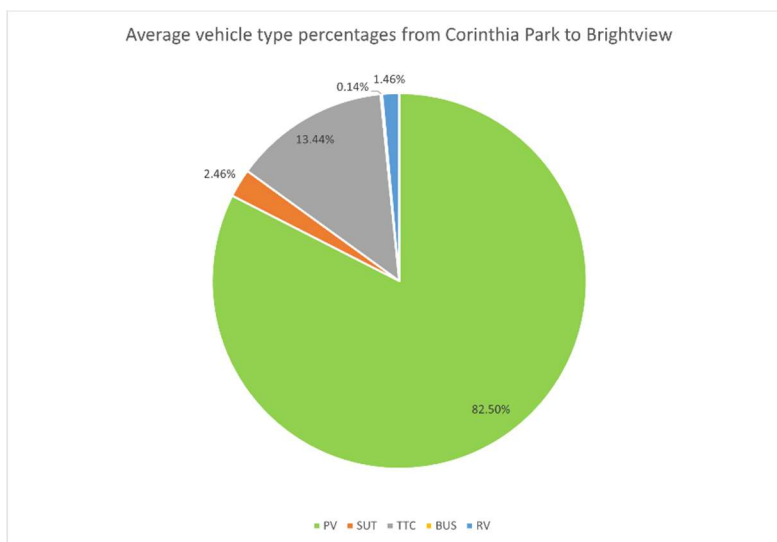


Figure 47: Average vehicle type percentages from Corinthia Park to Brightview

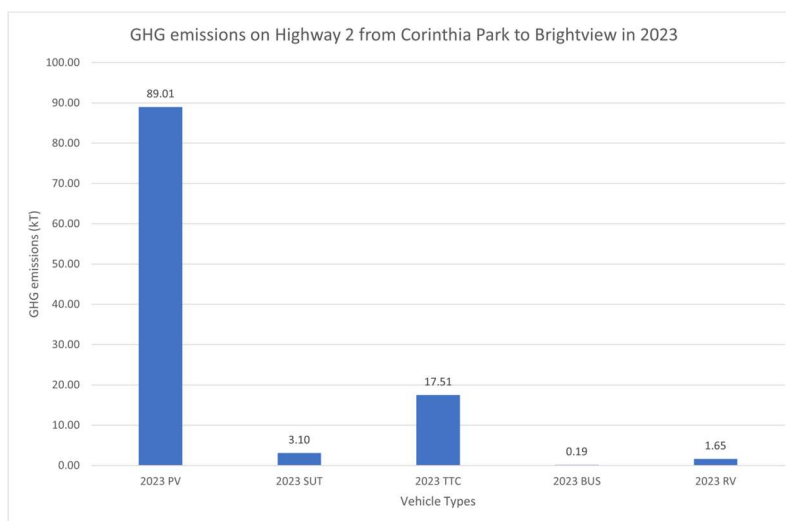


Figure 48: GHG emissions on Highway 2 from Corinthia Park to Brightview in 2023

Brightview to Les Trailer Park

The fourth one is from Brightview (#94390) to Les Trailer Park (#82330). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Brightview to Les Trailer Park are shown in Figure 49.

PV dominated the traffic type on Highway 2 from Brightview to Les Trailer Park, with 80.59% of all vehicle types. The BUS only occupied 0.16% of all vehicle types for public transportation. 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 50, 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%.

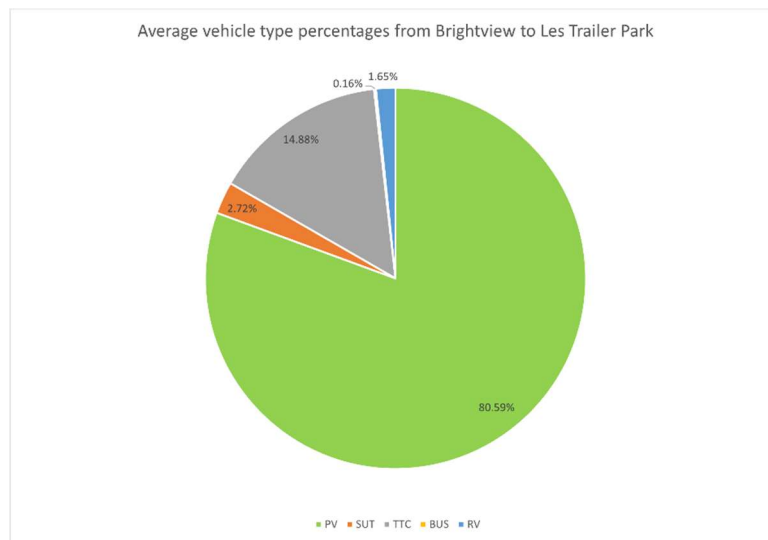


Figure 49: Average vehicle type percentages from Brightview to Les Trailer Park

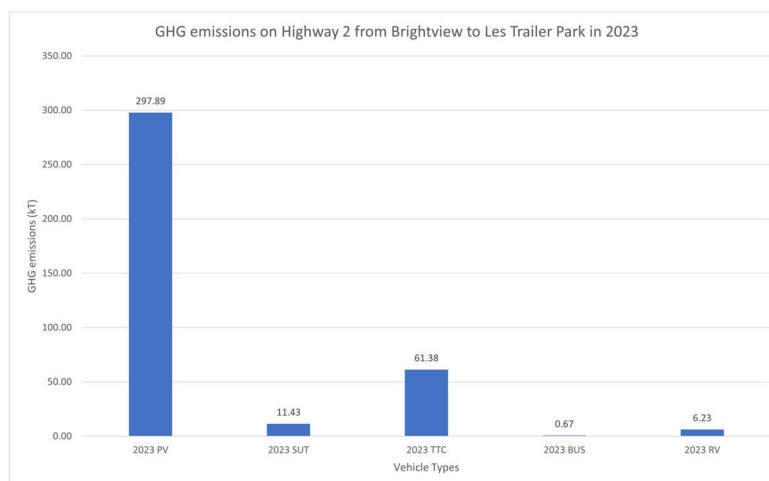


Figure 50: GHG emissions on Highway 2 from Brightview to Les Trailer Park in 2023

Les Trailer Park to Innisfail

The fifth is Les Trailer Park (#82330) to Innisfail (#84300). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Les Trailer Park to Innisfail are shown in Figure 51.

PV dominated the traffic type on Highway 2 from Les Trailer Park to Innisfail, with 84.29% of all vehicle types. The BUS only occupied 0.11% of all vehicle types for public transportation. 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 52, 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%.

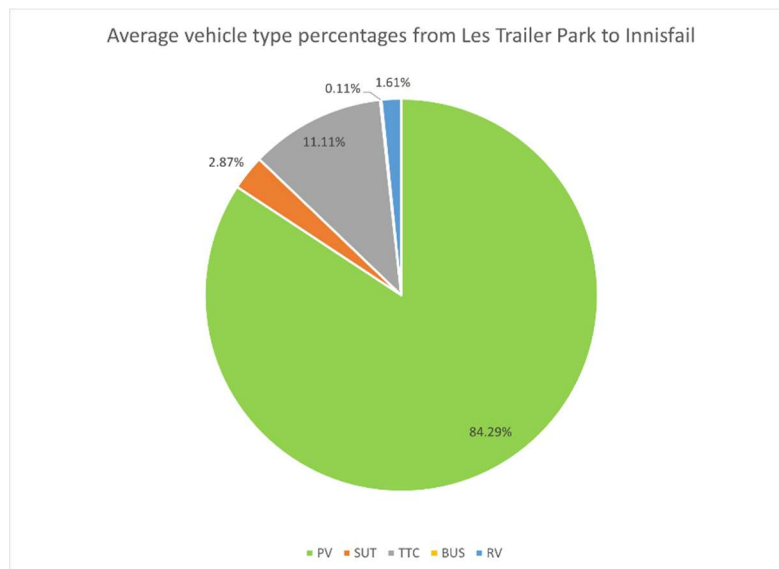


Figure 51: Average vehicle type percentages from Les Trailer Park to Innisfail

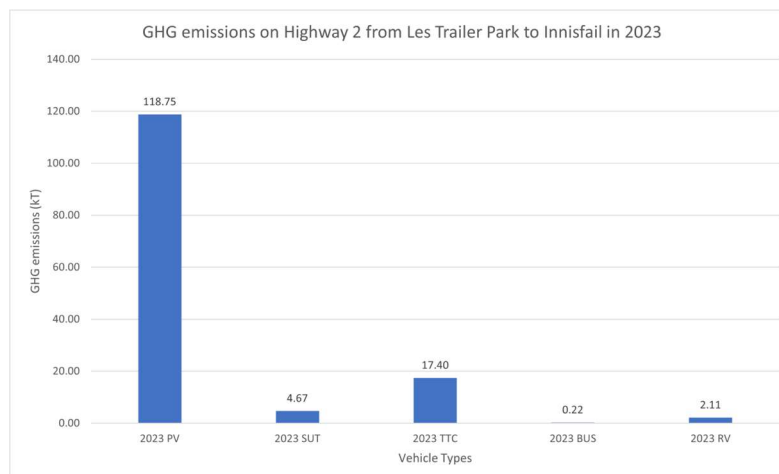


Figure 52: GHG emissions on Highway 2 from Les Trailer Park to Innisfail in 2023

Innisfail to Bowden

The sixth one is from Innisfail (#84300) to Bowden (#79290). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Innisfail to Bowden are shown in Figure 53.

PV dominated the traffic type on Highway 2 from Innisfail to Bowden, with 82.75% of all vehicle types. The BUS only occupied 0.2% of all vehicle types for public transportation. 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 54, 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%.

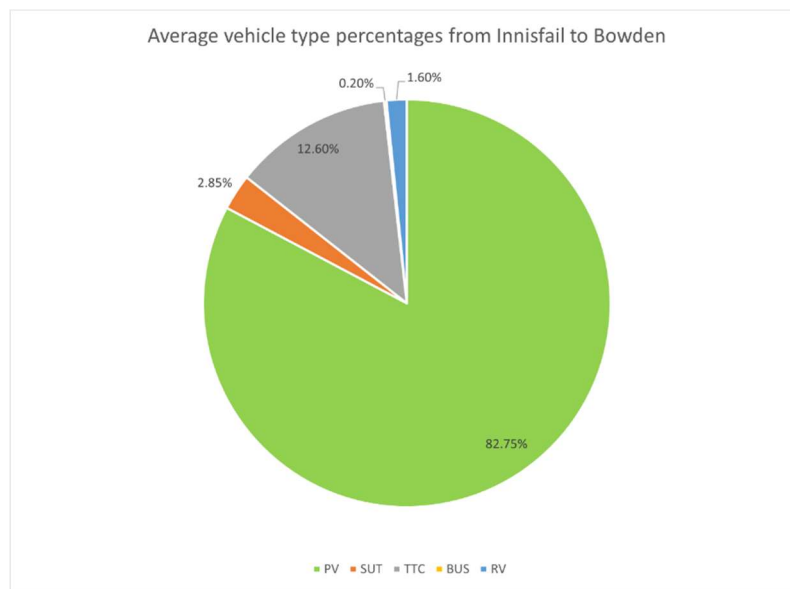


Figure 53: Average vehicle type percentages from Innisfail to Bowden

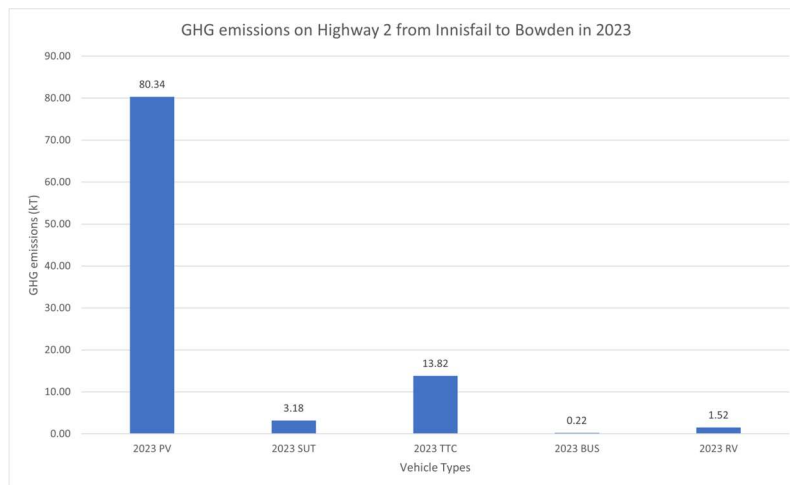


Figure 54: GHG emissions on Highway 2 from Innisfail to Bowden in 2023

Bowden to Airdrie

The seventh is Bowden (#79290) to Airdrie (#154820). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Bowden to Airdrie are shown in Figure 55.

PV dominated the traffic type on Highway 2 from Bowden to Airdrie, with 83.53% of all vehicle types. The BUS only occupied 0.13% of all vehicle types for public transportation. 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 56, 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%.

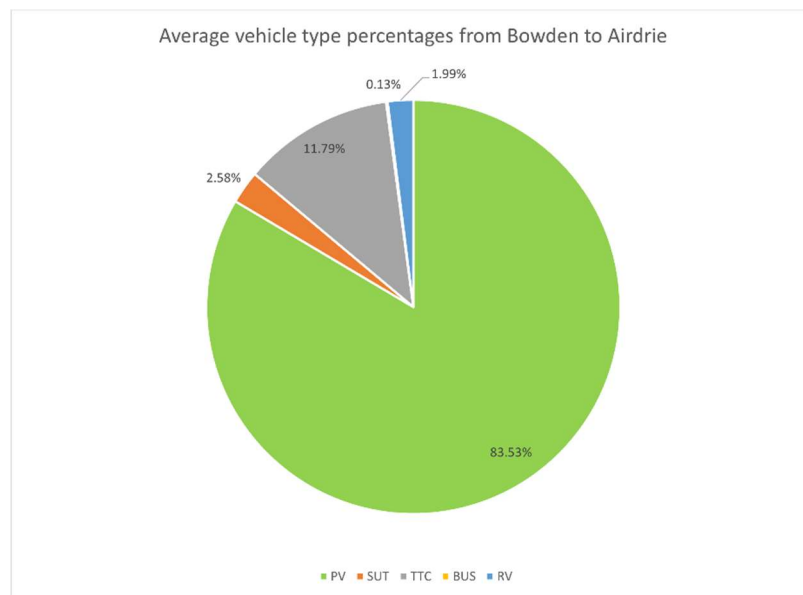


Figure 55: Average vehicle type percentages from Bowden to Airdrie

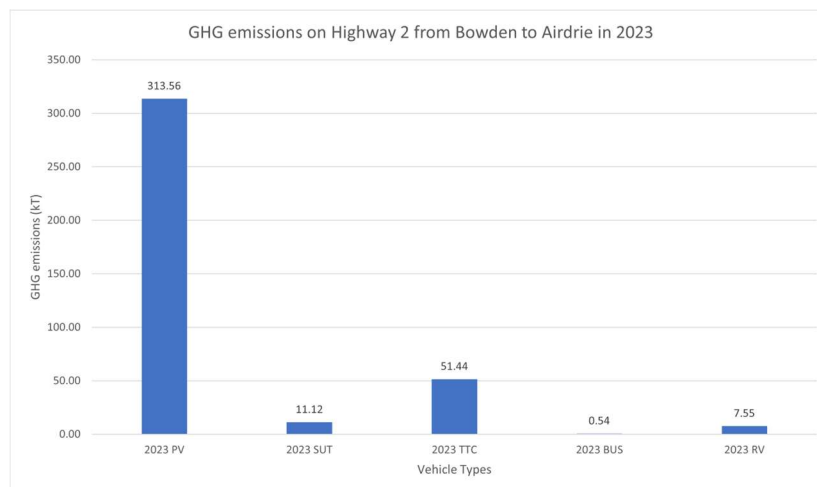


Figure 56: GHG emissions on Highway 2 from Bowden to Airdrie in 2023

Airdrie to Balzac

The eighth is Airdrie (#154820) to Balzac (#80210). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Airdrie to Balzac are shown in Figure 57.

PV dominated the traffic type on Highway 2 from Airdrie to Balzac, with 88.8% of all vehicle types. The BUS only occupied 0.1% of all vehicle types for public transportation. 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 58, 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%.

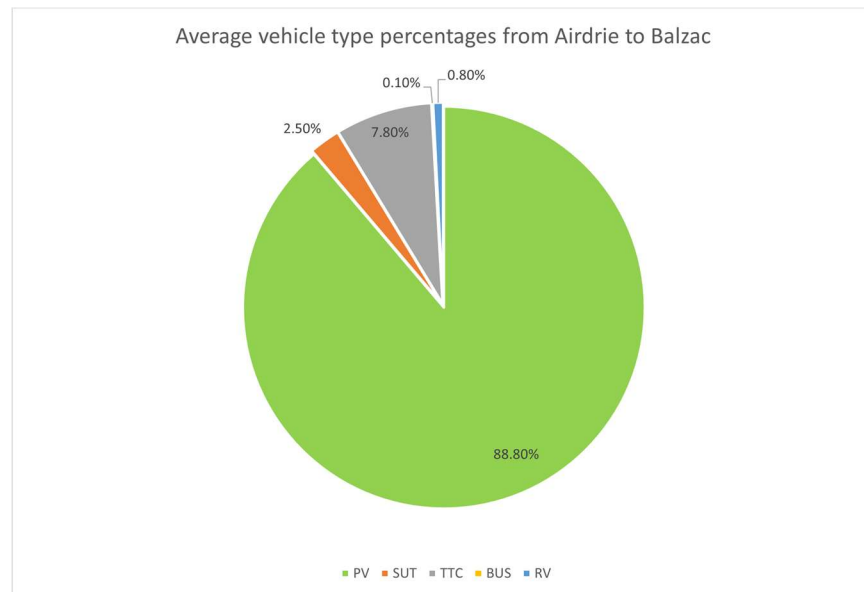


Figure 57: Average vehicle type percentages from Airdrie to Balzac

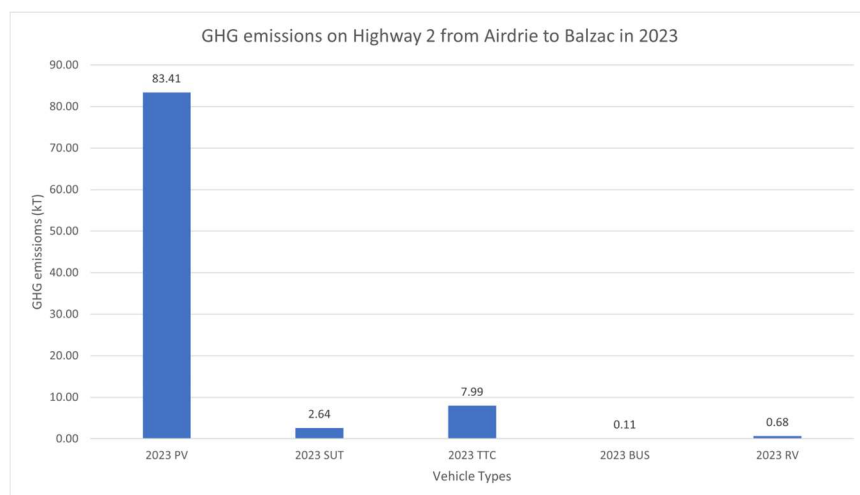


Figure 58: GHG emissions on Highway 2 from Airdrie to Balzac in 2023

Balzac to Calgary International Airport

The ninth is Balzac (#80210) to Calgary International Airport (#10000022). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Balzac to Calgary International Airport are shown in Figure 59.

PV dominated the traffic type on Highway 2 from Calgary International Airport to the center of Calgary, with 91.1% of all vehicle types. The BUS only occupied 0.18% of all vehicle types for public transportation. 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 60, 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%.

