Regional District of Nanaimo 2021 GPC BASIC+ Community Greenhouse Gas (GHG) Emissions Inventory Report

Prepared for:
Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC V9T 6N2

Prepared by:
Stantec Consulting Ltd.
200-325 25 Street SE
Calgary, AB T2A 7H8

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Prepared By

Daniel Hegg, MSc. CEM

Reviewed and Approved for Release By:

Nicole Flanagan, MASc. P.Eng (ON, BC)

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Executive Summary

There is increasing evidence that global climate change resulting from emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) is having a significant impact on the ecology of the planet. Delayed actions to respond to the effects of climate change are expected to have serious negative impacts on global economic growth and development.

Beyond the costs associated with delayed climate action, there are cost savings to be realized through efforts to improve energy efficiency, conserve energy, and reduce GHG emissions intensity. To make informed decisions on reducing energy use and GHG emissions at the community scale, community managers must have a good understanding of these sources, the activities that drive them, and their relative contribution to the total. This requires the completion of an energy and GHG emissions inventory. To allow for credible and meaningful reporting locally and internationally, the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (the GPC Protocol) was developed. The GPC Protocol has been adopted by the Global Covenant of Mayors—an agreement led by community networks to undertake a transparent and supportive approach to measure GHG emissions community-wide. The Global Covenant of Mayors and the Federation of Canadian Municipalities promotes the use of the GPC Protocol as a standardized way for municipalities to collect and report their actions on climate change.

This project set out to compile a detailed GHG inventory for the Regional District of Nanaimo (RDN) for the 2007 base year and the 2021 reporting year using the GPC Protocol. The RDN has historically relied on the Provincial 2007, 2010 and 2012 Community Energy and Emissions Inventories (CEEI) to baseline and track community GHG emissions. However, there have been some limitations to the CEEI which has resulted in the RDN preparing a GPC BASIC+ inventory. Following the requirements of the GPC Protocol, the GHG inventories considered emissions from all reporting Sectors, including Stationary Energy, Transportation, Waste, Industrial Process and Product Use (IPPU), and Agriculture, Forestry and Other Land Use (AFOLU). The purpose of this document is to describe the quantification methodologies used to calculate GHG emissions for the 2021 reporting year, and to present the RDN's 2021 community GHG emissions.

In 2021, the RDN's BASIC+ GHG emissions totaled 1,334,345 tonnes of carbon dioxide equivalent (tCO_2e). On an absolute basis, this is an 1.7% increase from the 2007 reporting year GHG emissions and a decline of 16.0% on a per capita basis. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and ecosystem sequestration, these GHG emissions have been excluded from the RDNs GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed. Aviation GHG emissions have been excluded from the GHG emissions inventory to allow time for the airport to quantify those emissions.

A summary of the 2021 GHG emissions is presented in Table E-1 and Figure E-1.

Table E-1 BASIC+ 2007 Base & 2021 Reporting Year GHG Emissions

Sector	Sub-Sector	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)
Stationary Energy	Residential Buildings	178,457	178,168
	Commercial & Institutional Buildings	88,577	76,497
	Manufacturing Industries & Construction	131,220	162,486
	Energy Industries	462	688
	Agriculture, Forestry & Fishing Activities	34,815	48,671
	Fugitive Emissions	583	1,151
Transportation	In-Boundary On-road Transportation	680,030	633,033
	Trans-Boundary On-road Transportation	93,773	87,915
	Waterborne Navigation	6,518	9,122
	Aviation	Not Estimated	Not Estimated
	Railway	1,248	1,602
	Off-road Transportation	24,215	35,024
Waste	Solid Waste	45,315	43,188
	Biological Treatment of Waste	394	3,112
	Incineration & Open Burning	126	147
	Wastewater Treatment & Discharge	1,965	2,887
IPPU	IPPU	20,388	46,361
AFOLU	Land-Use: Emissions Sequestered (Disclosure Only - Not Included In Total)	-304,136	-275,068
	Land-Use: Emissions Released (Disclosure Only - Not Included In Total)	9,322	9,322
	Livestock	3,818	4,184
	Non-CO2 Land Emission Sources	109	109
Change in GHG Emissions from Reporting year		**1,312,013**	**1,334,345**
Total Per Capita GHG Emissions (tCO_2e / Capita)		**9.2**	**7.8**
Change GHG Emissions Per Capita from 2007 Reporting year			**-16.0%**
Change in GHG Emissions from 2007 Reporting year			**1.7%**

Data in the table above is depicted in Figure E-1.

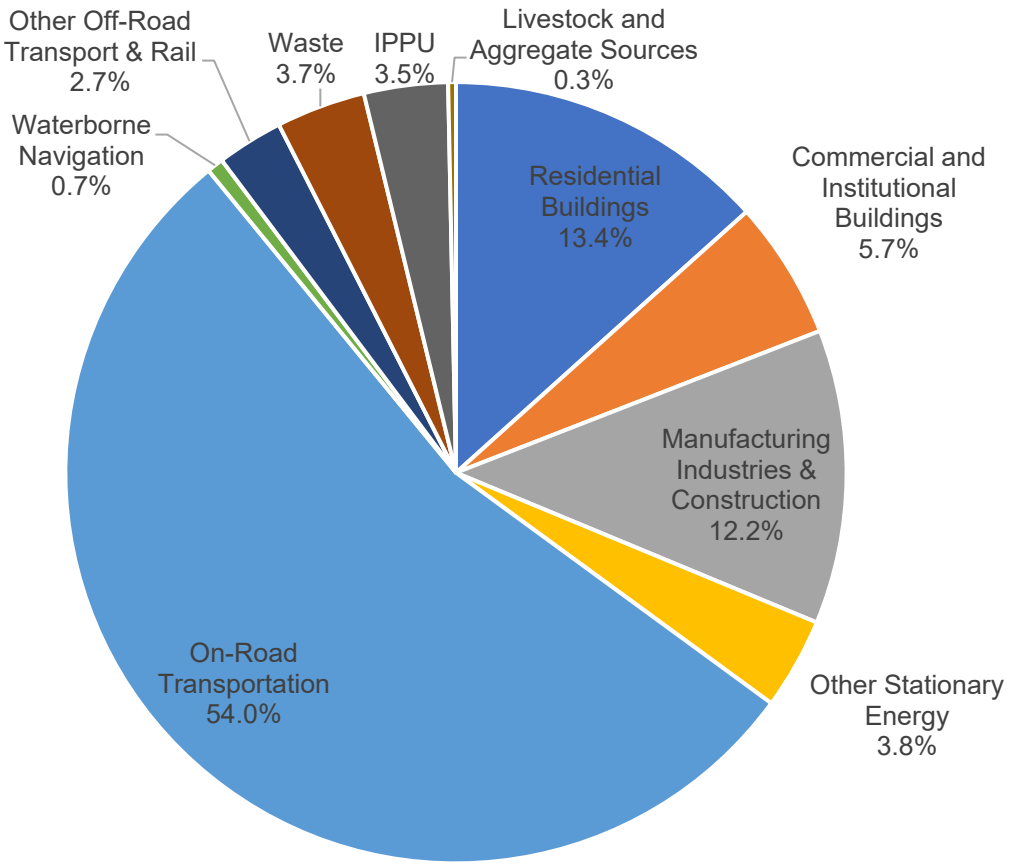

Figure E-1 RDN's 2021 BASIC+ GHG Emissions Profile (Excluding Land-Use)

Abbreviations

ACI	Annual Crop Inventory
AFOLU	Agriculture, Forestry, and Other Land Use
BC	British Columbia
C40	C40 Cities Climate Leadership Group
CH_4	Methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CEEI	Community Energy and Emissions Inventories
RDN	Regional District of Nanaimo
eMWh	megawatt hours equivalents
FCM	Federation of Canadian Municipalities
GDP	gross domestic product
GHG	greenhouse gas
GJ	Gigajoules
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP	global warming potentials
HDV	Heavy Duty Vehicle
HFC	Hydrofluorocarbons
ICBC	Insurance Corporation of BC
ICLEI	International Council for Local Environmental Initiatives
IE	included elsewhere
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
ISO	International Organization for Standardization

kg	Kilograms
kW	Kilowatt
kWh	kilowatt hours
L	Litres
LDT	Light Duty Truck
LDV	Light Duty Vehicle
MWh	megawatt hours
N_2O	nitrous oxides
NE	not estimated
NIR	National Inventory Report
NPRI	National Pollutant Release Inventory
NO	not occurring
ORVE	Off-Road Vehicle and Equipment
PCP	Partnership for Climate Protection
PFC	Perfluorocarbons
SC	Other Scope 3
SF_6	sulfur hexafluoride
T	Tonnes
WIP	waste-in-place
WRI	World Resources Institute

Glossary

Air pollution	The presence of toxic chemicals or materials in the air, at levels that pose a human health risk.
Reporting year	This is the reference or starting year to which targets and GHG emissions projections are based.
BASIC	An inventory reporting level that includes all Scope 1 sources except from energy generation, imported waste, IPPU, and AFOLU, as well as all Scope 2 sources (GPC, 2014).
BASIC+	An inventory reporting level that covers all GPC BASIC sources, plus Scope 1 AFOLU and IPPU, and Scope 3 in the Stationary Energy and Transportation Sectors (GPC, 2014).
Biogenic emissions	Emissions produced by living organisms or biological processes, but not fossilized or from fossil sources (GPC, 2014).
Carbon dioxide equivalent (CO_2e)	The amount of carbon dioxide (CO_2) emissions that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2e emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs, it is obtained by summing the CO_2e emissions of each gas (IPCC 2014).
Climate change	Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014).
Emission	The release of GHGs into the atmosphere (GPC, 2014).
Emission factor(s)	A factor that converts activity data into GHG emissions data (GPC, 2014).
Flaring	The burning of natural gas that cannot be used.
Fossil fuels	A hydrocarbon deposit derived from the accumulated remains of ancient plants and animals which is used as an energy source.
Fugitive emission	Emissions that are released during extraction, transformation, and transportation of primary fossil fuels. These GHG emissions are not combusted for energy.
Geographic boundary	A geographic boundary that identifies the spatial dimensions of the inventory's assessment boundary. This geographic boundary defines the physical perimeter separating in-boundary emissions from out-of-boundary and transboundary emissions (GPC, 2014).
Gigajoule (GJ)	A gigajoule (GJ), one billion joules, is a measure of energy. One GJ is about the same energy as: • Natural gas for 3-4 days of household use • The electricity used by a typical house in 10 days

Global warming	A gradual increase in the Earth's temperature which is attributed to the greenhouse effect caused by the release of greenhouse gas (GHG) emissions into the atmosphere.
Global warming potential (GWP)	An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing. The Kyoto Protocol is based on global warming potentials over a 100-year period (IPCC 2014).
Greenhouse gas (GHG)	GHGs are the seven gases covered by the UNFCCC: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3) (GPC, 2014).
GHG intensity	The annual rate to which GHG emissions are released in the atmosphere, relative to a specific intensity.
Gross domestic product (GDP)	An economic measure of all goods and services produced in an economy.
In-boundary	Occurring within the established geographic boundary (GPC, 2014).
Reporting year	The year for which emissions are reported (GPC, 2014).
Scope 1	Emissions that physically occur within a community.
Scope 2	Emissions that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross Community boundaries.
Scope 3	Emissions that occur outside a community but are driven by activities taking place within a community's boundaries.
Tonne of CO_2e	A tonne of greenhouse gases (GHGs) is the amount created when we consume: • 385 litres of gasoline (about 10 fill-ups) • Enough electricity for three homes for a year (38,000 kWh)
Transboundary GHG emissions	Emissions from sources that cross the geographic boundary (GPC, 2014). These include GHG emissions from on-road trips where the vehicle crosses municipal boundaries. For example, if travelling from Comox to Nanaimo, the on-road transportation GHG emissions in Nanaimo would be considered transboundary as the origin of the trip occurred in Comox.