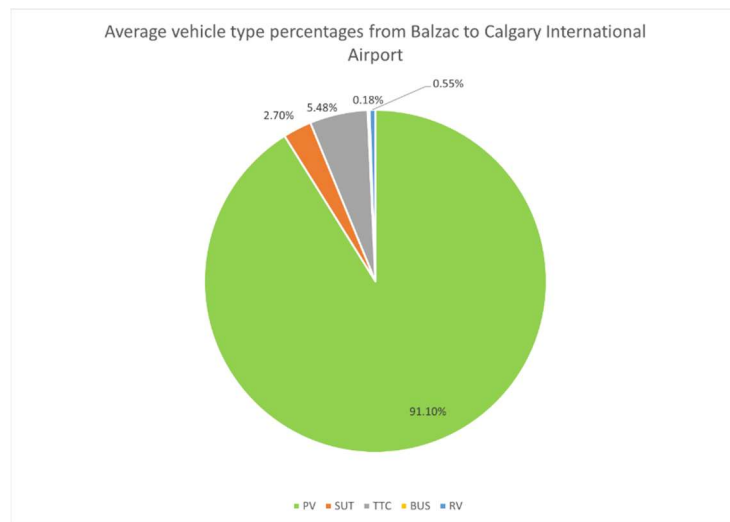


Figure 59: Average vehicle type percentages from Balzac to Calgary International Airport

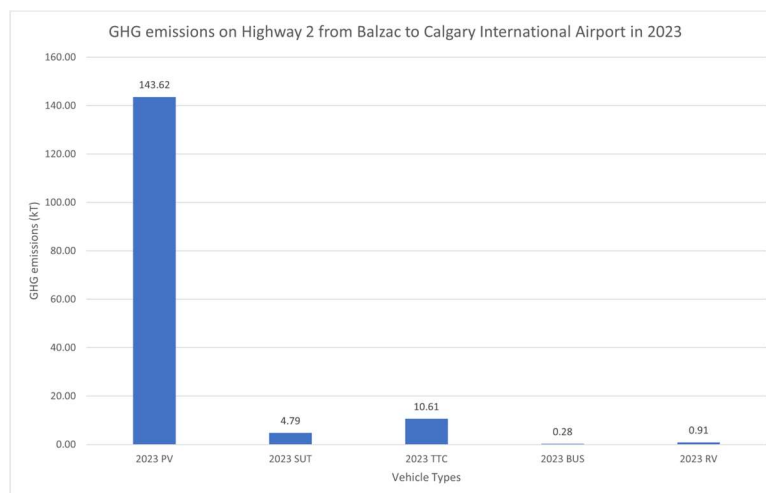


Figure 60: GHG emissions on Highway 2 from Balzac to Calgary International Airport in 2023

Calgary International Airport to Calgary

The last one is Calgary International Airport (#10000022) to Calgary (#10000007). Based on the dataset in GHG emissions based on locations (E-C), vehicle types from Calgary International Airport to Calgary are shown in Figure 61.

PV dominated the traffic type on Highway 2 from Calgary International Airport to the center of Calgary, with 93.69% of all vehicle types. The BUS only occupied 0.41% of all vehicle types for public transportation. 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 62, 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%.

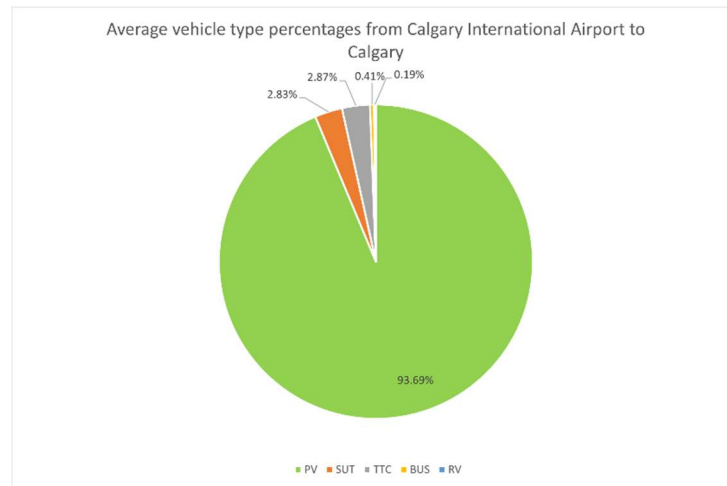


Figure 61: Average vehicle type percentages from Calgary International Airport to Calgary

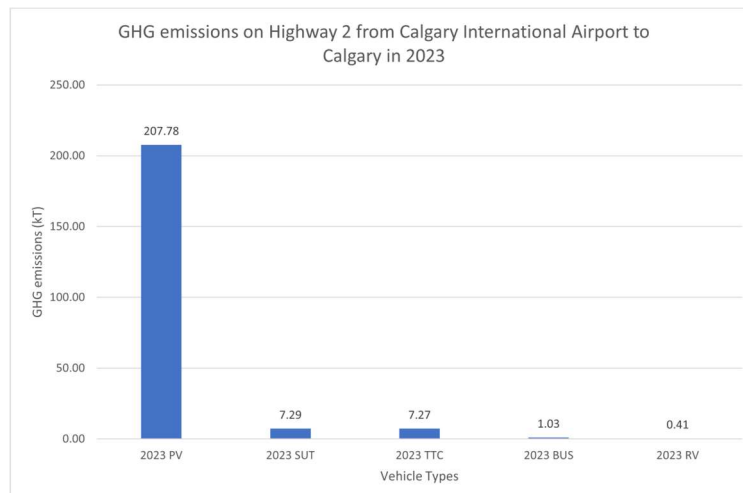


Figure 62: GHG emissions on Highway 2 from Calgary International Airport to Calgary in 2023

Impact of COVID-19 to GHG emissions

When the COVID-19 exploded, the GHG emission dropped 305.49 kT from 2019 to 2020. Specifically, 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, GHG emissions gradually increased and decreased slightly from 2020 to 2023. From 2020 to 2021, the GHG emission increased to 85.36 kT. From 2021 to 2022, the GHG emission decreased to 37.16 kT. From 2022 to 2023, the GHG emission increased to 96.63 kT.

Highway 2A

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

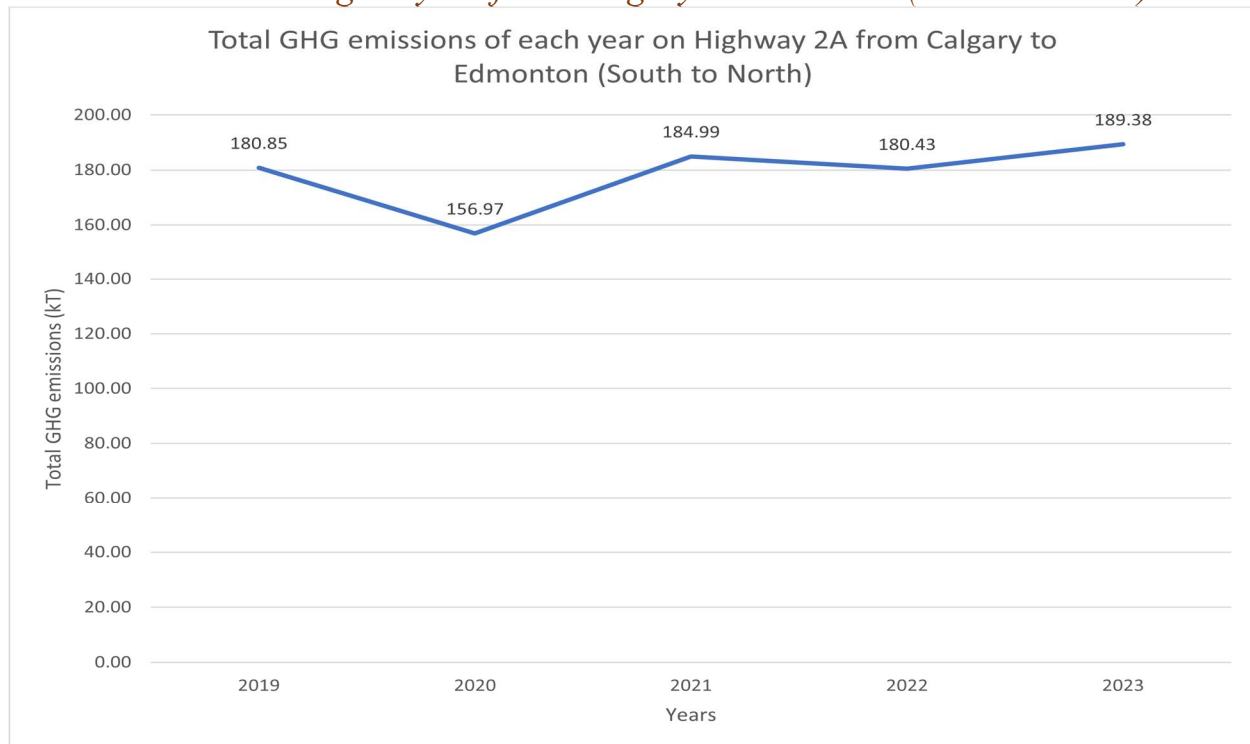


Figure 63: Total GHG emissions of each year on Highway 2A from Calgary to Edmonton (South to North) from 2019 to 2023

For Highway 2A, Figure 63 shows each intersection's total GHG emissions, 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 vehicles, the average is 3.15% for SUT, 4.09% for TTC, 0.3% for BUS, and 0.66% for RV. Because Highway 2A does not fully connect from Calgary to Edmonton, we divided 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 the dataset of GHG emissions calculation ^{viii}, in 2019, PV was 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

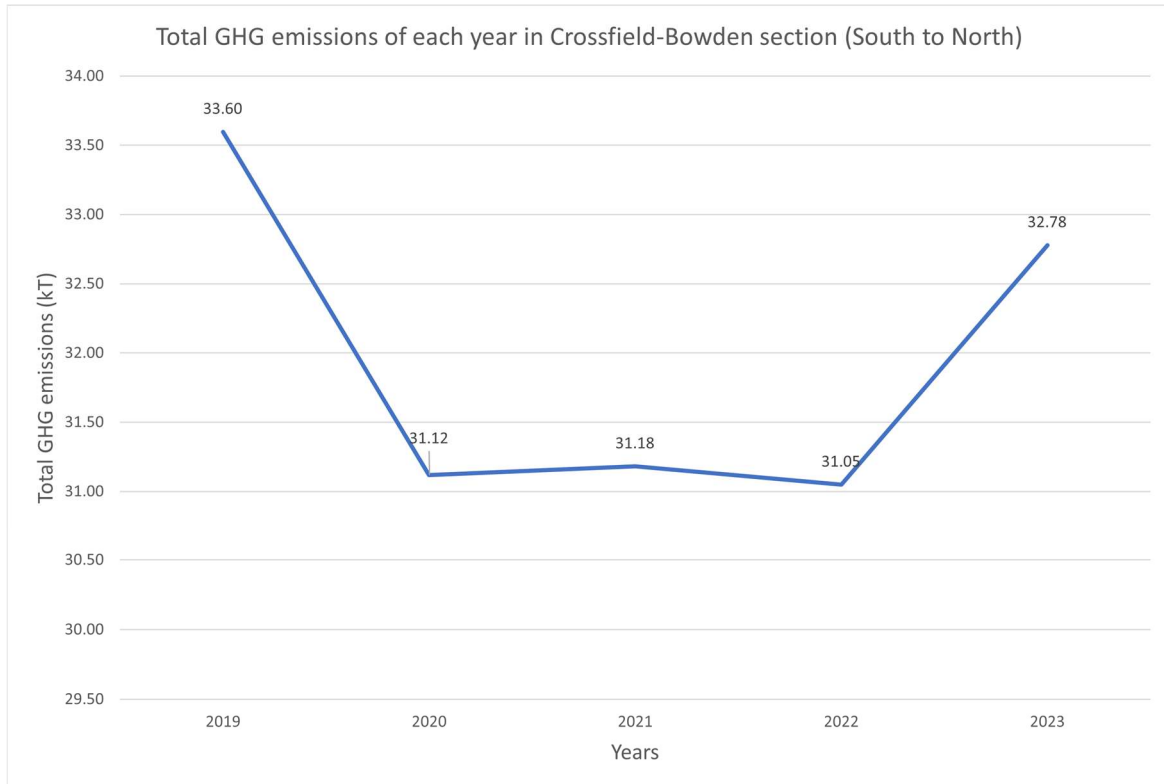


Figure 64: Total GHG emissions of each year in Crossfield-Bowden section (South to North)

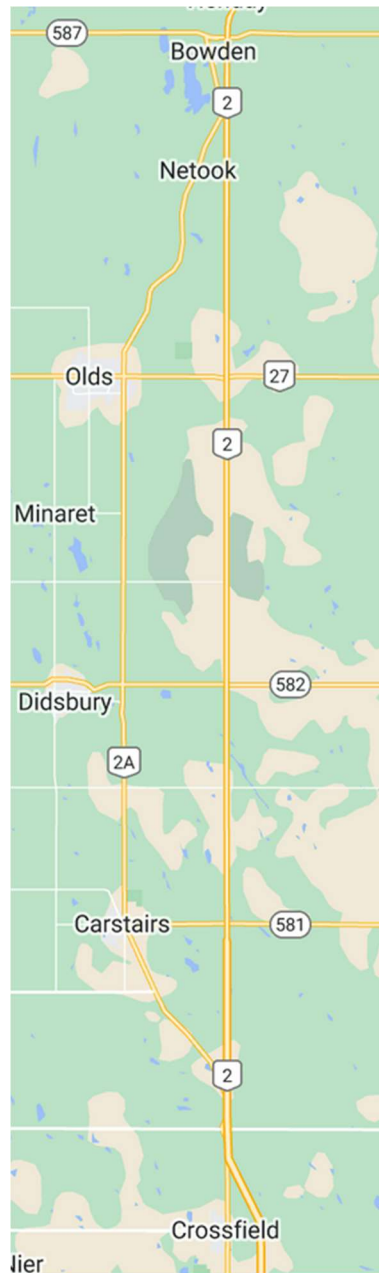


Figure 65: Intersections from Crossfield to Bowden

Based on the GHG emission calculations, the emissions on 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 starts in Crossfield, passing through critical locations such as Carstairs, Didsbury, Olds, and Netook, and ending in Bowden. Details are shown in Figure 74. According to Figure 73, 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 at the Crossfield, vehicle counts rose after arriving at Carstairs, increasing from 1270 to 2450 vehicles in 2023. Between Carstairs and Didsbury, the count 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 in 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

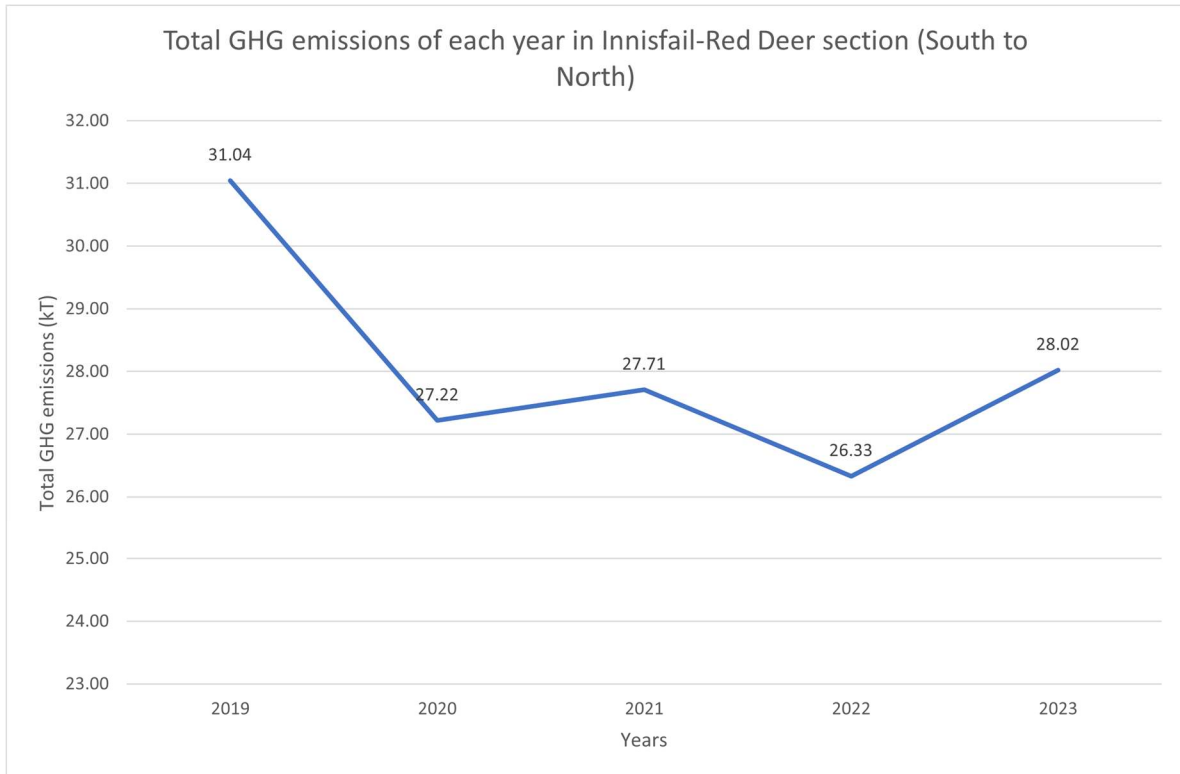


Figure 66: Total GHG emissions of each year in the Innisfail-Red Deer section (South to North)

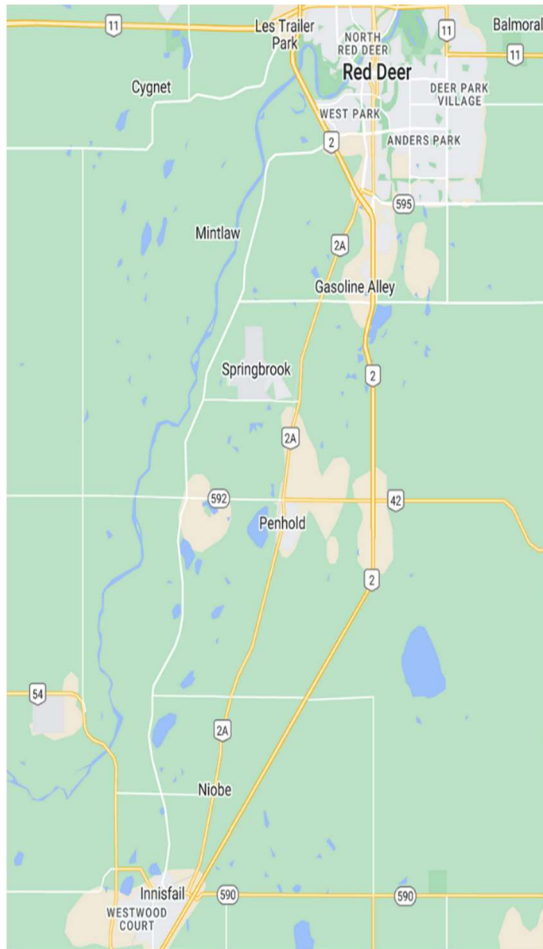


Figure 67: Intersections from Innisfail to Red Deer

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 are shown in Figure 67. According to Figure 66, the total GHG emissions between 2019 and 2023 were 31.04, 27.22, 27.71, 26.33, and 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

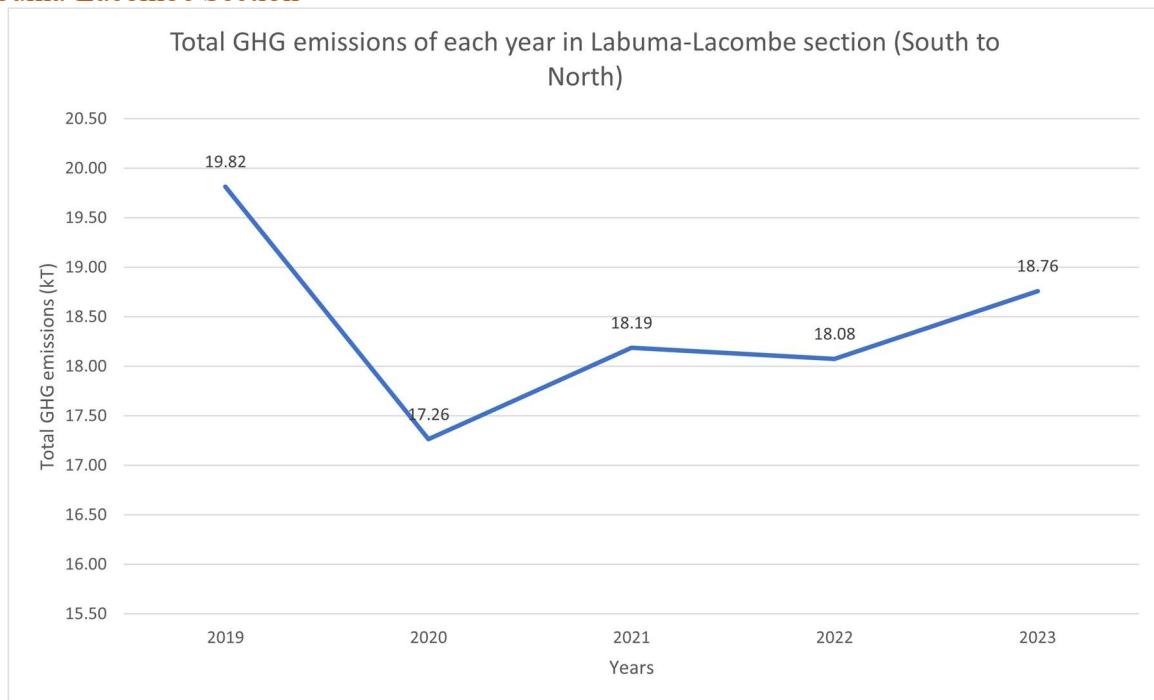


Figure 68: Total GHG emissions of each year in Labuma-Lacombe section (South to North)



Figure 69: 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 are shown in Figure 69. According to Figure 68, 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

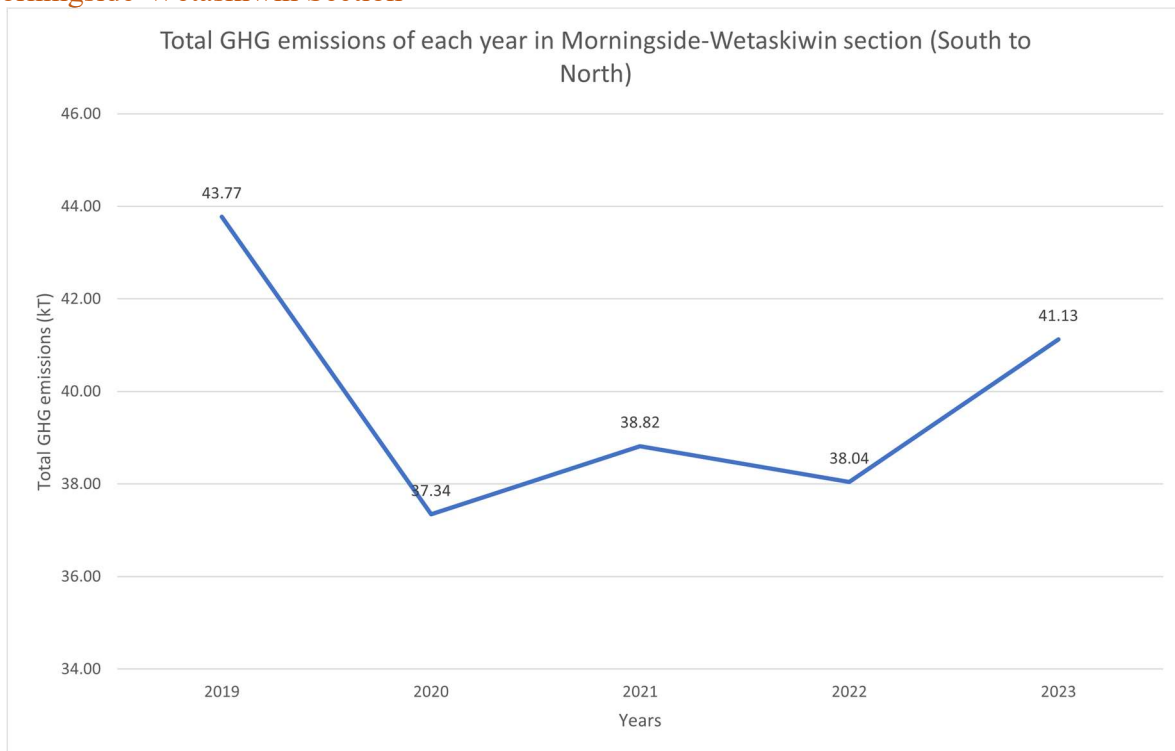


Figure 70: Total GHG emissions of each year in the Morningside-Wetaskiwin section (South to North)



Figure 71: 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 are shown in Figure 71. According to Figure 70, 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

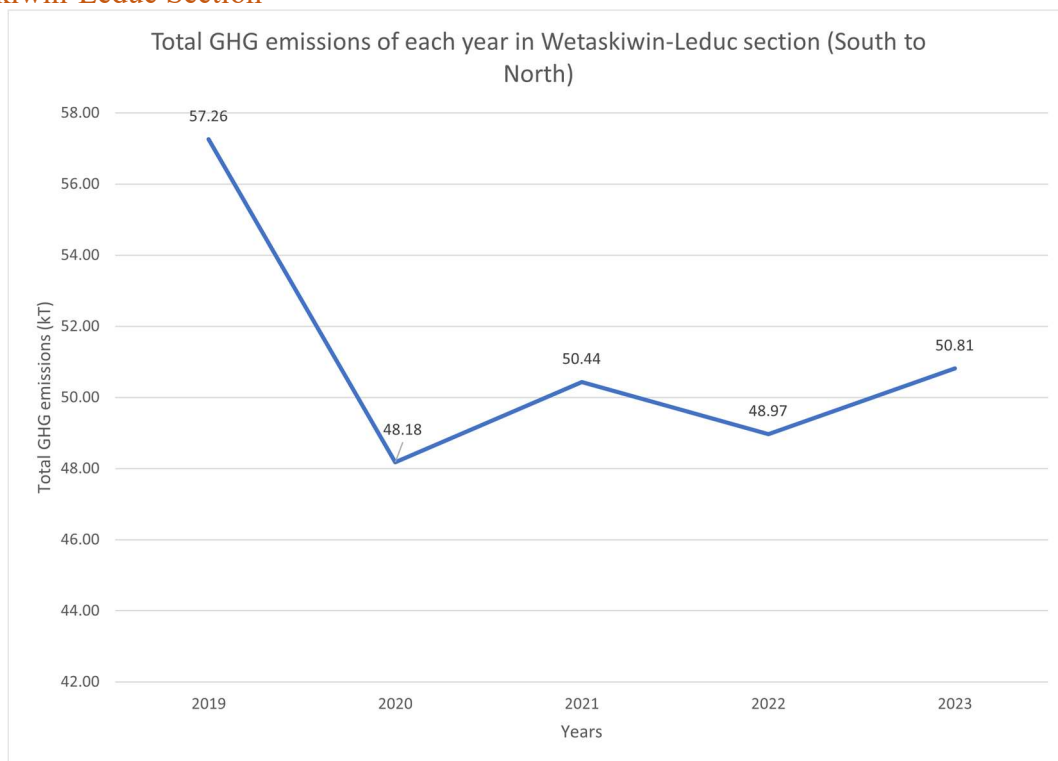


Figure 72: Total GHG emissions of each year in Wetaskiwin-Leduc section (South to North)



Figure 73: 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 are shown in Figure 73. According to Figure 72, 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)

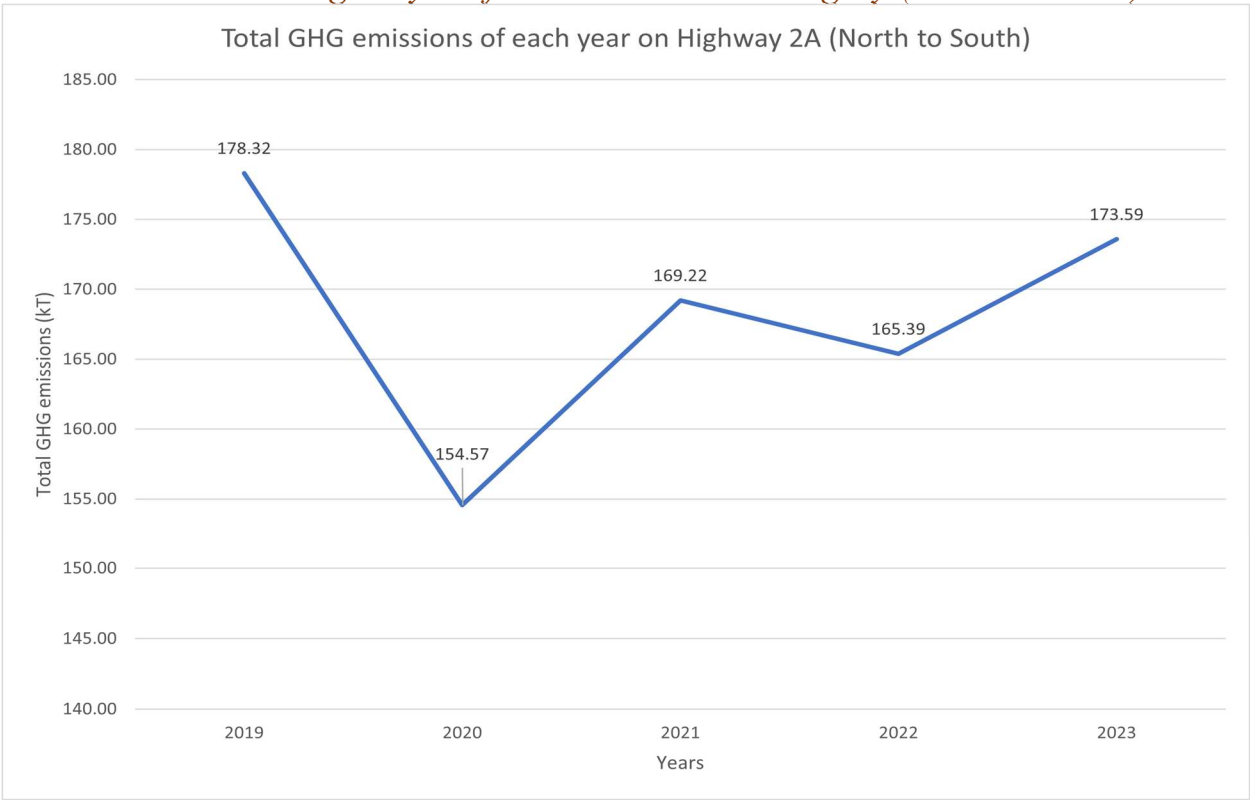


Figure 74: Total GHG emissions of each year on Highway 2A (North to South)

For Highway 2A, Figure 74 shows 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 vehicles, the average is 3.48% for SUT, 4.12% for TTC, 0.16% for BUS, and 0.88% for RV. Because Highway 2A does not fully connect from Edmonton to Calgary, we divided 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. In 2019, PV was 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%).

GHG emissions surged after vaccines were introduced in 2020, 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

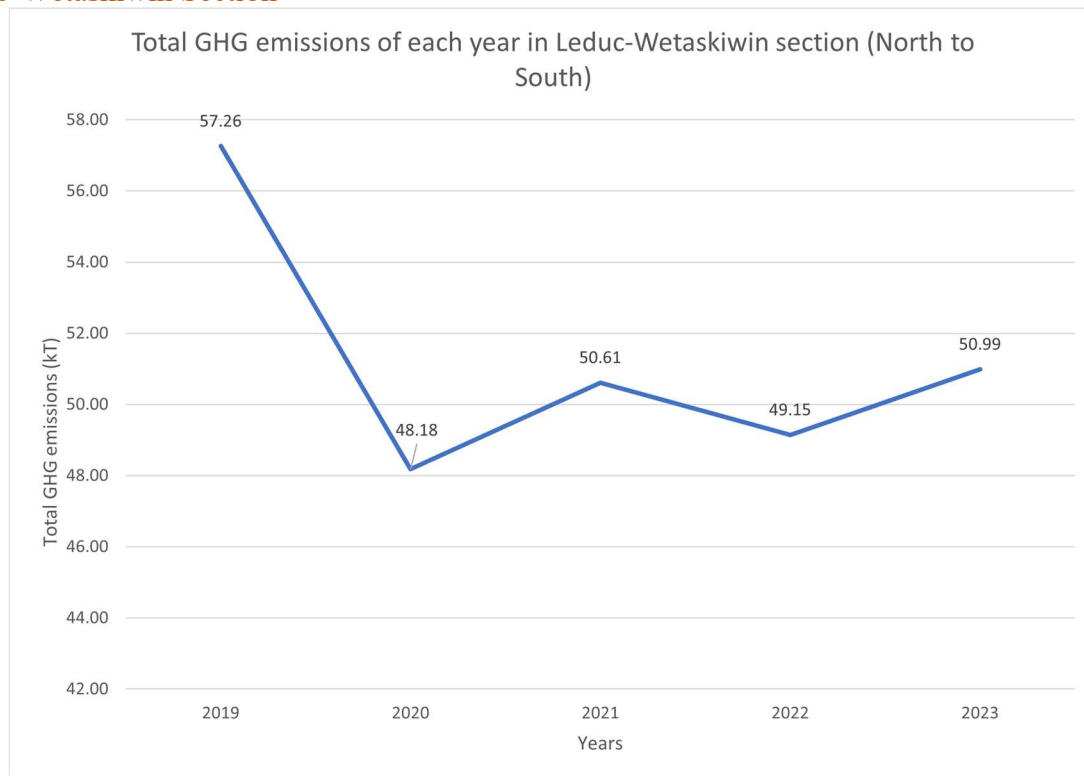


Figure 75: Total GHG emissions of each year in Leduc-Wetaskiwin section (North to South)

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 and Milet, and ends in Wetaskiwin. According to Figure 75, 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, remaining the same for 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

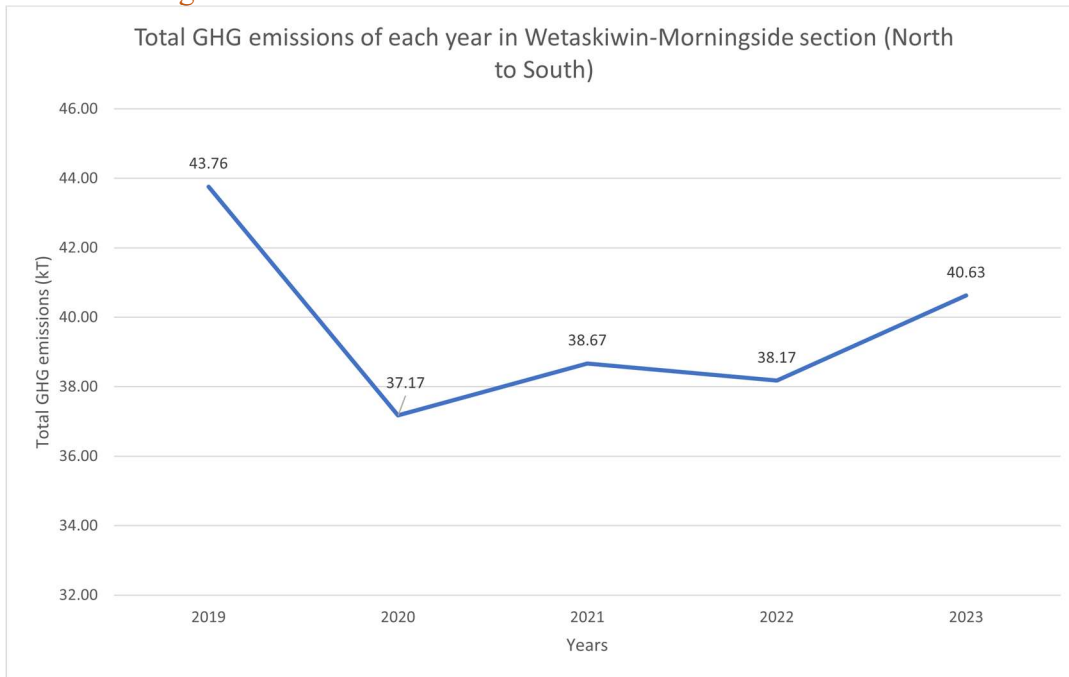


Figure 76: Total GHG emissions of each year in Wetaskiwin-Morningside section (North to South)

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, and Ponoka Industrial Airport, and ends in Morningside. According to Figure 76, 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 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

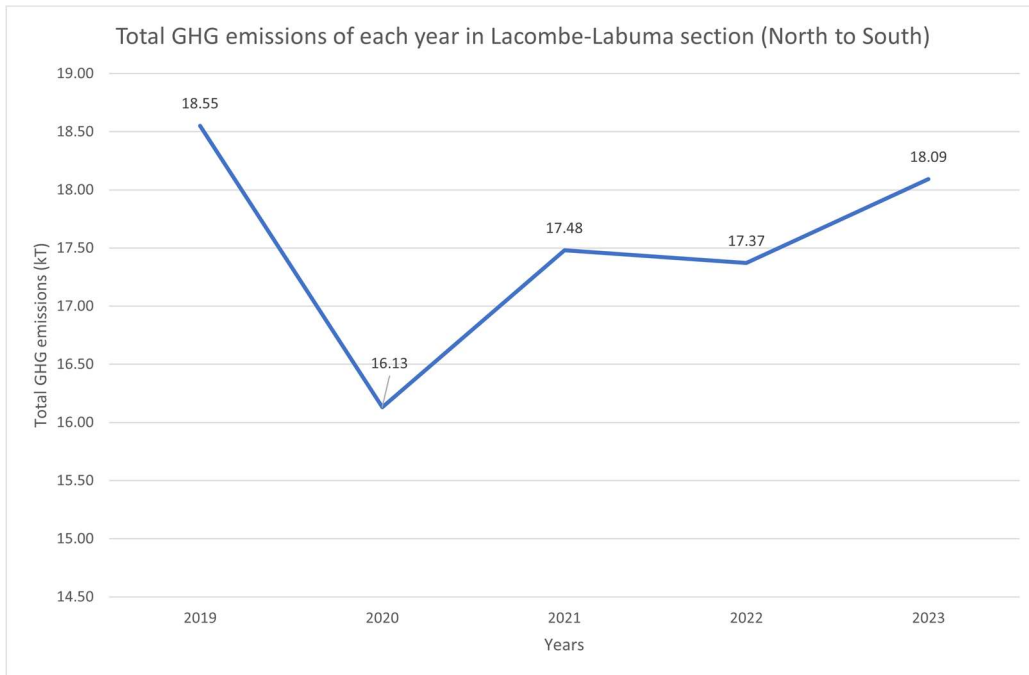


Figure 77: Total GHG emissions of each year in the Lacombe-Labuma section (North to South)

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%. Lacombe to Labuma begins in Heritage Estates, passes through Lacombe, Jackson, and Blackfalds, and ends in Labuma. According to Figure 77, 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

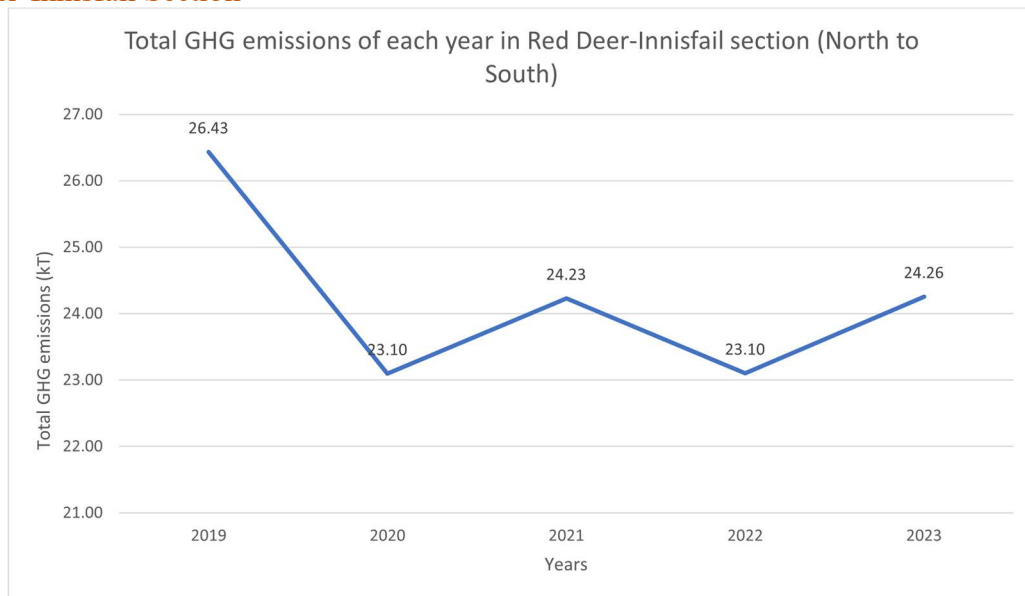


Figure 78: Total GHG emissions of each year in the Red Deer-Innisfail section (North to South)