1.0 INTRODUCTION

1.1 CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS

Since the industrial revolution, human activities such as burning fossil fuels, deforestation, agricultural practices, and other land use changes have resulted in the release of unnaturally large volumes of greenhouse gas (GHG) emissions into the Earth's atmosphere causing global climate systems to change. In its sixth assessment report, the Intergovernmental Panel on Climate Change (IPCC) concluded that "the scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years."[1] To substantially reduce the risks and effects of climate change, and limit global warming to 1.5°C, scientists and policy makers have come to the agreement that global society must dramatically reduce greenhouse gas (GHG) emissions 50–60% by 2030, 80% by 2040, more than 90% by 2050 with the remaining emissions being offset or neutralized (e.g., direct air capture, reforestation, etc.) and be net negative in the second half of the century. Recognizing the importance and benefits to addressing climate change, many governments – including the Government of Canada and Province of British Columba, and the RDN as well as publicly traded organizations representing more than $23 trillion in market capitalization have now committed to these GHG reduction targets.[2]

1.2 COMMUNITIES AND GREENHOUSE GAS EMISSIONS

Communities are centers of communication, commerce, and culture. They are, however, also a significant and growing source of energy consumption and GHG emissions. On a global scale, communities are major players in GHG emissions. They are responsible for more than 70% of global energy-related carbon dioxide emissions and thus represent the single greatest opportunity for tackling climate change.

For a community to act on mitigating climate change and monitor its progress, it is crucial to have good quality GHG emissions data to build a GHG inventory. Such an inventory enables cities to understand the breakdown of their emissions and plan for effective climate action. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol) seeks to support exactly that, by giving cities the standards and tools that are needed to measure the emissions, build more effective emissions reduction strategies, set measurable and more ambitious emission reduction goals, and to track their progress more accurately and comprehensively.

Until recently there has been no internationally recognized way to measure community-level emissions. Inventory methods that community managers have used to date around the globe vary significantly. This inconsistency has made comparisons between cities and over the years difficult. The GPC Protocol offers

[1] https://www.ipcc.ch/assessment-report/ar6/
[2] sciencebasedtargets.org/news/more-than-1000-companies-commit-to-science-based-emissions-reductions-in-line-with-1-5-c-climate-ambition

an internationally accepted, credible emissions accounting and reporting practice that will help communities to develop comparable GHG inventories.

1.3 VARIANCE FROM COMMUNITY ENERGY AND EMISSIONS INVENTORIES (CEEI)

The RDN has historically relied on annual Provincial Community Energy and Emissions Inventories (CEEI) to track community GHG emissions. However, there have been some limitations to the CEEI in that it is an in-boundary inventory, the most recent version containing transportation data was published in 2010, and the CEEI Protocol does not fully meet the requirements of the GPC Protocol BASIC or BASIC+ reporting requirements which is the required reporting standard for local governments that have committed to the Global Covenant of Mayors—an agreement led by city networks to undertake a transparent and supportive approach to measure GHG emissions community-wide. A high-level summary of the differences between the CEEI and GPC Protocol inventories are presented in Table 1.

Table 1 Summary of GHG Inventory Scope Differences

Reporting Sector	CEEI	GPC BASIC	GPC BASIC+
Residential Buildings	✓	✓	✓
Commercial And Institutional Buildings And Facilities	✓	✓	✓
Manufacturing Industries And Construction	✓	✓	✓
Energy Industries		✓	✓
Energy Generation Supplied To The Grid		✓	✓
Agriculture, Forestry And Fishing Activities		✓	✓
Non-Specified Sources		✓	✓
Fugitive Emissions From Mining, Processing, Storage, And Transportation Of Coal		✓	✓
Fugitive Emissions From Oil And Natural Gas Systems		✓	✓
On-Road Transportation	✓	✓	✓
Railways		✓	✓
Waterborne Navigation		✓	✓
Aviation		✓	✓
Off-Road Transportation		✓	✓
Solid Waste	✓	✓	✓
Biological Waste	✓	✓	✓
Incinerated And Burned Waste		✓	✓

Reporting Sector	CEEI	GPC BASIC	GPC BASIC+
Wastewater		✓	✓
Emissions From Industrial Processes			✓
Emissions From Product Use			✓
Emissions From Livestock	✓		✓
Emissions From Land			✓
Emissions From Aggregate Sources And Non-CO_2 Emission Sources On Land	✓		✓

1.4 PURPOSE OF THIS DOCUMENT

The purpose of this document is to describe the quantification methodologies used by the RDN to calculate its BASIC+ GHG emissions for the 2007 base and 2021 reporting years. The focus of this report is on the 2021 reporting year. The RDN has elected to prepare a BASIC+ GHG emissions inventory to align with global best practices in community GHG emissions and to provide its members with the more comprehensive GHG emissions inventory database.

This document also supports the preparation of future community GHG emissions inventories, by:

- Defining GHG emissions data sources to be used for future inventory work
- Establishing quantification methods and assumptions.
- Evaluating the quality of the data sources and emission factors.
- Supporting consistent quantification of the inventory results over time.

2.0 GLOBAL PROTOCOL FOR COMMUNITY (GPC) SCALE EMISSION INVENTORIES PROTOCOL

2.1 OVERVIEW

The GPC Protocol is the result of a collaborative effort between the GHG Protocol at the World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and ICLEI—Local Governments for Sustainability (ICLEI). The GPC Protocol is recognized as one of the first set of standardized global rules for cities to measure and publicly report community wide GHG emissions. It sets out requirements and provides guidance for calculating and reporting community wide GHG emissions, consistent with the 2006 IPCC guidelines on how to estimate GHG emissions (IPCC, 2006). Specifically, the GPC Protocol seeks to:

- Help cities develop a comprehensive and robust GHG inventory to support climate action planning.
- Help cities establish a reporting year GHG emissions inventory, set GHG reduction targets, and track performance.
- Ensure consistent and transparent measurement and reporting of GHG emissions between cities, following internationally recognized GHG accounting and reporting principles.
- Enable community wide GHG inventories to be aggregated at subnational and national levels.
- Demonstrate the important role that cities play in tackling climate change and facilitate insight through benchmarking—and aggregation—of comparable GHG data.