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. According to Figure 78, 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

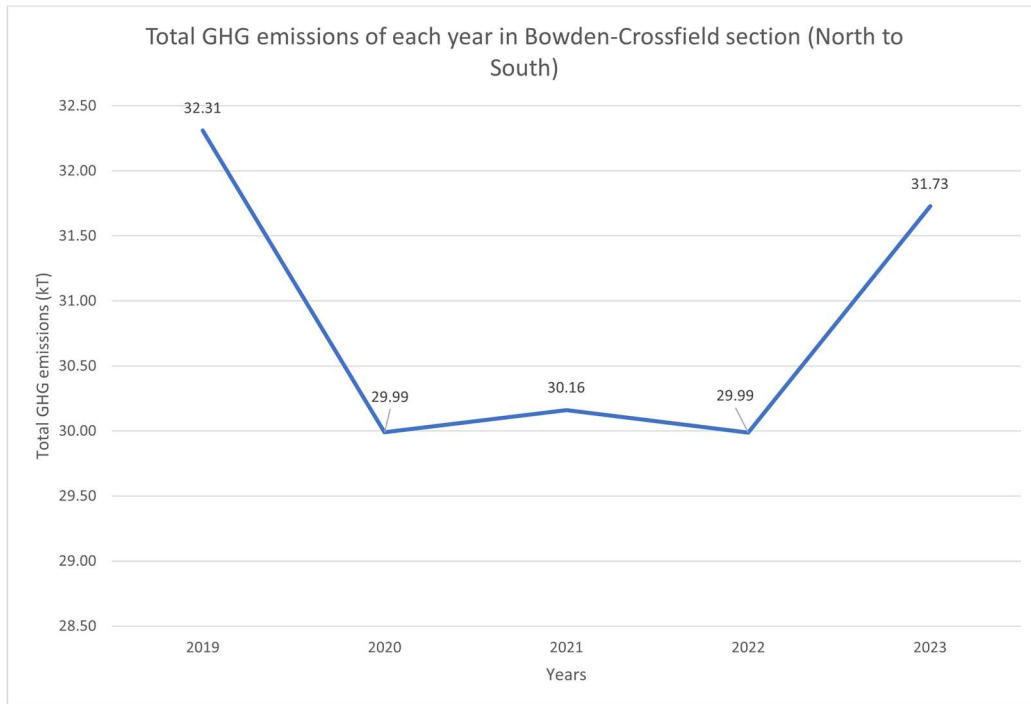


Figure 79: Total GHG emissions of each year in the Bowden-Crossfield section (North to South)

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, and Carstairs, and ends in Crossfield. According to Figure 79, 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 Carstairs, 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. From the result in Figure 2, 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 Les Trailer Park, the average traffic counts still rose from 30998 to 34375 vehicles. However, the average traffic counts lost almost 7000 vehicles in Les Trailer Park-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 3 shows the total WAADT from 2019 to 2023, demonstrating that total vehicle counts gradually increase 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, PV occupied the most significant proportion of all kinds of vehicles, with an average of 85.92%. Even though other cars did not have as many as PV, we should concentrate on the vehicle type of TTC. 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 Figure 6, 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 6, 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 6, 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 6, 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 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 6, 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 6, 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: Calgary to Edmonton and Edmonton to Calgary. We aim better to analyze the traffic load from Calgary to Edmonton to 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, Les Trailer Park, Brightview, Corinthia Park, Leduc, and arrived at Edmonton. Based on the result from Figure 2, 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 Les Trailer Park, the average traffic counts increased from 15410 to 18303 vehicles. However, the traffic counts fell when passing through Brightview and Corinthia Park. The average traffic counts began surging when we arrived at Leduc and Edmonton, with 22175 and 34728 vehicles from Corinthia Park to Leduc and from Leduc to Edmonton.

We compared the traffic counts and GHG emissions on Highway 2 from South to North. 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 showed that the Calgary-Calgary International Airport section only has 7.96 miles. The vehicle types are mainly PV (93.7%), meaning the EF will multiply by 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 80, we noticed that GHG emissions sections from Calgary to Edmonton should be reckoned with the following arrangement:

- Airdrie-Bowden
- Les Trailer Park-Brightview

- Calgary-Calgary International Airport
- Leduc-Edmonton
- Calgary International Airport-Balzac
- Innisfail-Les Trailer Park
- Brightview-Corinthia Park
- Bowden-Innisfail
- Balzac-Airdrie
- Corinthia Park-Leduc

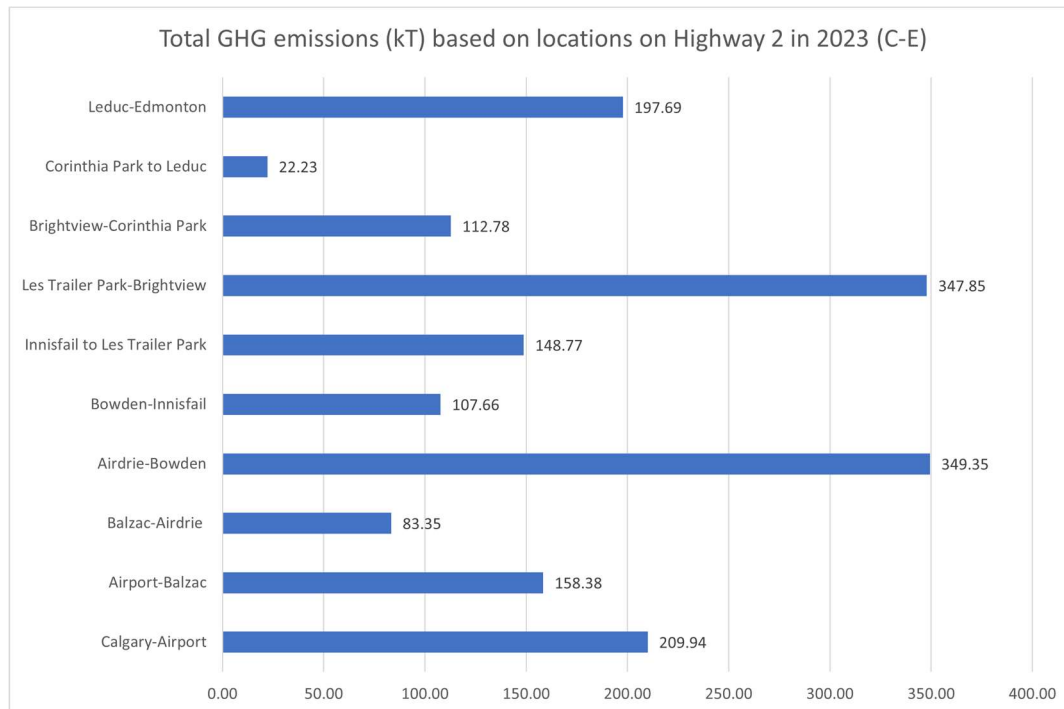


Figure 80: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (C-E)

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, Corinthia Park, Brightview, Les Trailer Park, Innisfail, Bowden, Airdrie, Balzac, Calgary International Airport, and ending in Calgary. The Edmonton-Leduc segment recorded an average traffic count of 32578 vehicles per the WAADT dataset. Upon reaching the Leduc-Corinthia Park segment, the average traffic count dropped to 16380 vehicles. From Corinthia Park to Brightview, and through Brightview, Les Trailer Park, 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. The GHG emission pattern includes several factors and does not mirror the traffic counts. For instance, Brightview-Les Trailer Park produced the second-highest GHG emissions. This section won first place in the segment length. 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 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, Brightview-Les Trailer Park has higher GHG emissions than the Balzac-Calgary International Airport section.

As shown in Figure 81, we recommend the following priority for addressing GHG emissions between Calgary and Edmonton:

- Bowden-Airdrie
- Brightview-Les Trailer Park
- Edmonton-Leduc
- Balzac-Calgary International Airport
- Les Trailer Park-Innisfail
- Corinthia Park-Brightview
- Innisfail-Bowden
- Airdrie-Balzac
- Leduc-Corinthia Park

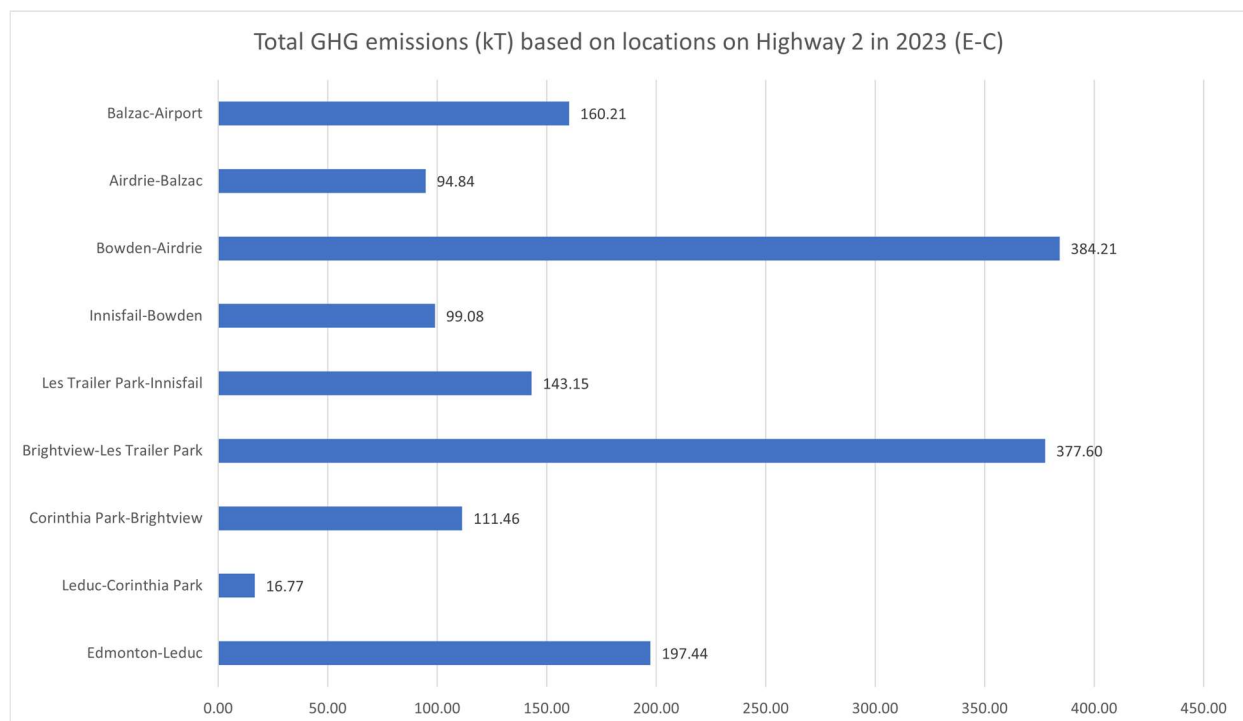


Figure 81: Total GHG emissions (kT) based on locations on Highway 2 in 2023 (E-C)

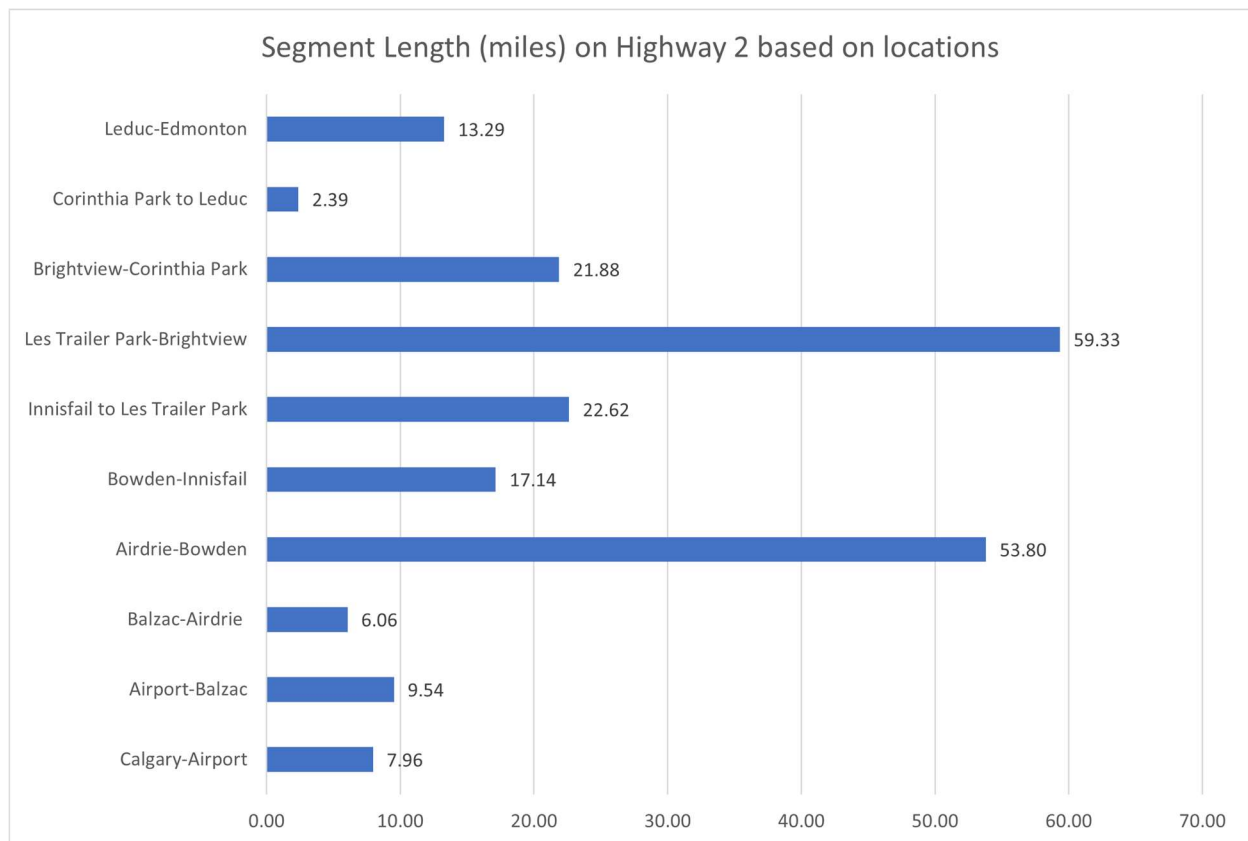


Figure 82: Segment Length (miles) on Highway 2 based on locations

Highway 2A

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

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

For the GHG emissions on Highway 2A from South to North, each section had a similar pattern from 2019 to 2023: starting from the highest value in 2019, plunging in 2020, fluctuating between 2020 and 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. Specifically, the Olds has the highest segment length and third place in traffic counts in all intersections, as shown in Figures 84 and 85. Since the primary 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.

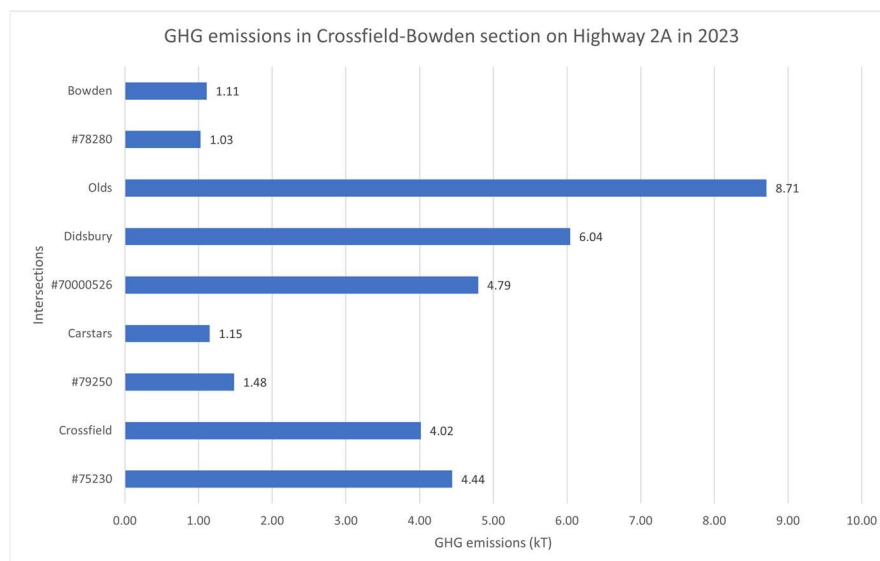


Figure 83: GHG emissions in Crossfield-Bowden section on Highway 2A in 2023



Figure 84: Segment length in Crossfield-Bowden section on Highway 2A

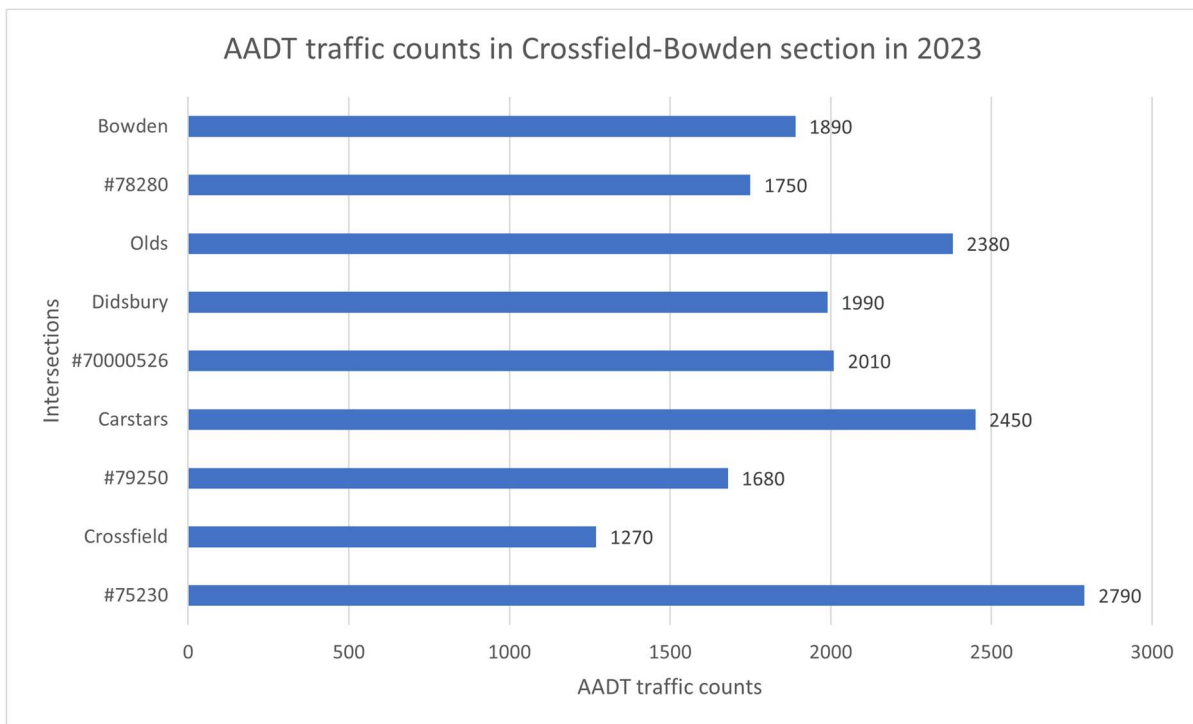


Figure 85: AADT traffic counts in Crossfield-Bowden section on Highway 2A in 2023

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. Specifically, the Innisfail has the highest segment length and third place in traffic counts in all intersections, as shown in Figures 87 and 88. Since the primary vehicle type was PV (94.65%), the EF will be occupied at 94.65%, multiplied 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. The Red Deer 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 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.

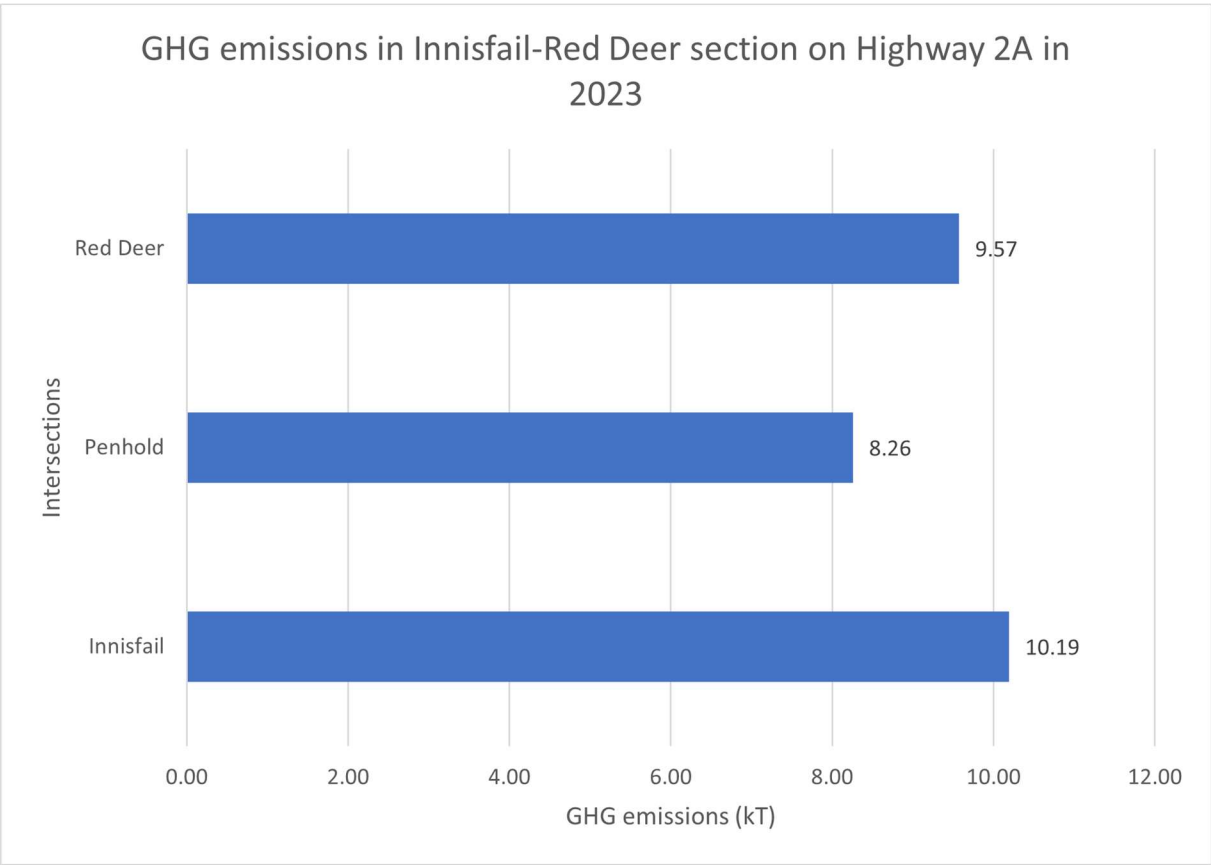


Figure 86: GHG emissions in the Innisfail-Red Deer section on Highway 2A in 2023

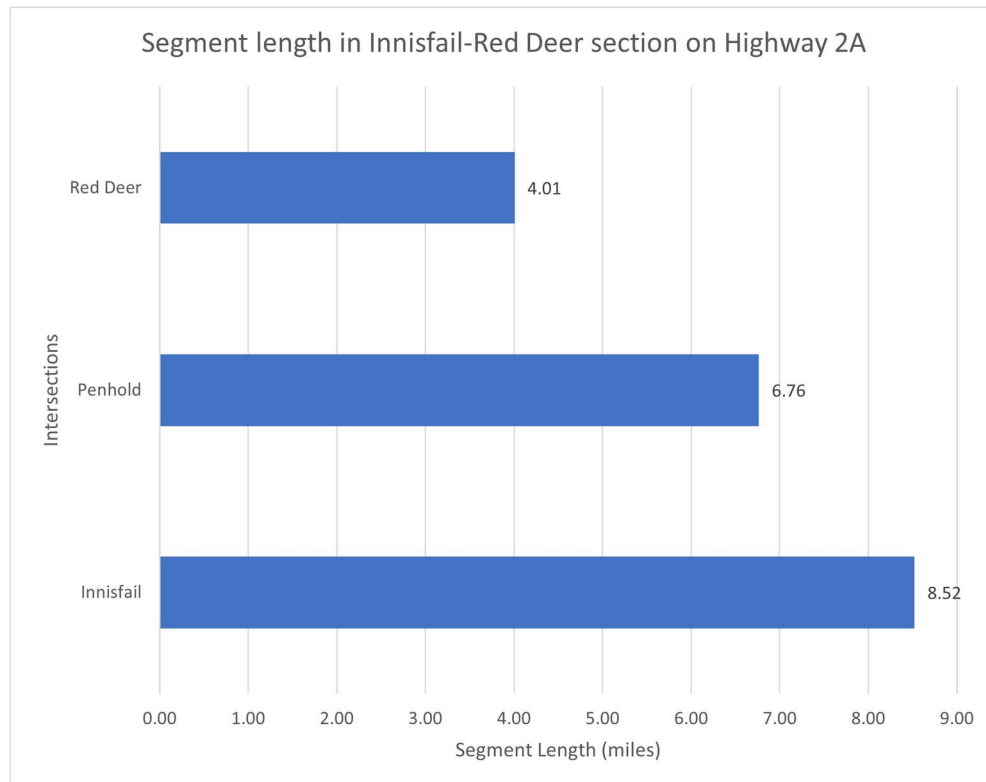


Figure 87: Segment length in the Innisfail-Red Deer section on Highway 2A

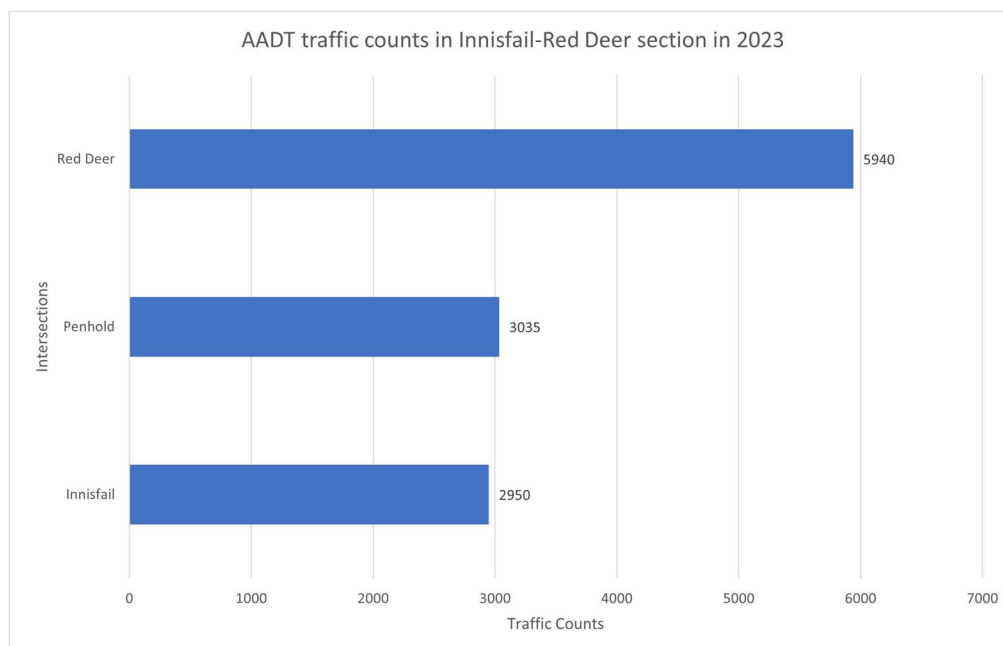


Figure 88: AADT traffic counts in the Innisfail-Red Deer section in 2023

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 89, 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 did not 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.

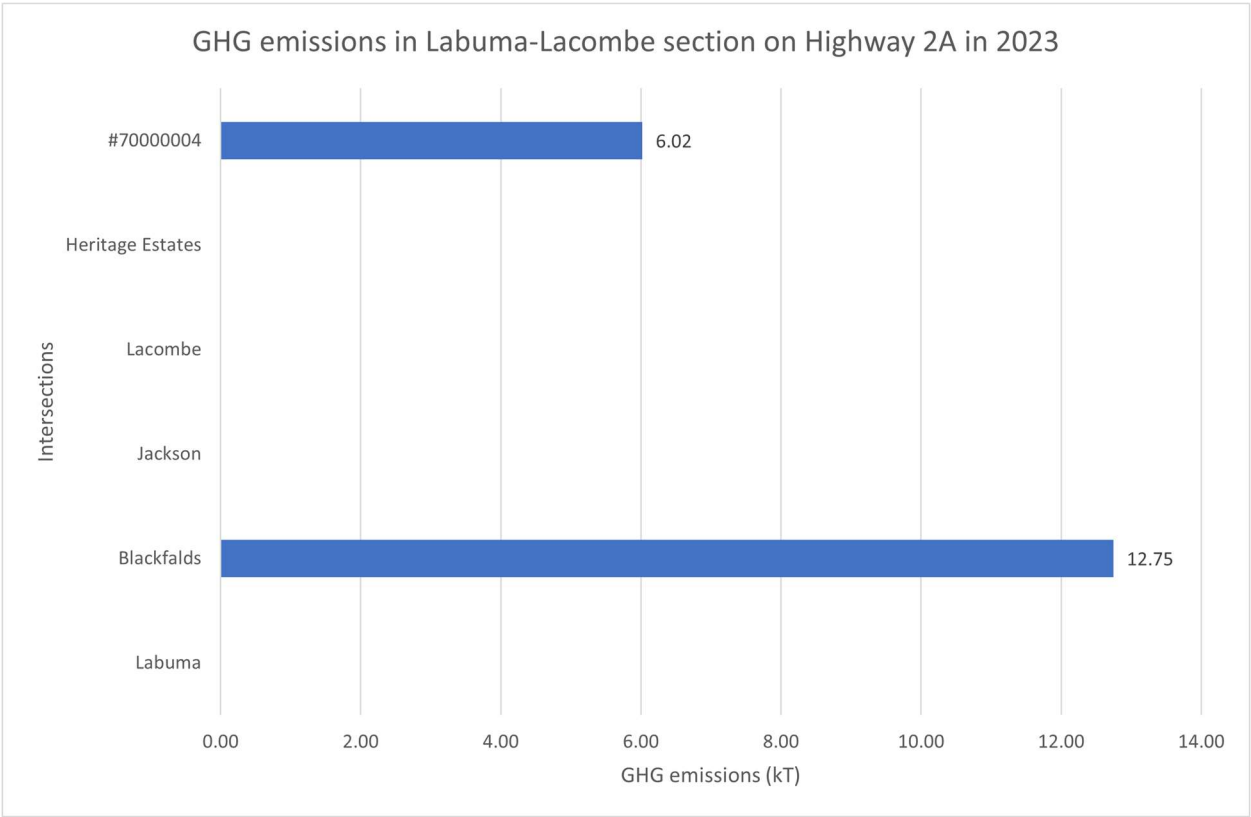


Figure 89: GHG emissions in the Labuma-Lacombe section on Highway 2A in 2023

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 90, 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.

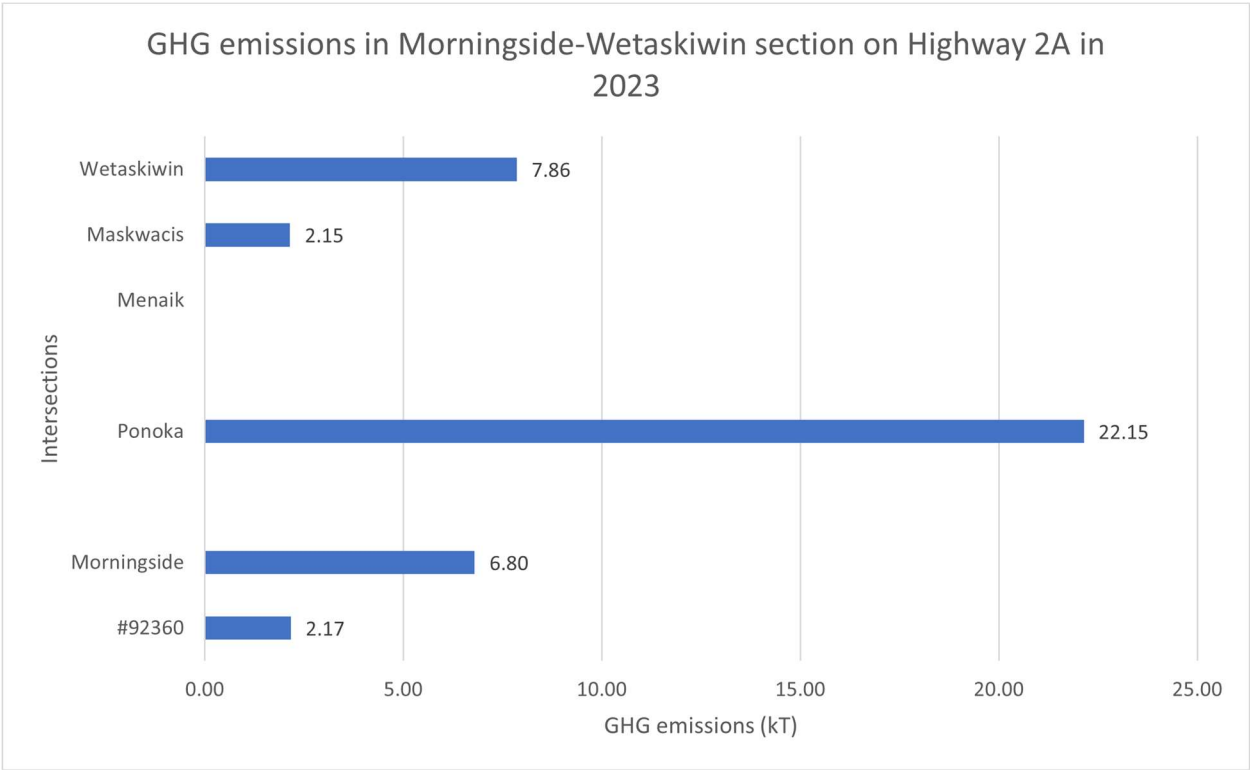


Figure 90: GHG emissions in the Morningside-Wetaskiwin section on Highway 2A in 2023

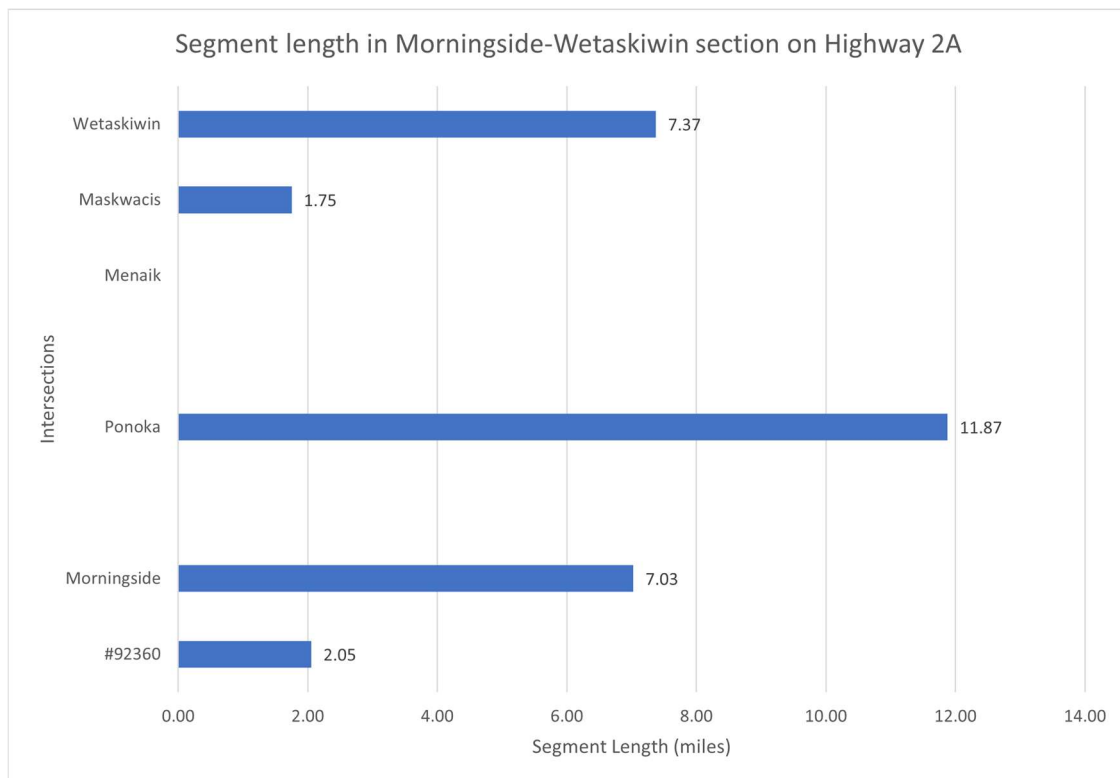


Figure 91: Segment length in the Morningside-Wetaskiwin section on Highway 2A

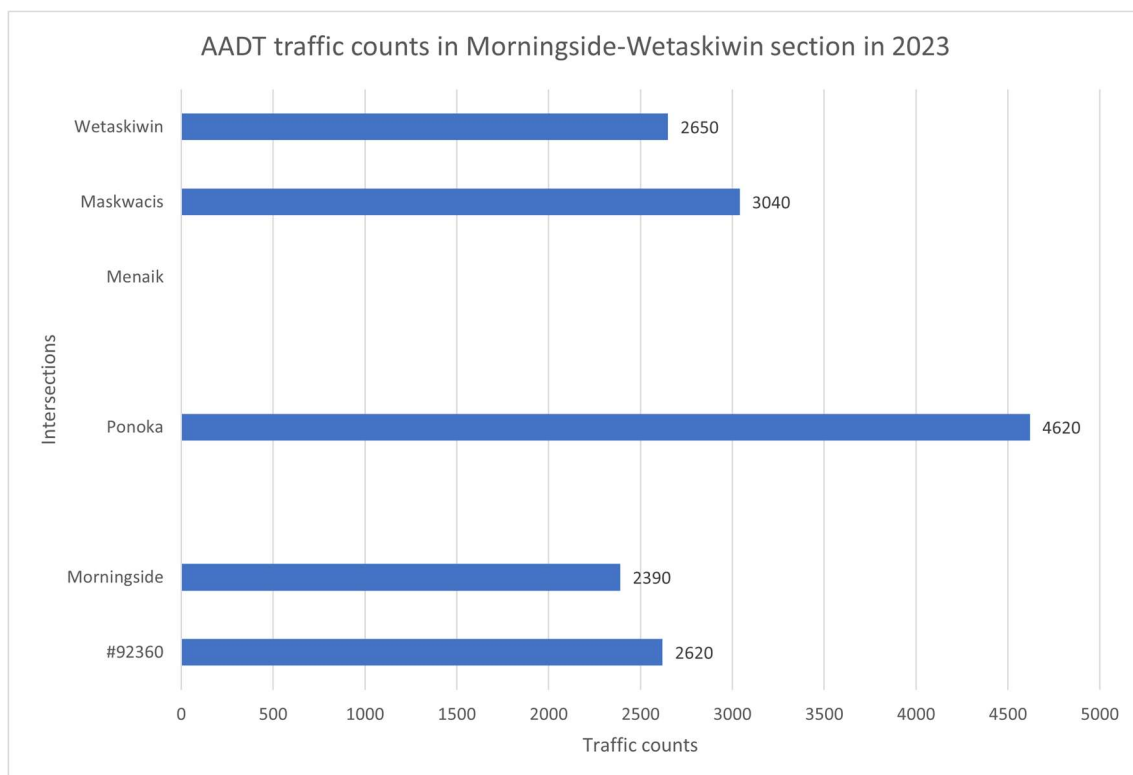


Figure 92: AADT traffic counts in the Morningside-Wetaskiwin section in 2023

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. Specifically, the Leduc has the second-highest segment length and first place in traffic counts in all intersections, as shown in Figures 94 and 95. 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.