2.2 GPC PROTOCOL STRUCTURE

The GPC Protocol sets several assessment boundaries which identify the restrictions for gases, emission sources, geographic area, and time span covered by a GHG inventory:

- The GHG inventory is required to include all seven Kyoto Protocol GHGs occurring within the geographic boundary of a community. These include:
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
  - Hydrofluorocarbons (HFCs)
  - Perfluorocarbons (PFCs)
  - Sulfur hexafluoride (SF_6)
  - Nitrogen trifluoride (NF_3)
- The GHG emissions from community-wide activities must be organized and reporting under the following five Sectors, based on the selected reporting level:
  - Stationary Energy
  - Transportation
  - Waste
  - Industrial Processes and Product Use (IPPU)

- Agriculture, Forestry, and Other Land Use (AFOLU)

The GPC Protocol also requires that a community define an inventory boundary, identifying the geographic area, time span, gases, and emission sources.

Under the GPC Protocol, a community has the option of reporting GHG emissions under three different levels:

- Territorial - A City only reports on GHG emissions occurring within the city boundaries
- City-Induced – A City accounts for all GHG emissions as a result of activities that occur within Under the City-Induced framework, there are two levels of reporting available to cities - BASIC and BASIC+
  - **BASIC—**This level covers stationary energy and transportation GHG emissions that physically occur within a city (Scope 1) and those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (Scope 2). The BASIC level also includes waste GHG emissions that may occur outside of a city but are driven by activities taking place within a city's boundaries (Scope 3). The BASIC level aligns with the current GHG reporting requirements of most voluntary reporting programs for local governments.
  - **BASIC+—**This level covers the same scopes as BASIC and includes more in-depth and data dependent methodologies. Specifically, it expands the reporting scope to include Scope 1 emissions from Industrial Process and Product Use (IPPU), Agriculture, Forestry, and Other Land-Use (AFOLU), and Scope 3 GHG emissions from transboundary transportation. The sources covered in BASIC+ also align with sources required for national reporting in IPCC guidelines.

Activities taking place within a community can generate GHG emissions that occur inside a Community boundary as well as outside a Community boundary. To distinguish between these, the GPC Protocol groups emissions into three categories based on where they occur: Scope 1, Scope 2, or Scope 3 emissions. The GPC Protocol distinguishes between emissions that physically occur within a Community (Scope 1), from those that occur outside a Community but are driven by activities taking place within a Community's boundaries (Scope 3), from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross community boundaries (Scope 2). Scope 1 emissions may also be termed "territorial" emissions, because they are produced solely within the territory defined by the geographic boundary (see Figure 1).

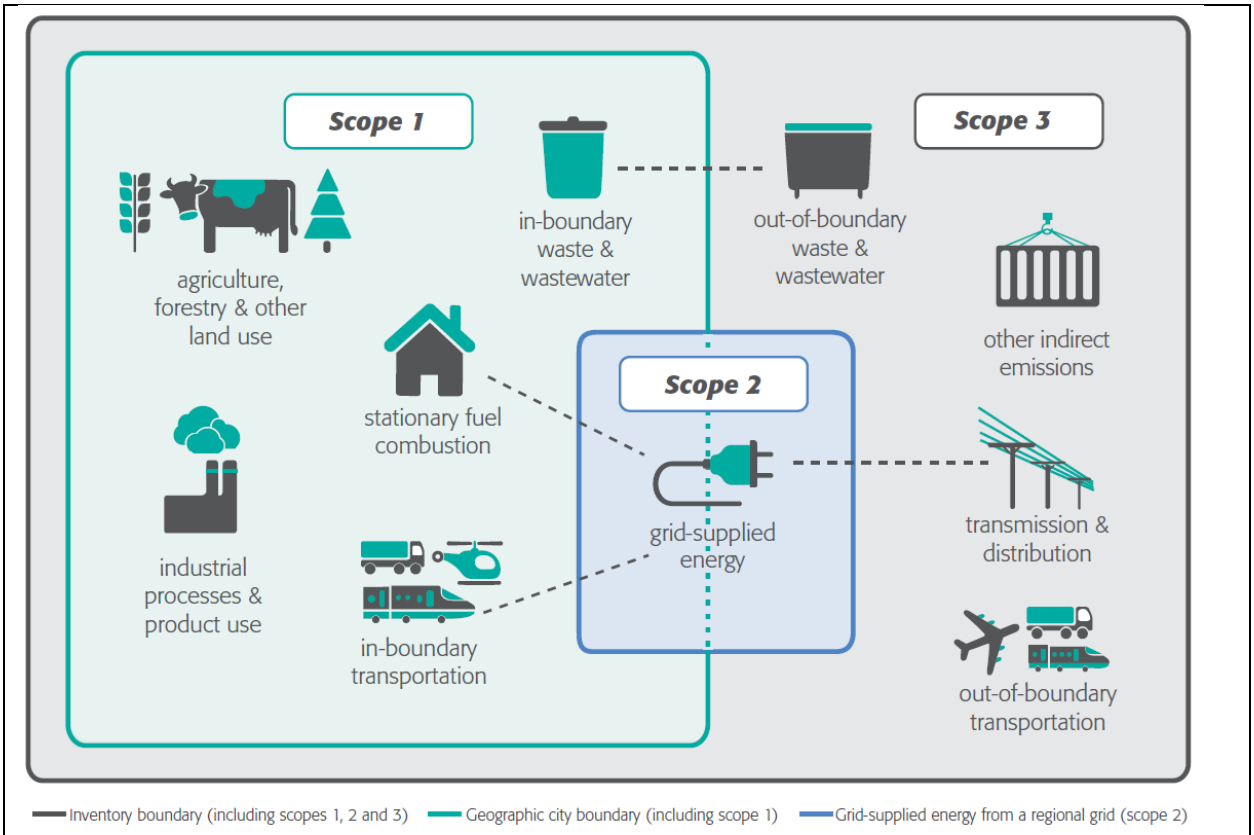

Figure 1 Sources and Boundaries of a Community's GHG Emissions (GPC 2014)