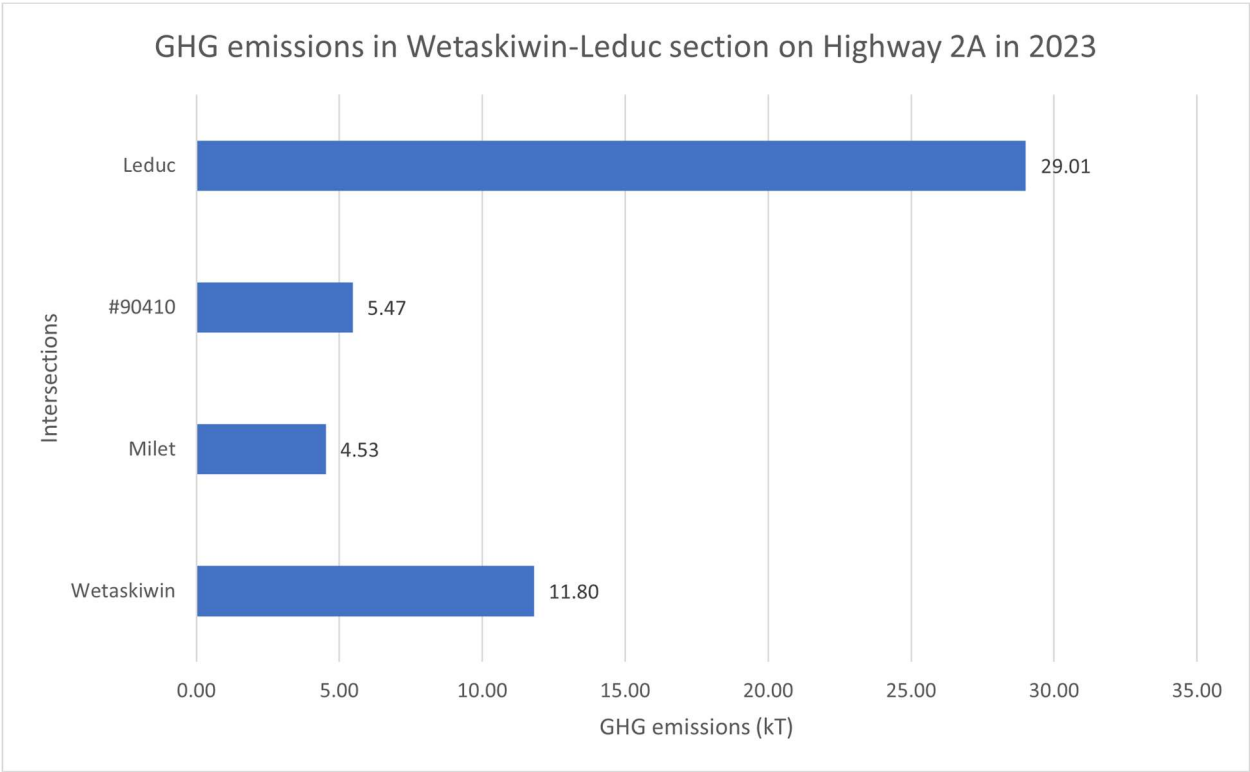


Figure 93: GHG emissions in Wetaskiwin-Leduc section on Highway 2A in 2023

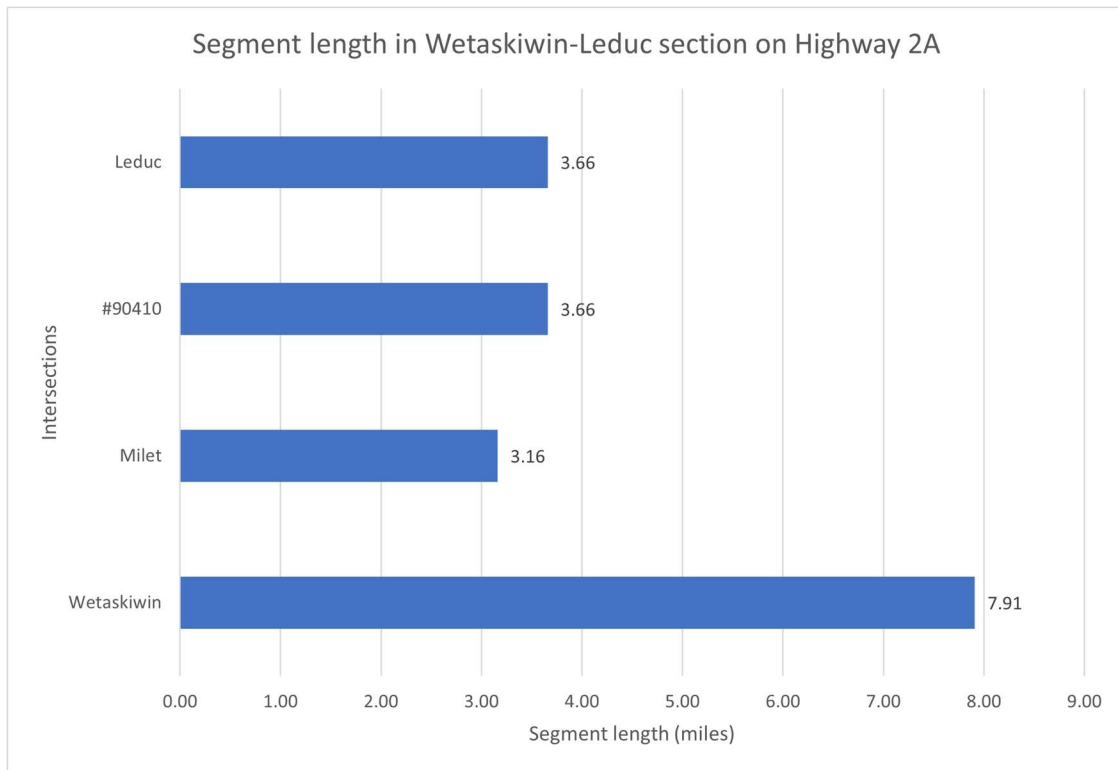


Figure 94: Segment length in Wetaskiwin-Leduc section on Highway 2A

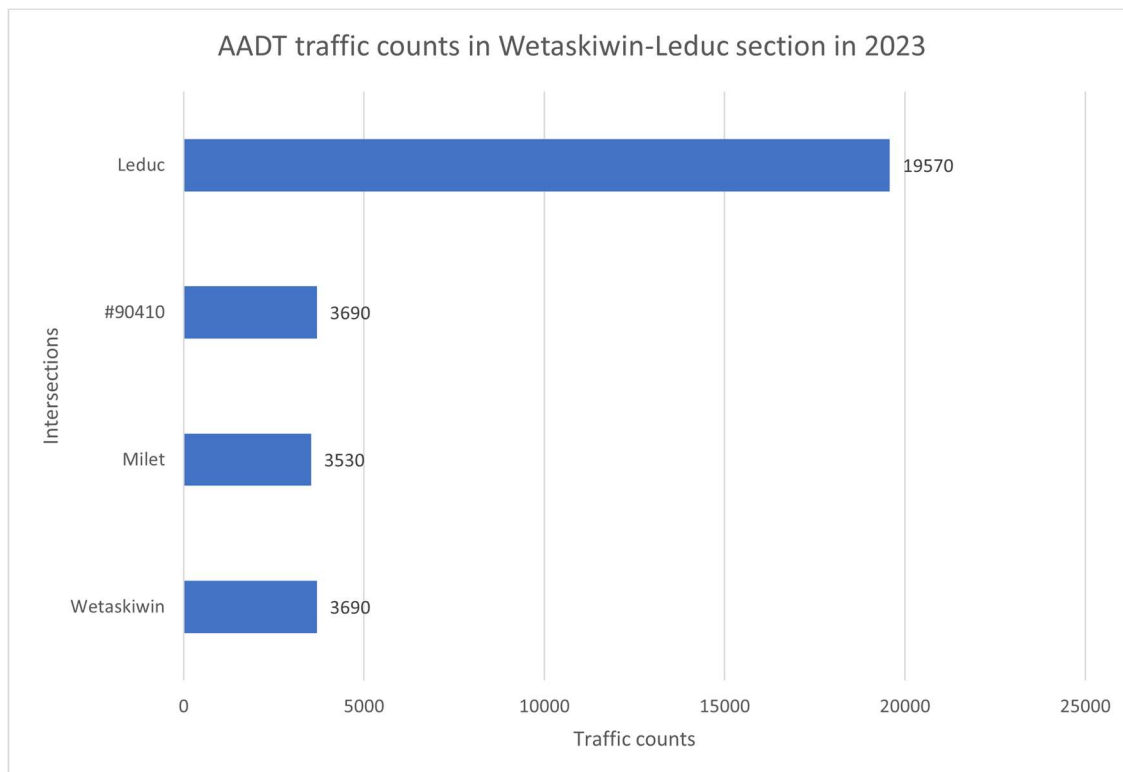


Figure 95: AADT traffic counts in Wetaskiwin-Leduc section in 2023

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 97, 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, Wetaskiwin was the most extended 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 was not the top in all intersections, the GHG emissions still greatly outdistanced other intersections.

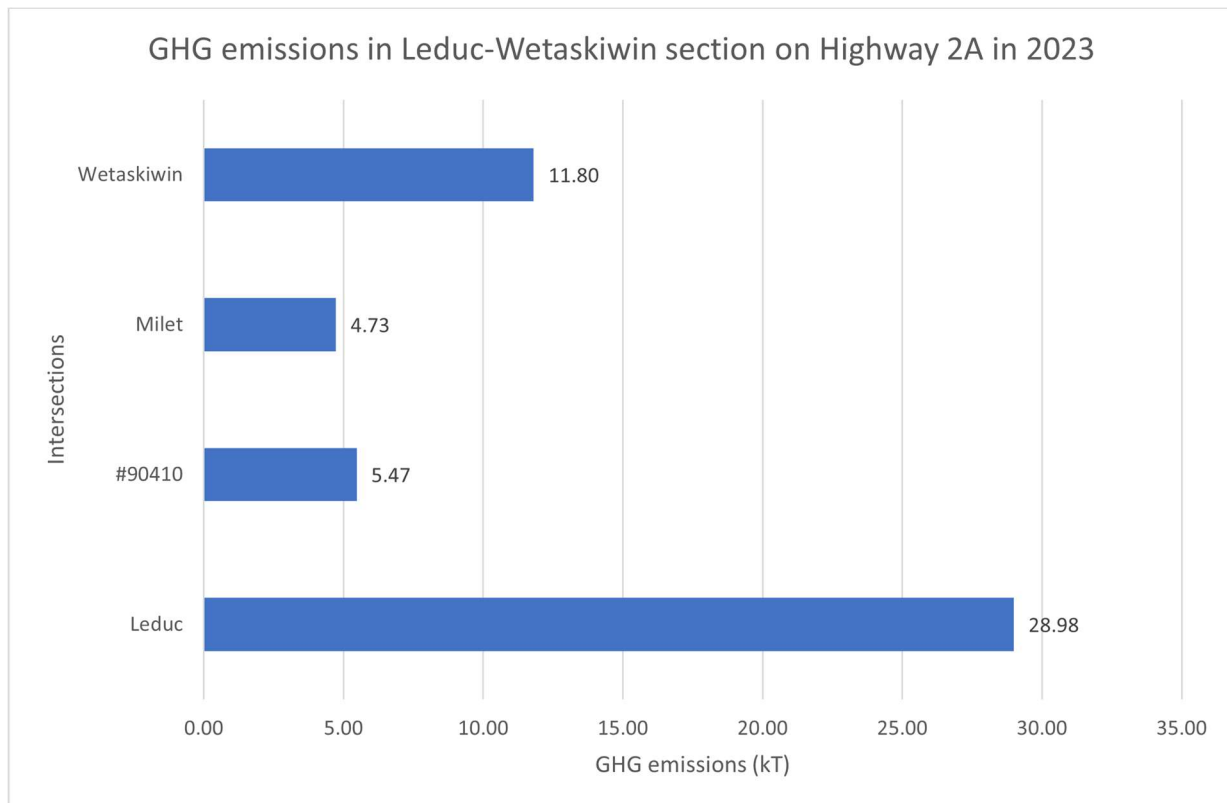


Figure 96: GHG emissions in the Leduc-Wetaskiwin section on Highway 2A in 2023

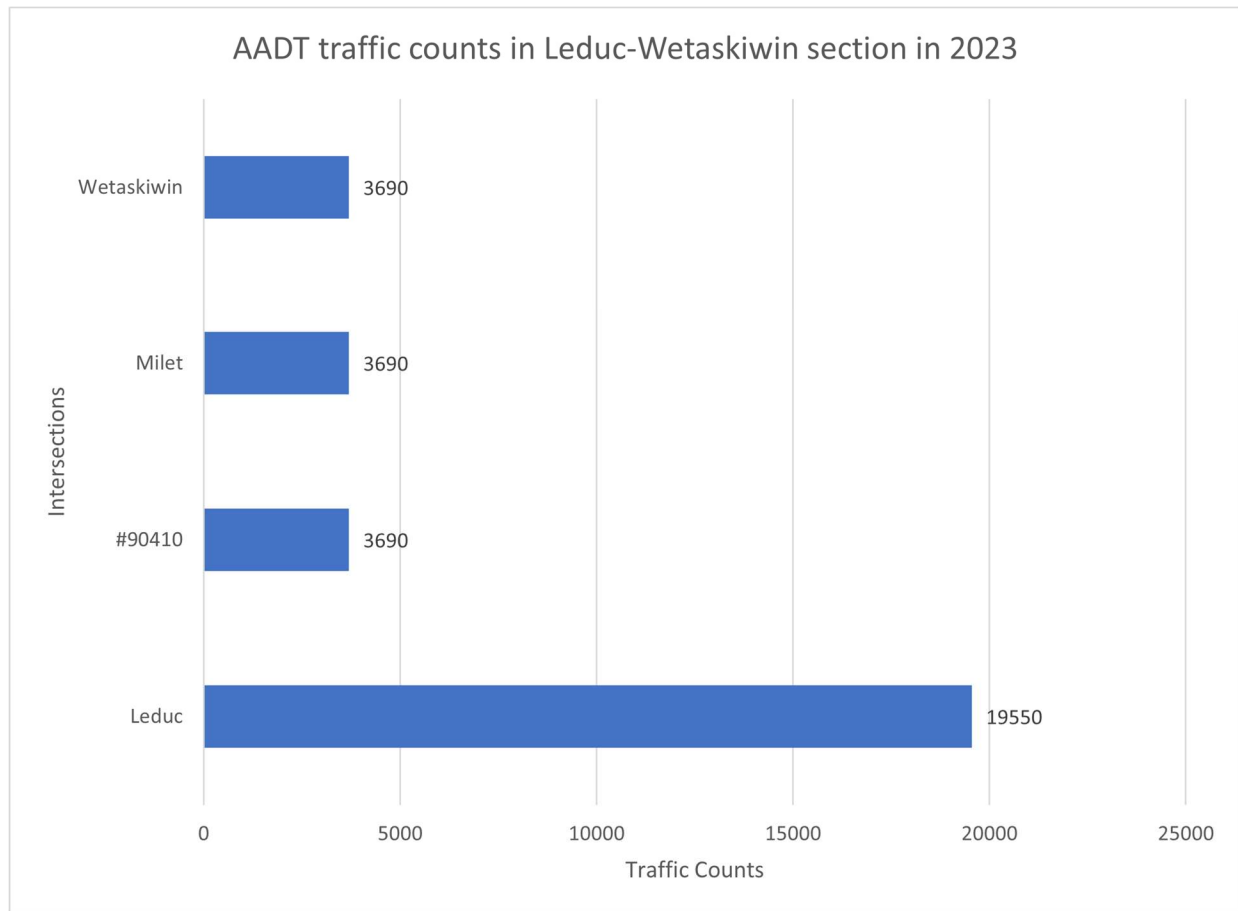


Figure 97: AADT traffic counts in the Leduc-Wetaskiwin section in 2023

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 99), 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.

The segment lengths were as follows: 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.

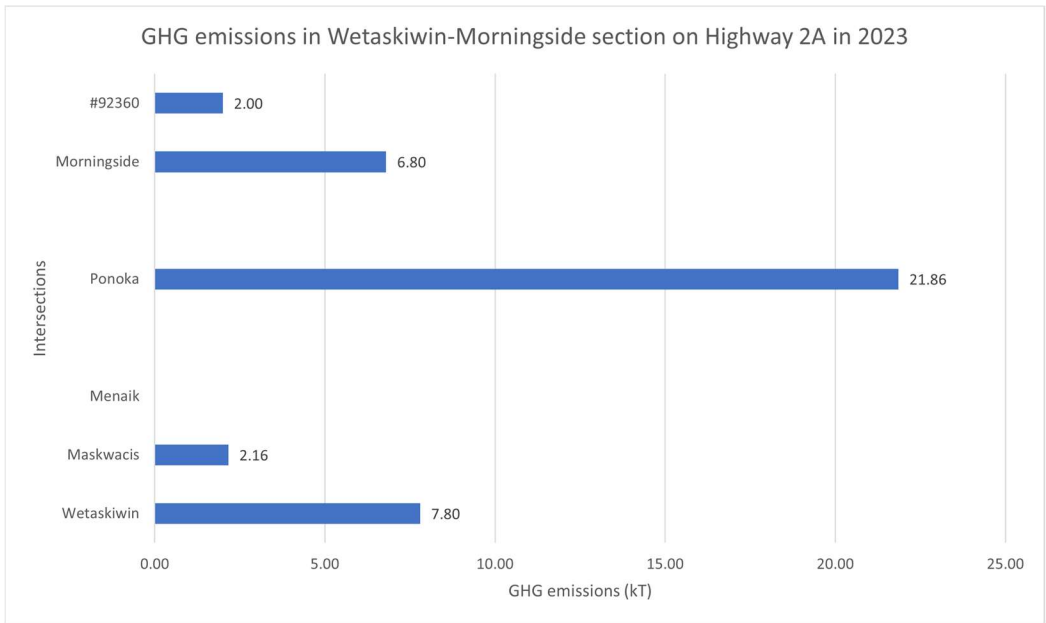


Figure 98: GHG emissions in the Wetaskiwin-Morningside section on Highway 2A in 2023

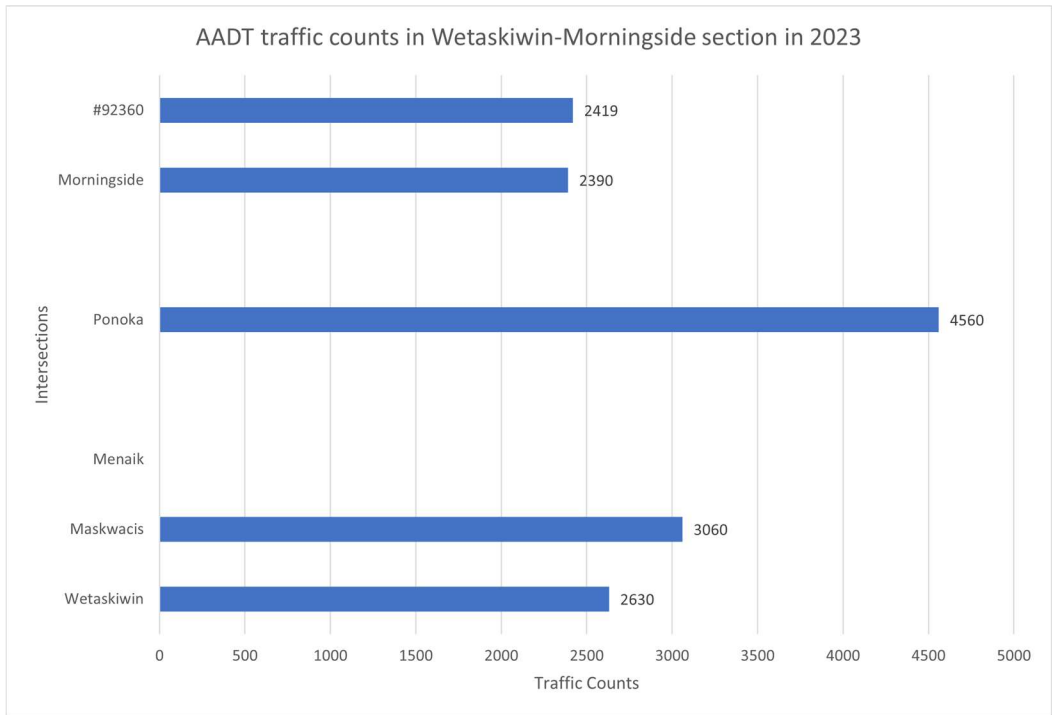


Figure 99: AADT traffic counts in the Wetaskiwin-Morningside section in 2023

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. 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 101), 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.

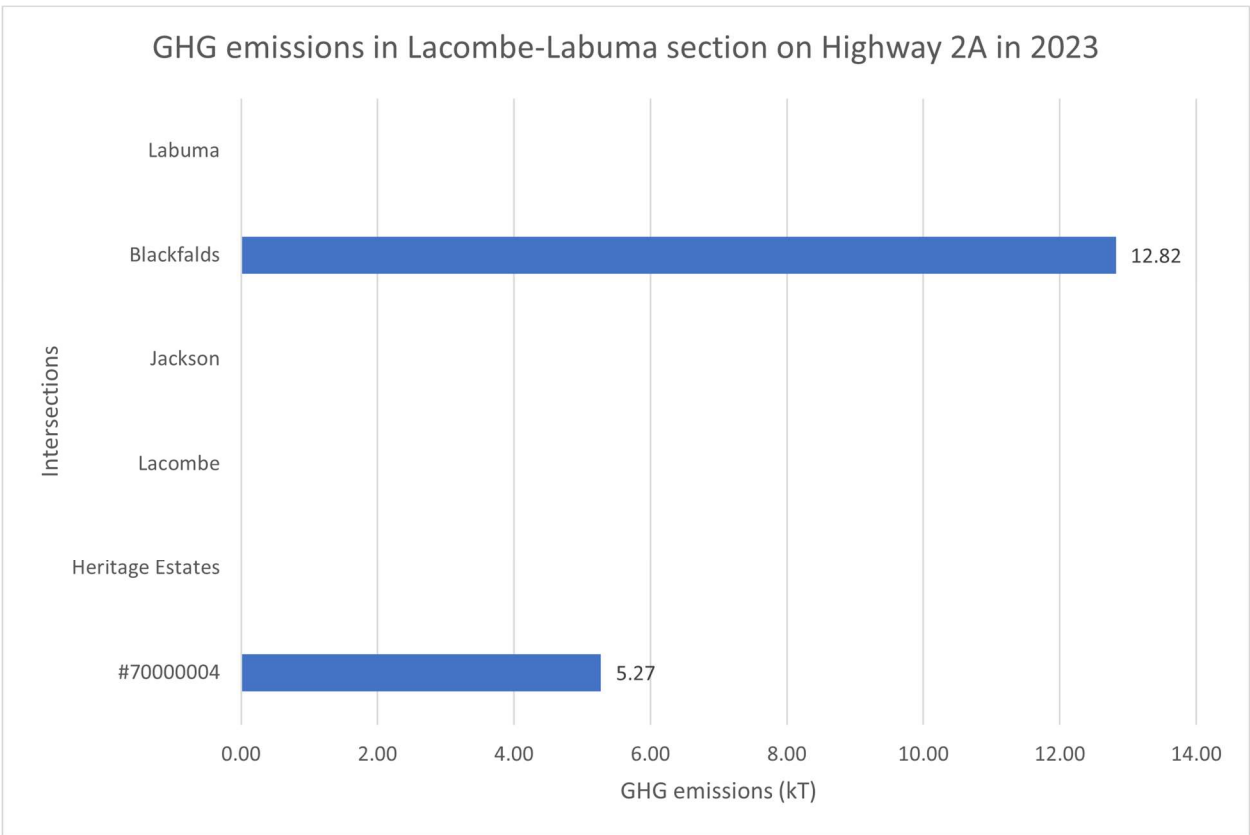


Figure 100: GHG emissions in the Lacombe-Labuma section on Highway 2A in 2023

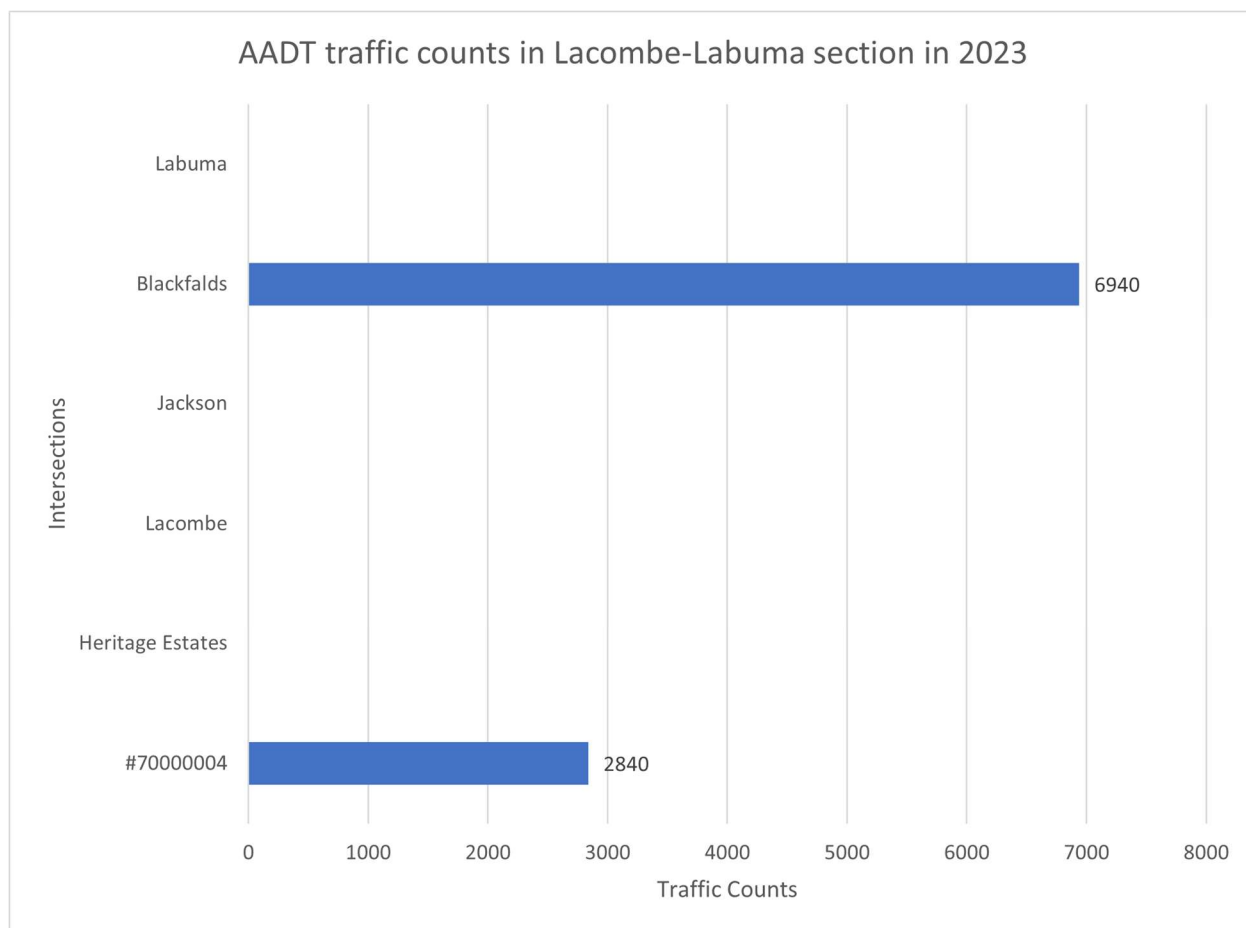


Figure 101: AADT traffic counts in the Lacombe-Labuma section in 2023

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 north to south. 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. Red Deer and Penhold had 6.6% more gasoline vehicles than Innisfail. However, 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 103), Red Deer had 2,900 more vehicles than Innisfail and Penhold combined. In segment length, 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.

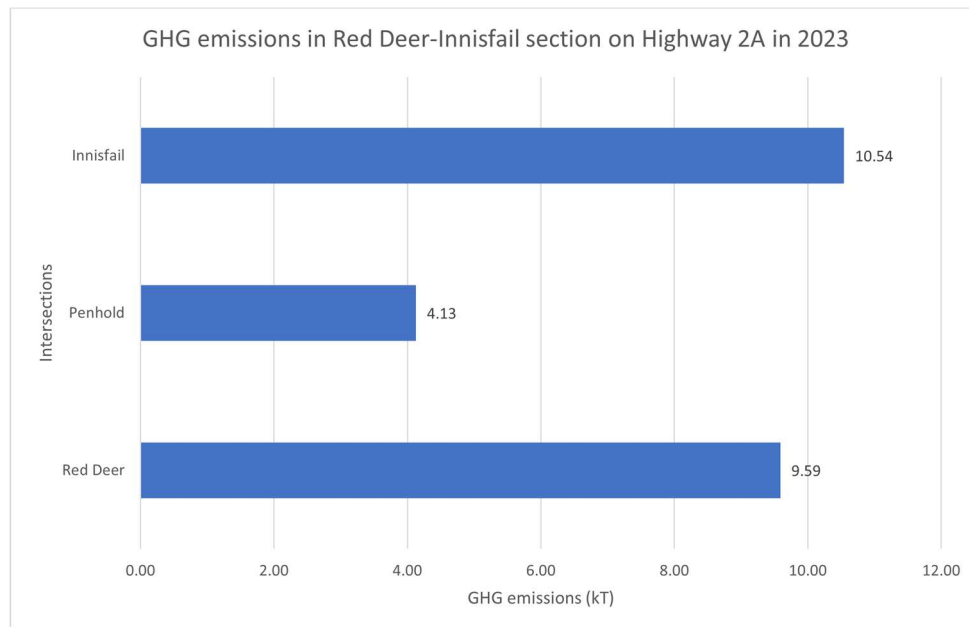


Figure 102: GHG emissions in the Red Deer-Innisfail section on Highway 2A in 2023

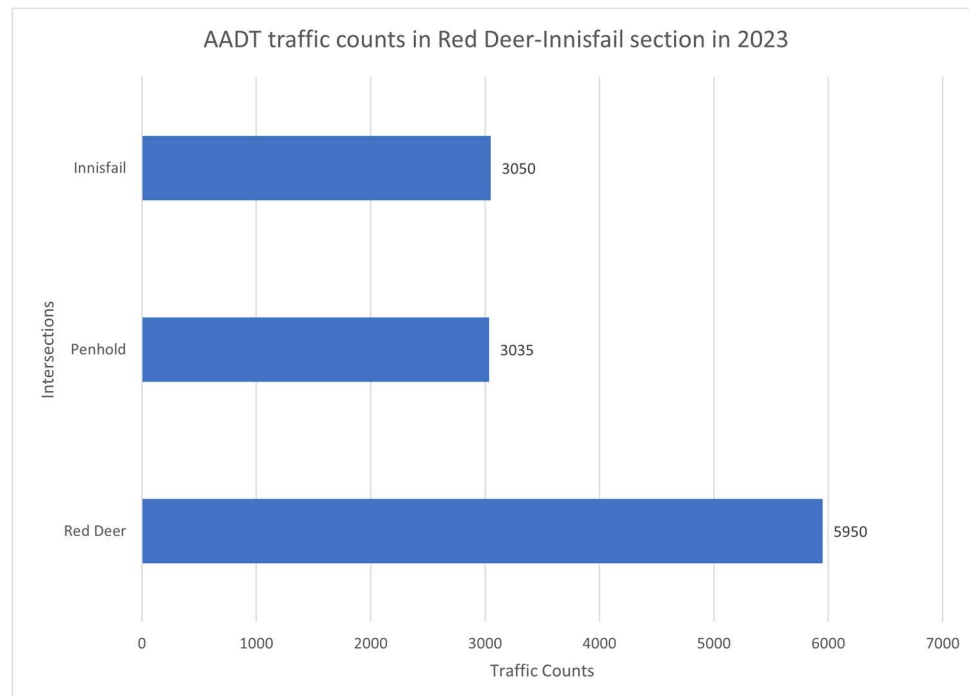


Figure 103: AADT traffic counts in the Red Deer-Innisfail section in 2023

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. 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. At the same time, Olds showed only slight differences in vehicle type distribution except when compared to Bowden and intersection #78280.

In terms of traffic counts (Figure 105), 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, 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 significantly impacted 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.

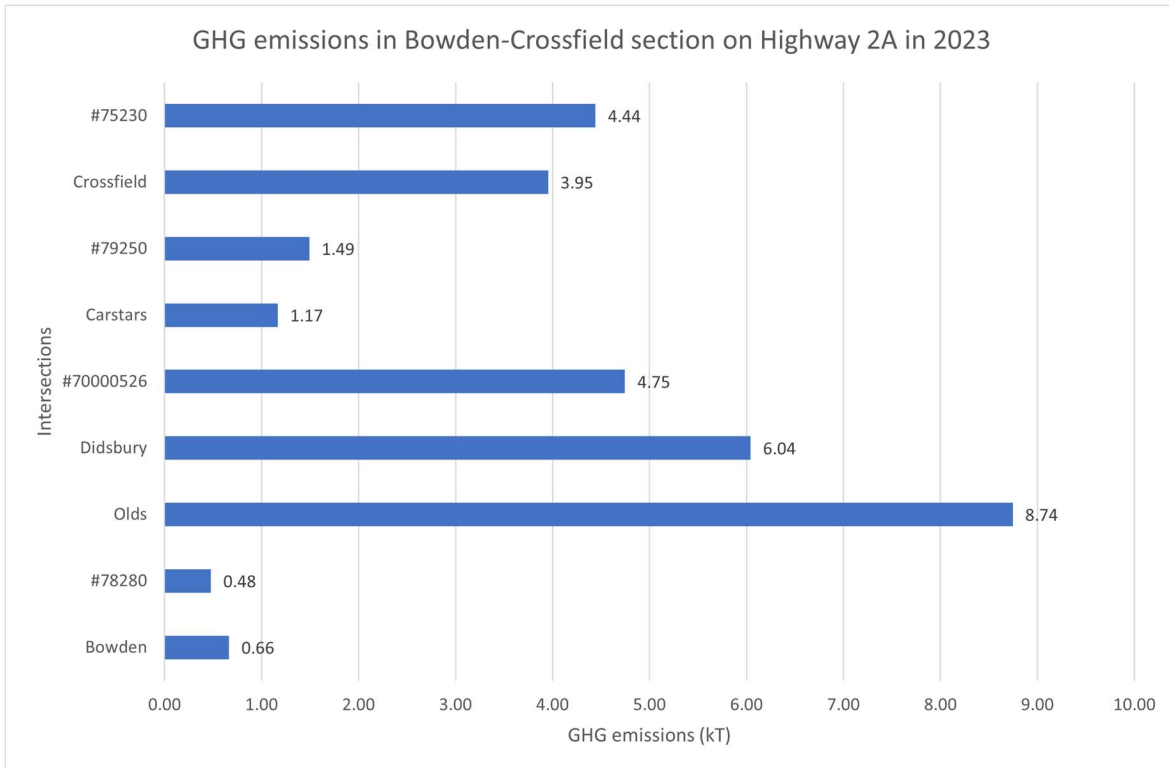


Figure 104: GHG emissions in the Bowden-Crossfield section on Highway 2A in 2023

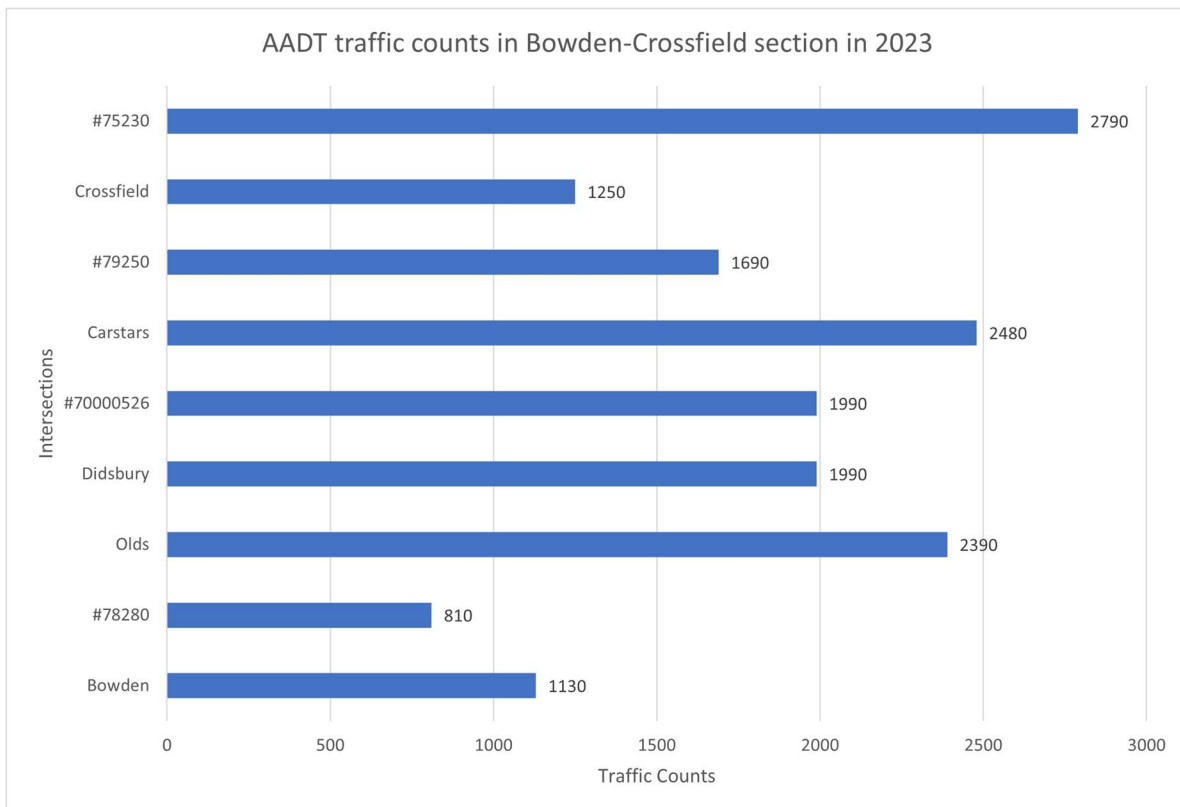


Figure 105: AADT traffic counts in the Bowden-Crossfield section in 2023

Conclusions

Based on the traffic counts, GHG emissions, the impact of COVID-19 on Highway 2 and 2A, and the government's future vision, we provided some ideas for the construction of the railway between Calgary and Edmonton in the future.