2.3 GHG EMISSION CATEGORIES

As noted previously, the GPC Protocol requires that different emission sources to be categorized into six main reporting Sectors. These high-level categories are described in more detail in Section 2.3.1 to Section 2.3.6. More information on how GHG emissions are captured within the GPC Protocol is available on the Greenhouse Gas Protocol website.

2.3.1 Stationary Energy

Stationary energy sources are typically one of the largest contributors to a community's GHG emissions. In general, these emissions come from fuel combustion and fugitive emissions. They include the emissions from energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within these residences and facilities. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are some fugitive emissions from sources such as coal piles, natural gas. They include the emissions from energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within the residences

and facilities. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are fugitive emissions from sources such as coal piles, natural gas pipelines, and related Off-road Transportation GHG emission sources.

The Stationary Energy Sector includes the following Sub-Sectors:

- Residential buildings
- Commercial and institutional buildings and facilities
- Agriculture, forestry, and fishing activities
- Manufacturing industries and construction
- Energy industries
- Energy generation supplied to the grid*
- Non-specific sources
- Fugitive emissions from mining, processing, storage, and transportation of coal
- Fugitive emissions from oil and natural gas systems

*Emissions related with electricity generation activities occurring within a community's boundaries are to be reported; however, the GHG emissions from these sources are not reported separately as they are accounted for elsewhere and to prevent double counting (GPC 2014).

Under the GPC Protocol, cities are to report off-road GHG emissions under the Off-road Transportation Sub-Sector if and only if the GHG emissions are occurring at transportation facilities (e.g., airports, harbors, bus terminals, train stations, etc.). Other off-road transportation GHG emissions that occur on industrial premises, construction sites, agriculture farms, forests, aquaculture farms, and military premises, etc., are to be reported under the most relevant Stationary Energy Sub-Sector (GPC, 2014). For example, GHG emissions from commercial building off-road construction equipment would be included in the Commercial And Institutional Buildings And Facilities Sub-Sector, whereas GHG emissions from residential lawn mowers would be reported under the Residential Buildings Sub-Sector.

2.3.2 Transportation

The GHGs released to the atmosphere to be reported in the Transportation Sector are those from combustion of fuels in journeys by on-road, railway, waterborne navigation, aviation, and off-road. GHG emissions are produced directly by the combustion of fuel, and indirectly using grid-supplied electricity. Unlike the Stationary Energy Sector, transit is mobile and can pose challenges in both accurately calculating GHG emissions and allocating them to a specific Sub-Sector. This is particularly true when it comes to transboundary transportation, which includes GHG emissions from trips that either start or finish within a community's boundaries (e.g., departing flight emissions from an airport outside a Community boundaries) (GPC, 2014). Transboundary GHG emissions are only required for GPC BASIC+ GHG reporting.

The Transportation Sector includes the following Sub-Sectors:

- On-road

- Railways
- Waterborne
- Aviation
- Off-road

As noted previously, cities are to report off-road GHG emissions under the Off-road Transportation Sub-Sector if and only if the GHG emissions are occurring at transportation facilities (e.g., airports, harbors, bus terminals, train stations, etc.). For example, off-road railway maintenance support equipment GHG emissions are reported under the Off-Road Transportation Sub-Sector.

2.3.3 Waste

Cities produce GHG emissions that arise from activities related to the disposal and management of solid waste. Waste does not directly consume energy, but releases GHG emissions because of decomposition, burning, incineration, and other management methods.

The Waste Sector includes the following Sub-Sectors:

- Solid waste disposal
- Biological treatment of waste
- Incineration and open burning
- Wastewater treatment and discharge

Under the GPC Protocol, the Waste Sector includes all GHG emissions that result from the treatment or decomposition of waste regardless of the source of the waste (e.g., another community's waste in a Community's landfill). However, the GHG emissions that are associated with waste from outside a Community's boundary that is treated or decomposes within a Community boundary are deemed to be "reporting only" emissions and do not contribute to the GHG inventory (GPC 2014).

Any GHG emissions that result from the combustion of waste or waste related gases to generate energy, such as a methane capture and energy generation system at a landfill, are reported under Stationary Energy Generation Supplied to The Grid Sub-Sector (GPC, 2014). Any waste related GHG emissions that are combusted but not related to energy generation are reported in the appropriate Waste Sub-Sector. Lastly, any waste GHG emissions that are released to the atmosphere are also captured in the appropriate Waste Sub-Sector.

2.3.4 Industrial Processes and Product Use (IPPU)

Emissions from this Sector are only required for BASIC+ GHG reporting under the GPC Protocol. This Sector encompasses GHG emissions produced from industrial processes that chemically or physically transform materials and using products by industry and end-consumers (e.g., refrigerants, foams, aerosol cans) (GPC, 2014).

The IPPU Sector includes the following Sub-Sectors:

- Industrial processes
- Product use

Any GHG emissions associated with energy use for industrial processes are not reported in the IPPU Sector; rather, they are reported under the appropriate Stationary Energy Sub-Sector.

2.3.5 Agriculture, Forestry, and Other Land Use (AFOLU)

Emissions from the AFOLU Sector are only required for BASIC+ GHG reporting. AFOLU GHG emissions are those that are captured or released because of land-management activities. These activities can range from the preservation of forested lands to the development of crop land. Specifically, this Sector includes GHG emissions from land-use change, manure management, livestock, and the direct and indirect release of nitrous oxides (N_2O) from soil management, rice cultivation, biomass burning, urea application, fertilizer, and manure application (GPC, 2014).