Passenger Rail Connection

After careful consideration, we suggested creating a loop from the start point at Calgary, passing through Calgary International Airport, Red Deer, Edmonton International Airport, Jasper National Park, Banff National Park, and back to Calgary. Since Calgary is the most prosperous city in the Calgary-Edmonton corridor, the railway should be built from Calgary, giving the residents and travelers an additional option to travel and commute, reducing GHG emissions from the highway, and earning profits for the government to improve future transportation systems. To analyze the possible obstacles to railway construction, we analyze weather and topography in Calgary, Red Deer, Edmonton, Jasper, and Banff. Based on a topographic map from the Topographic Map ^{ix} and weather from Weather Spark ^x, we suggest the following procedures to build the railway transportation system:

- Calgary-Red Deer Railway
- Red Deer-Edmonton Railway
- Calgary-Banff Railway
- Banff-Jasper Railway

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

Calgary-Red Deer Railway

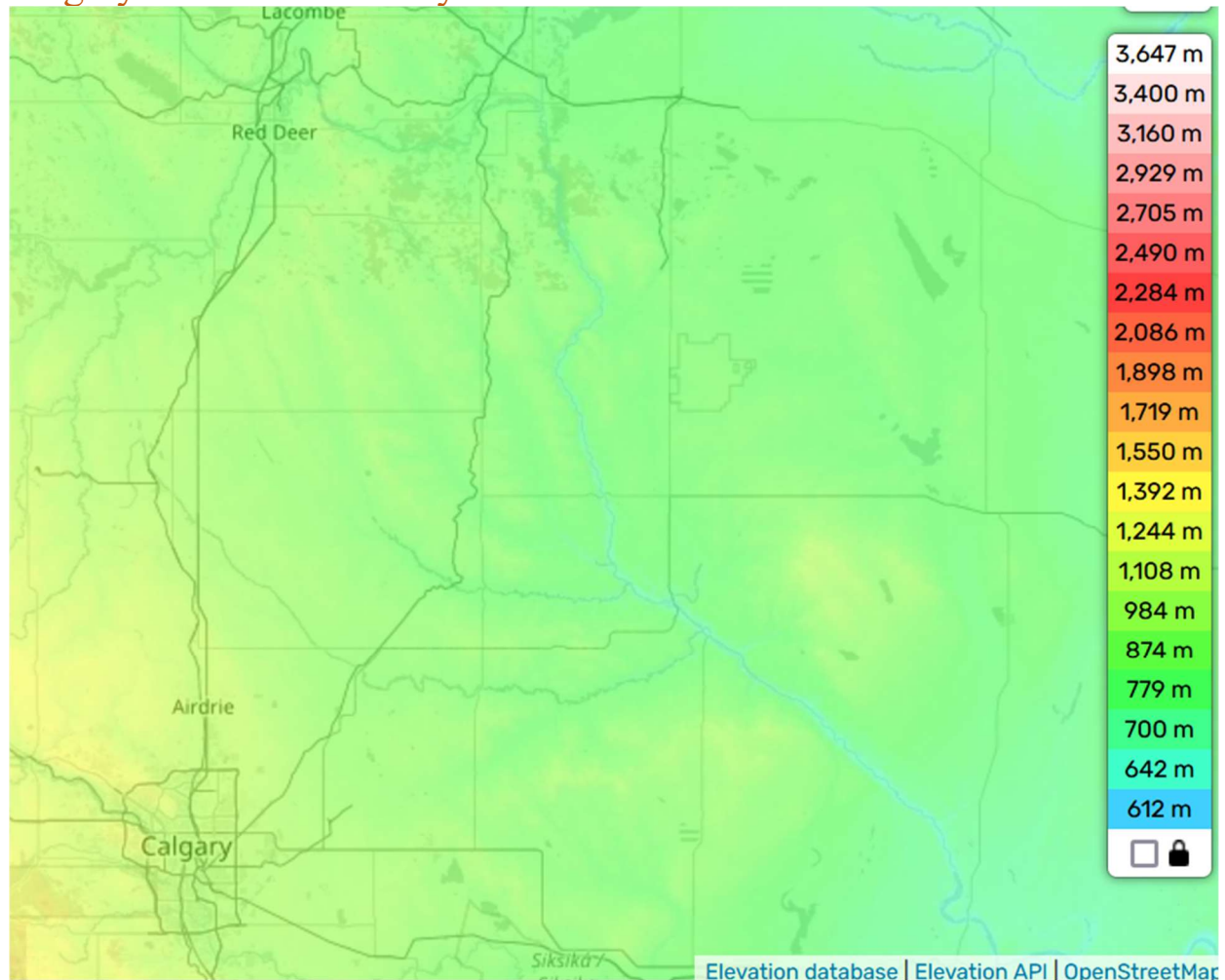


Figure 107: Topographic map from Calgary to Red Deer

Based on the topographic map in Figure 107, the topography between Calgary and Red Deer does not differ much, in a range of 1108 to 1392 meters. The distance is approximately 150 km. The weather in Figure 106 is above zero degrees Celsius from April to October. Due to the topography, winter weather will not be too severe to continue the railroad construction. However, snow and ice will slow down the procedure of railroad construction, such as snow accumulation and the need to remove workers, frozen ground, and heave increase the difficulties in aligning the rail, slow down the curing of concrete, delay the construction timelines, and so on. As a result, the government should prioritize and speed up the railway construction from Calgary to Red Deer from April to October. In the other months, they are focusing on the safety of workers and stability of railroad construction to avoid unpredictable delays.

Red Deer-Edmonton Railway

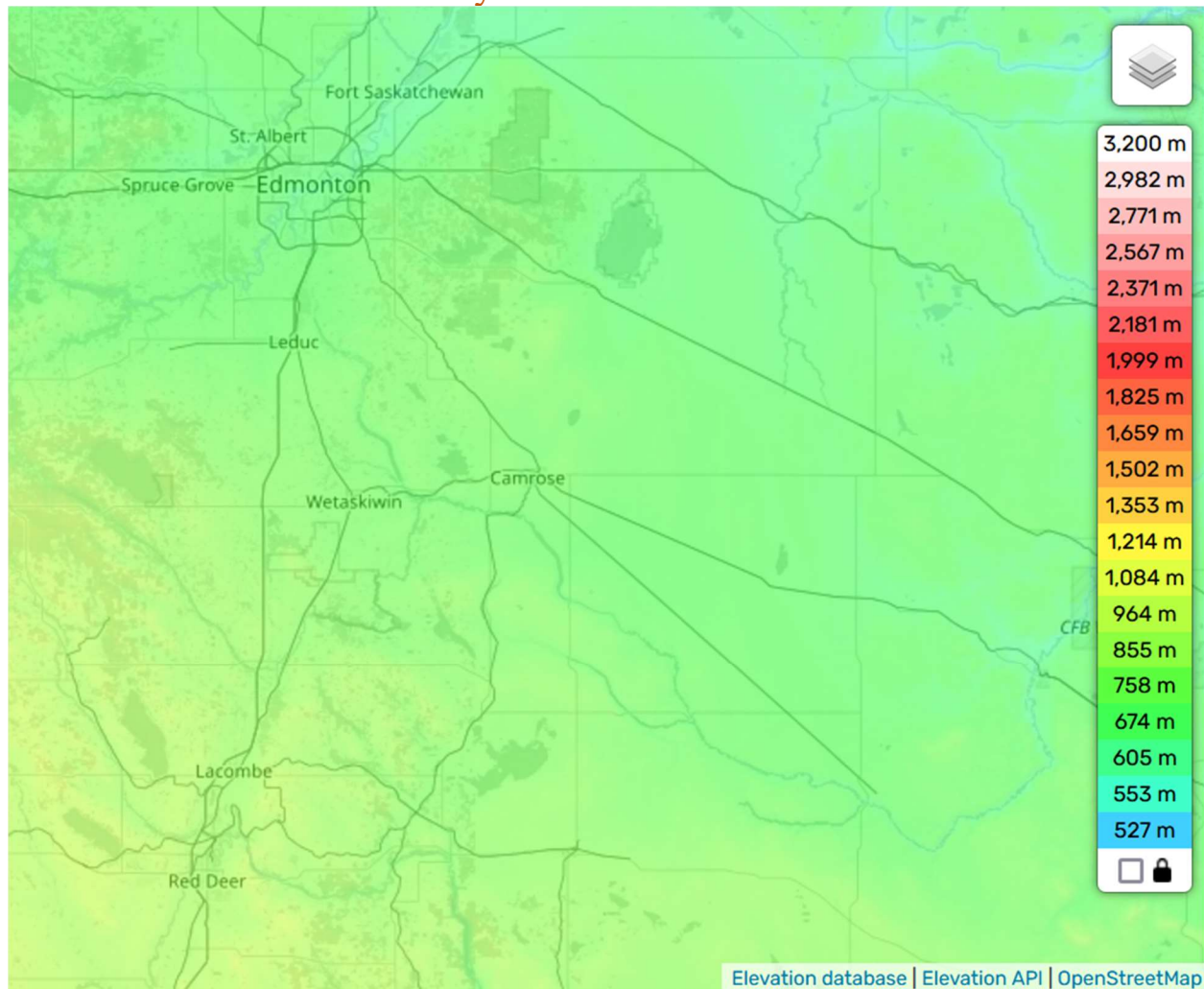


Figure 108: Topographic map from Red Deer to Edmonton

Based on the topographic map in Figure 108, the topography between Red Deer and Edmonton is similar to Calgary to Red Deer, in a range of 1214 to 855 meters. The distance is approximately 150 km. The weather in Figure 106 is above zero degrees Celsius from March to October. Due to the topography, winter weather will not be too severe to continue the railroad construction. However, snow and ice will slow down the procedure of railroad construction. Other reasons will affect the construction timelines besides those in the previous paragraph. For example, snowfall and storms can reduce visibility to workers, increase the difficulties for workers to operate machines, and may need to stop working if the weather is too severe. Also, the maintenance cost will increase because the difference in temperature results in railroad cracks. As a result, the government should focus on constructing the railway from Red Deer to Edmonton from April to October. Safety should be kept first in the other months, and construction speed should be slowed to avoid additional costs and time.

Calgary-Banff Railway

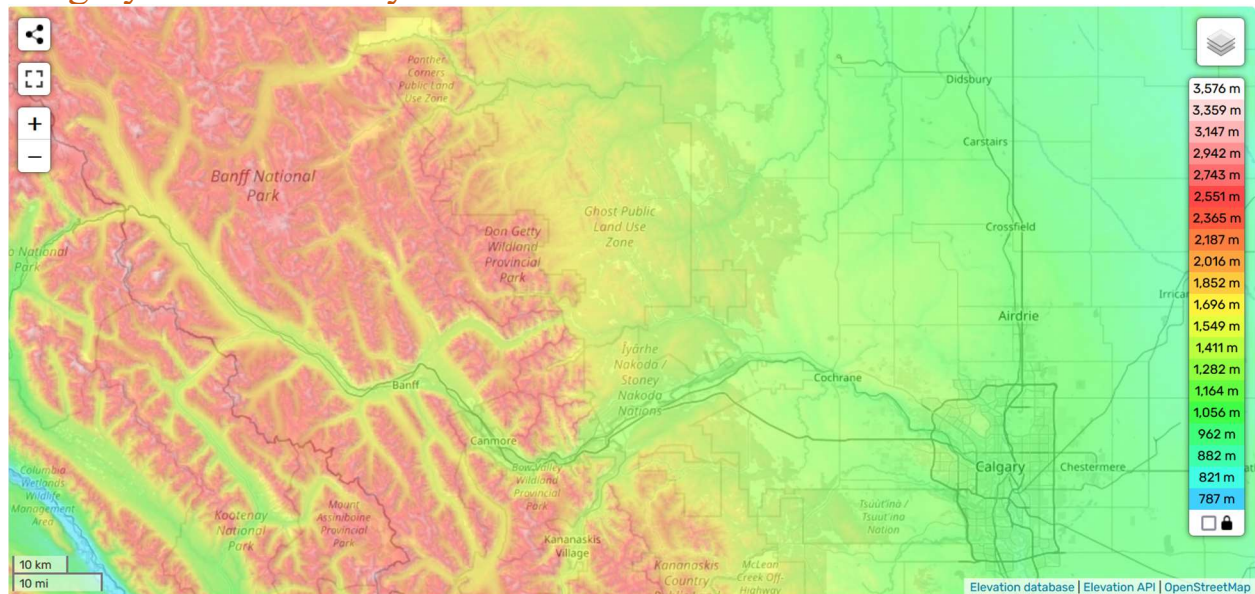


Figure 109: Topographic map from Calgary to Banff

The government is currently planning this railway to give another method for visitors to travel to Banff National Park. The reasons for planning this railway behind the Calgary-Red Deer and Red Deer-Edmonton are based on the temperature and topography in Figures 106 and 158. Based on the temperature although the temperature is above zero Celsius between May and September, rainfall is expected in June and July. Specifically, half of June and July will have precipitation in Banff, increasing the risk of railroad construction in the high-altitude area. Besides, there are several obstacles that the railroad construction needs to conquer in high-altitude areas:

1. Cold temperatures will cause brittleness, increased susceptibility on the railroad, and fractures. Snow and ice will also affect train operations and hinder construction.
2. Railroad construction requires slope stability. The topographic map in Figure 109 shows that even if the route for the vehicles is enough to build an additional railway, uneven terrain and landslides may appear during construction.
3. High-altitude terrain often requires tunnels and bridges to connect the National Park to the city so that the railroad will require more planning expense and time.

As a result, this railway will cost more and require more construction time.

Jasper-Banff Railway

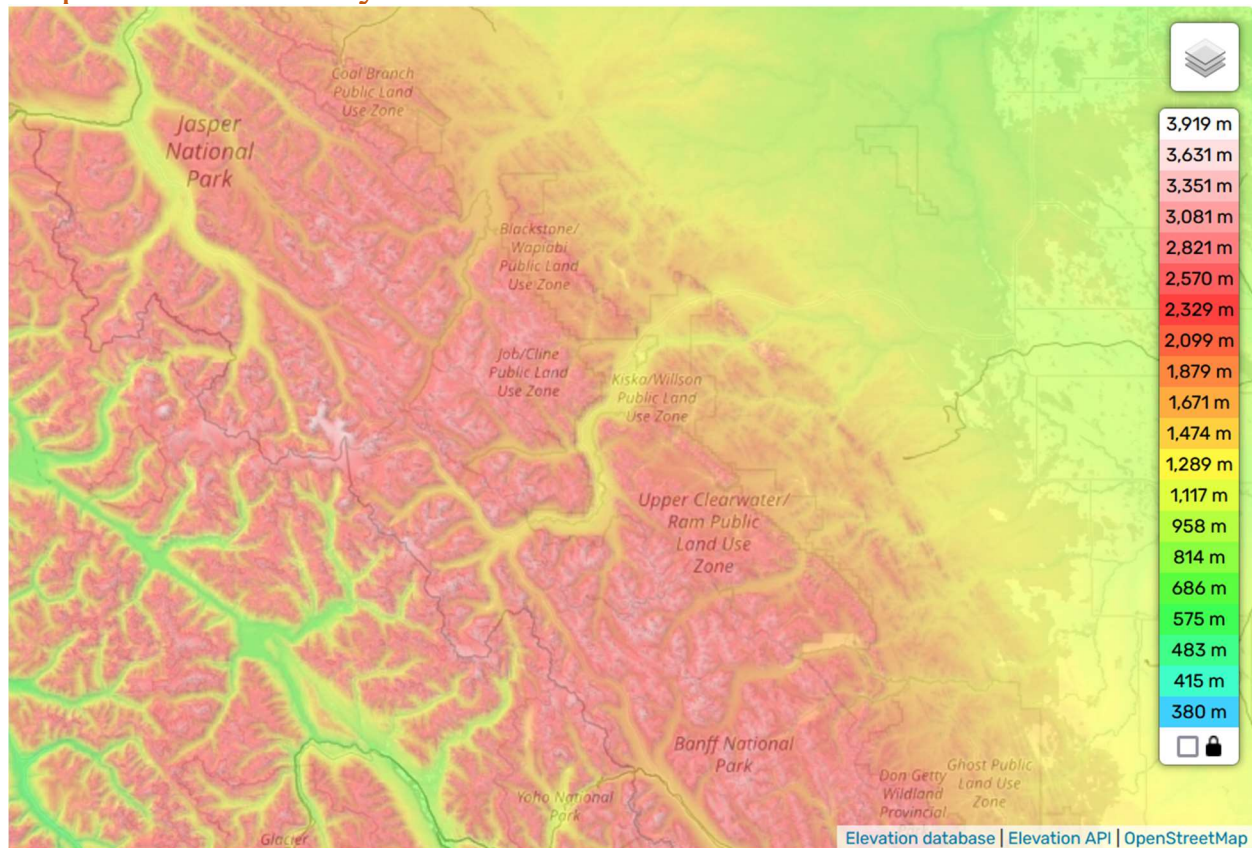


Figure 110: Topographic map from Jasper to Banff

The Jasper to Banff railway will be the last to be constructed between Calgary and Edmonton because of the difficulties in connecting the railroad in the high-altitude mountains. Besides the troubles discussed on the Calgary-Banff railway, other reasons will affect the construction speed between these two areas. First, because the railway construction needs to build tunnels and bridges on the mountain, it will have an environmental impact on the national park. For example, the habitat of wild animals will be influenced and disrupt local flora and fauna; that is, the biodiversity will decrease, and some species might disappear due to the rail construction. The government has to consider how to protect natural assets and animals and prevent accidents on the railway. Besides, the soil will degrade and cause erosion of the mountains. Second, the railway materials are difficult and expensive to transfer to the mountain, and the workers need places to live without long commutes, so the railway construction has not been implemented. Last, weather is the most significant reason the construction will be interrupted. In Figure 106, each month is primarily below zero Celsius. Snow and ice will be difficult to avoid during the railway construction. Even though the temperature is below zero Celsius in July and August, the precipitation is 42 percent at Jasper and 35 percent at Banff. Consequently, this railway construction between Jasper and Banff will be the most arduous project in the Calgary-Edmonton corridors.

References

1. Alberta Highway traffic counts

<https://www.alberta.ca/highway-traffic-counts>

2. Connecting Communities: An AADT Analysis of the Calgary - Edmonton Corridor

<https://integrated.travel/gallery/AADT%20Report%20RV.pdf>

3. 'Massive undertaking': Province eyes commuter, Edmonton-Calgary passenger rail links by early 2040s

<https://calgaryherald.com/news/local-news/alberta-commuter-edmonton-calgary-rail-plan>

4. LRT Lessons That Can Be Learned from Edmonton and Calgary

<https://onlinepubs.trb.org/Onlinepubs/trr/1992/1361/1361-005.pdf>

5. Alberta Transportation Study_ Hwy 2 & 370 Ave 2019.pdf

https://www.okotoks.ca/sites/default/files/2022-03/Alberta%20Transportation%20Study_%20Hwy%202%20%26%20370%20Ave%202019.pdf

6. Highway 2A Function Planning Study

https://www.leduc.ca/sites/default/files/Highway%202A%20Function%20Planning%20Study_.pdf

7. Light Rail Transit Direct Fixation Track Rehabilitation: The Calgary Experience

<https://onlinepubs.trb.org/Onlinepubs/trr/1992/1361/1361-033.pdf>

8. Railways, Airports and Harbor Engineering

https://vcetcivil.weebly.com/uploads/4/6/0/6/46062219/rahe_unit_-_1.pdf

ⁱ Alberta Highway 2

https://en.wikipedia.org/wiki/Alberta_Highway_2#cite_note-gmapsouth-8

ⁱⁱ Alberta Highway 2A

https://en.wikipedia.org/wiki/Alberta_Highway_2A

ⁱⁱⁱ Asymptomatic SARS-CoV-2 Infection by Age: A Global Systematic Review and Meta-analysis

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9935239/>

^{iv} The impact of COVID-19 on transportation-related and risky driving behaviors in Canada

<https://www.sciencedirect.com/science/article/pii/S1369847823002474>

^v Traffic Data Mapping

<http://www.transportation.alberta.ca/mapping/>

^{vi} Table A11–18 GHG Emission Summary for Alberta, Selected Years

https://publications.gc.ca/collections/collection_2024/eccc/En81-4-2022-3-eng.pdf

^{vii} GHG emission formula

<https://crp.trb.org/nchrpwebresource1/16-0-transportation-system-management-and-operations/>

^{viii} Dataset of GHG emissions calculation

https://docs.google.com/spreadsheets/d/17eRT-EFCRGgGy_0SmXuk4Fo75nxrlgWL/edit?usp=drive_link&ouid=115200208647257088899&rtpof=true&sd=true

^{ix} The Topographic Map

<https://en-ca.topographic-map.com/map-sgdf3/Edmonton/?center=51.73383%2C-114.34809&zoom=8>

^x Weather Spark

<https://weatherspark.com/compare/y/2428~2349~2414~150465~150464/Comparison-of-the-Average-Weather-in-Edmonton-Calgary-Red-Deer-Jasper-National-Park-of-Canada-and-Banff-National-Park-of-Canada>