The AFOLU Sector is organized into the following Sub-Sectors:

- Livestock
- Land
- Aggregate sources and non-CO_2 emission sources on land

2.3.6 Other Scope 3 Emissions

Cities, by their size and connectivity, inevitably give rise to GHG emissions beyond their boundaries – often referred to as Other Scope 3 GHG emissions under the GPC Protocol. In the community context, Other Scope 3 GHG emissions include upstream GHG emissions, such as fuel extraction, production, and transportation GHG emissions, as well as cradle to-gate GHG emissions associated with the consumption of goods and services like food and drink, water, construction materials, and other goods and services that are estimated to make a material contribution to a city's GHG inventory. The GPC Protocol already includes the following Scope 3 emissions in other Sectors:

- On-road, waterborne, and aviation transboundary transportation
- Transmission and distribution losses associated with grid-supplied energy
- Solid waste disposal
- Biological treatment of solid waste
- Wastewater treatment and discharge

Cities may voluntarily report on Other Scope 3 emissions as they are estimated. In the case of the RDN, no other Scope 3 GHG emissions, other than those listed above, have been estimated.

2.4 ACCOUNTING AND REPORTING PRINCIPLES

All GHG inventories following the GPC Protocol are required to meet GHG accounting principles. Specifically, these inventories should be relevant, consistent from year to year, accurate and transparent about methodologies, assumptions, and data sources. The transparency of inventories is fundamental to the success of replication and assessment of the inventory by interested parties.

The GHG inventories must also properly account for key energy and GHG emission sinks, sources, and reservoirs (SSR) that are occurring within municipal boundaries. The SSRs are a convenient way to identify and categorize all the GHG emissions to determine if they should be included or excluded from a GHG inventory. A “Source” is something that releases GHG emissions to the atmosphere, such as a diesel generator. A “Sink” is a process or item that removes GHG from the atmosphere, such as photosynthesis and tree growth. Finally, a “Reservoir” is a process or item with the capability to store or accumulate a GHG removed from the atmosphere by a GHG sink, such as a wetland or a peat bog. By assessing and reporting on the applicable SSRs, users of the GHG inventory can have confidence that the inventory is complete and representative of the types and quantities of the GHGs being released within community limits.

2.5 BASE AND REPORTING YEAR RECALCULATIONS

As communities grow and expand, significant changes to the GHG emissions profile can alter materially thus making it difficult to meaningfully assess GHG emission trends and changes over time. The GPC Protocol has requirements on how to treat changes in a community’s GHG profile—this is presented in Table 2.

Table 2 GPC Protocol Recalculation Thresholds

Threshold	Example Change	Recalculation Needed	No Recalculation Needed
Changes in the assessment boundary	A local government is annexed in or removed from the administrative boundary	✓	
	Change in protocol reporting method (e.g., from BASIC to BASIC+, addition of GHGs reported, etc.)	✓	
	Shut down of a power plant		✓
	Building a new cement factory		✓
Changes in calculation methodology or improvements in data accuracy	Change in calculation methodology for landfilled municipal solid waste (MSW) that results in a material change in GHG emissions to that sector (i.e., +/-10%).	✓	
	Adoption of more accurate local emission factors, instead of a national average emission factor that results in a material change in GHG emissions (i.e., +/-10%).	✓	

Threshold	Example Change	Recalculation Needed	No Recalculation Needed
	Change in electricity emission factor due to energy efficiency improvement and growth of renewable energy utilization.		✓
Discovery of significant errors	Discovery of mistake in unit conversion in formula used.	✓	

2.6 DATA QUALITY

Data collection and the assessment of its quality is an integral component of compiling any GHG inventory. Like the IPCC, the GPC Protocol requires users to establish first whether a source exists, and then assess the data availability and quality. To support GHG reporting, the following notation keys are used.

- If the GHG sink, source or reservoir does not exist, a “NO” is used to indicate it is “not occurring”.
- If the GHG sink, source or reservoir does occur, and data is available, then the emissions are estimated. However, if the data is also included in another emissions source category or cannot be disaggregated, the notation key “IE” would be used to indicate “included elsewhere” to avoid double counting.
- When GHG emissions are occurring in the RDN, but data is not available, then the notation key “NE” would be used to indicate “not estimated”.

For GHG data that does exist, in accordance with the GPC Protocol, an assessment of quality is also made on emission factors and GHG estimation methodologies deployed. The GPC Protocol data quality assessment notation keys are summarized in Table 3.

Table 3 GPC Protocol Data Quality Assessment Notation Keys

Data Quality	Activity Data	Emission Factor
High (H)	Detailed activity data. Data accuracy is high.	Site-specific emission factors
Medium (M)	Modeled activity data using robust assumptions. Data accuracy is moderate.	More general emission factors
Low (L)	Highly modeled or uncertain activity data. Data accuracy is low / very poor.	Default emission factors

3.0 GHG ASSESSMENT BOUNDARIES

This section sets out the reporting boundaries of the RDN's GHG inventory.

3.1 SPATIAL BOUNDARIES

This GHG inventory is defined geographically by the RDN's jurisdictional boundaries. As shown in Figure 2, the RDN consists of 4 municipalities and 7 electoral areas. For the purposes of this report, only the RDN GHG emissions are presented. A breakdown of GHG emissions by each RDN municipality and electoral area has been presented in a separate report.

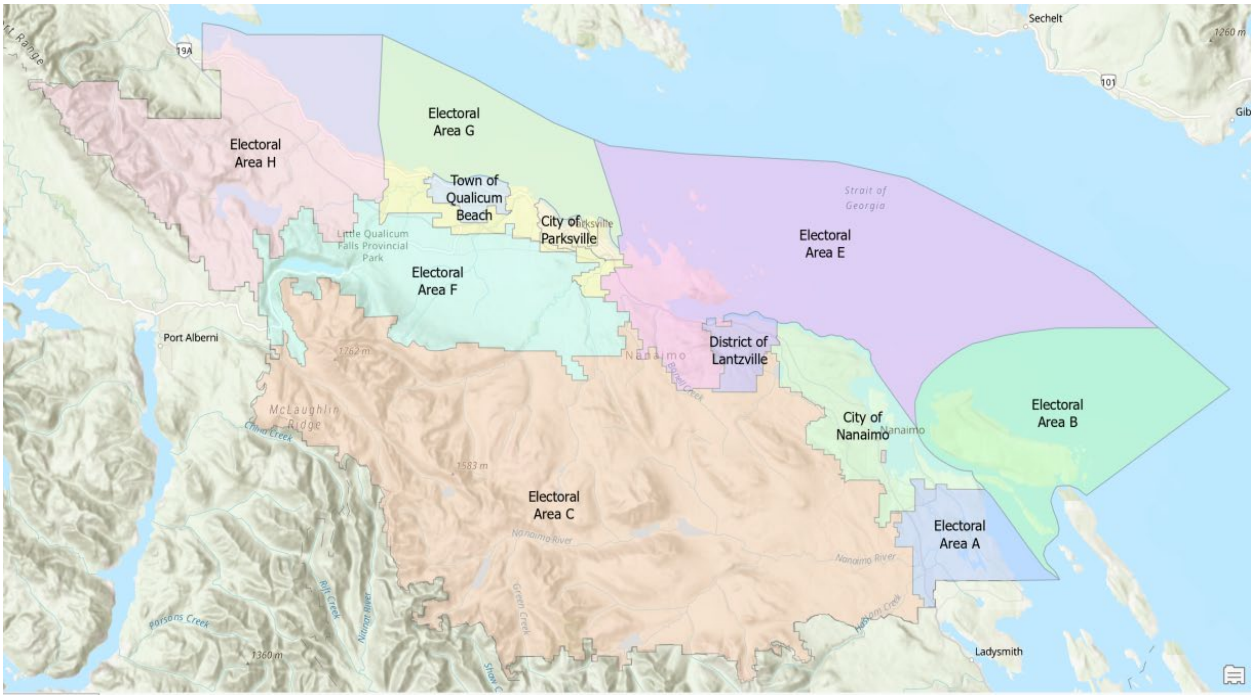

Figure 2 GHG Boundary

Additional GHG inventory related information is presented in the following table.

Table 4 Inventory Information

Inventory Boundary	Community / District Information
Name of Community / District	Regional District of Nanaimo
Municipality / Electoral Area	• City of Nanaimo • City of Parksville • Town of Qualicum Beach

	• District of Lantzville • Electoral Area A • Electoral Area B • Electoral Area C • Electoral Area E • Electoral Area F • Electoral Area G • Electoral Area H
Country	Canada
Inventory Year	2021
Geographic Boundary	See Figure 2
Land Area (hectares)	312,706
Resident population	171,993
GDP (CAN$)	Unknown at time of reporting
Composition of Economy	Government; some commercial and industrial
Climate	Temperate, warm summer

3.2 TEMPORAL BOUNDARIES

3.2.1 2007 Base Year

To maintain consistency with the current reporting year, and as required by the GPC Protocol, the RDN has updated its 2007 GHG base year GHG emissions profile to be consistent with the GPC Protocol BASIC+ reporting level. Between the current reporting year and the 2007 base year, there were no boundary changes (e.g., annexes) and thus no additional modifications were made. All methods and assumptions used in the 2021 reporting year, adjusted for the 2007 reporting year, are the same.

Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development), these GHG emissions have been excluded from the RDN's 2007 and 2021 GHG emissions inventories, but have been disclosed, until a more robust measurement methodology can be developed.

Table 5 summaries the original RDN 2007 and the updated 2007 base year GHG emissions reported as tonnes of carbon dioxide equivalent (tCO_2e). The GHG emissions inventory baseline data for RDN members is presented in Appendix A.

Table 5 Original And Updated BASIC+ Base Year

Sector	CEEI: 2007 GHG Base Year (tCO_2e)	Updated GPC Protocol: 2007 GHG Base Year (tCO_2e)
Residential Buildings	161,287	178,457

Sector	CEEI: 2007 GHG Base Year (tCO_2e)	Updated GPC Protocol: 2007 GHG Base Year (tCO_2e)
Commercial & Institutional Buildings	69,716	88,577
Manufacturing Industries & Construction	6,574	131,220
Energy Industries	-	462
Non-Specified Sources	-	-
Agriculture, Forestry & Fishing activities	12,482	34,815
Fugitive Emissions	-	583
In-Boundary On-road Transportation	527,905	680,030
Trans-Boundary On-road Transportation	-	93,773
Waterborne Navigation	-	6,518
Aviation	-	Not Estimated*
Railway	-	1,248
Off-road Transportation	-	24,215
Solid Waste	51,146	45,315
Biological Treatment of Waste	-	394
Incineration & Open Burning	-	126
Wastewater Treatment & Discharge	-	1,965
IPPU	-	20,388
Land-Use Change	83,158	(294,814)
Livestock	5,628	3,818
Non-CO_2 Land Emission Sources	-	109
Total Without Land Use GHG Emissions	**834,738**	**1,312,013**
Total With Land Use GHG Emissions	**917,896**	**1,017,198**

** Aviation GHG emissions have been excluded from the GHG emissions inventory to allow time for the airport to quantify those emissions.*

3.2.2 2021 GHG Boundary

This inventory covers all in-scope GHG emissions for the 2021 reporting year. Where 2021 data was not available, the most recent year's data have been used, and the timescale noted accordingly. These are as follows:

- **Global Warming Potentials (GWP)**. The BC government has communicated that is adopting GWPs from the fifth IPCC report. On this basis, the RDN is applying GWPs from the fifth IPCC report.
- **Stationary Energy: Residential, Commercial and Institutional Buildings**. The 2021 natural gas and electricity energy data was provided to the RDN in draft form and may be subject to change.

Furthermore, the 2021 data did not include an estimate for the Electoral Areas, which had to be estimated. The estimate was derived by taking the total energy for the City of Nanaimo, City of Parksville, Town of Qualicum Beach, and the District of Lantzville for the 2020 and 2021 reporting years, calculating the change in energy consumption, and applying this factor to the 2020 Electoral Area natural gas and electricity energy volumes.

- **Stationary Energy: Residential, Commercial and Institutional Buildings**. The 2019-2021 propane, heating oil and wood GHG emissions were estimated using linear regression methods because the data was not available from the province later past 2018. The data used in the estimates included historical propane and wood energy data published in the 2007-2018 CEEIs, and heating degree days (HDD) published by Environment and Climate Change Canada.
- **Stationary Energy: Other Off-Road.** The ECCC 2023 NIR prepared for the Province of BC for the 2020 reporting year was used to estimate GHG emissions for:
    - Off-road agriculture and forestry GHG emissions
    - Off-road commercial and institutional GHG emissions
    - Off-road manufacturing, mining and construction GHG emissions
    - Off-road residential GHG emissions

  These GHG emissions were assigned to the RDN on a per capita basis.
- **Stationary Energy: Fugitives**. Fugitive emissions data was not available for the RDN. As such, the Victoria Capital Regional District's reported fugitive emissions per connection for the 2020 reporting year was used to derive 2007 and 2021 estimates.
- **Transportation: On-Road**.
    - The on-road transportation emissions for City of Nanaimo and the District of Lantzville are based on the number of registered vehicles for the 2020 reporting year and grown using the reported population change between 2020 and 2021. While the 2021 vehicle registration data is available, it is believed that the data is incorrect as it shows a 12% increase in vehicle registrations at the City of Nanaimo and an 11% increase in the District of Lantzville (a 14% increase at the RDN scale) between 2020 and 2021 which does not align with the change in the local government populations.
    - Vehicle registration counts between 2007 and 2015greatly exceed population growth for the City of Parksville (87% increase in vehicle registrations vs 9% increase in population) and Town of Qualicum Beach (75% increase in vehicle registration vs 2% increase in population). As such, 2015-2021 vehicle populations were grown for these local governments using 2010 vehicle population data and census population data and then adjusted to align with the proportion of registered vehicle classes (e.g., gasoline-LDV) for each of the reporting years.
    - Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the 2007 and 2021 on-road GHG emission estimates are based on the number of registrations from April 1 – March 31 and may not accurately represent the actual vehicle population for each given reporting year.
    - ICBC does not fully report vehicle registration data for the RDN Electoral Areas. To estimate these GHG emissions, the 2010 Electoral Area vehicle counts (as available in the 2010 CEEI) were grown using the total change in population for each of the EAs and then adjusted to align with the proportion of registered vehicle classes (e.g., gasoline-LDV) at the RDN scale for each of the reporting years.

    - ICBC' s publicly available vehicle registration data does not contain detailed vehicle and fuel class breakdowns for personal vehicles (it does release this data for commercial vehicles). To split out the data by class and fuel type, the vehicle classes were re-allocated based on the Victoria Capital Regional District's reported vehicle class breakdown in the 2021 GHG emissions report.
- **Transportation: Waterborne**.
    - The number of recreational boats was estimated from the total number of pleasure craft and large vessels registered in the RDN as tracked by Transport Canada. Transport Canada does not track annual data, so the 2022 count is applied to all historical years. Recreational vessel fuel consumption rates are based on the study entitled "Marine Vessel Air Emissions in BC and Washington State Outside of the Greater Victoria Regional District (GVRD) and FVRD for the Year 2000".
    - Cruise ship emissions are based on the number of reported vessels at the Nanaimo Port and the Greater Victoria Harbor Authority's 2018 estimate of GHG emissions per cruise ship.
    - Deep vessel shipment GHG emissions are based on Nanaimo Port data and the Port of Vancouver's 2015 estimate of GHG emissions per tonne of cargo throughput.
- **Waste: Incineration & Opening Burning.** Open burning GHG emissions are estimated using 2015 data reported by the Comox Valley Regional District as not value has been publicly reported by the RDN. The GHG emissions are adjusted to 2007 and 2021 using population data and are assumed to only occur in the EA's.
- **AFOLU: Land-Use.** The land cover change analysis requires a consistent land-use category attribution and spatial data. Landsat spatial data was available for the 2005, 2010, 2015 and 2020 reporting years only. Since annual data is not available, the change between land cover data years (2005-2010, 2010-2015, 2015-2020) for all areas was averaged and may not represent actual changes in land-use each year.

The implications of using this data on the GHG emissions inventory is presented in Section 7.1.

3.3 GHG EMISSION SOURCES AND SCOPES

The following table summarizes the RDN's GHG emissions by source and GHG emission scope.

Table 6 Summary of Emissions Scope and GPC Protocol Reporting Sector

GHG Emissions Scope	GPC Protocol Reporting Sector
Scope 1	The GHG emissions occurring from sources located within the RDN's limits: • Stationary fuel combustion: – Residential buildings – Commercial and institutional buildings and facilities – Manufacturing industries and construction – Energy industries – Energy generation supplied to the grid. – Agriculture, forestry and fishing activities

GHG Emissions Scope	GPC Protocol Reporting Sector
	– Fugitive emissions from oil and natural gas systems • Transportation: – On-road transportation – Railways – Waterborne navigation – Aviation (Not Estimated) – Off-road transportation • Waste: – Solid waste generated in the city. – Biological waste generated in the city. – Incinerated and burned waste generated in the city. – Wastewater generated in the city. – Solid waste generated outside the city. • Industrial processes and product use (IPPU): – Emissions from industrial processes occurring in the city boundary. • Agriculture, Forestry, and Other Land Use (AFOLU): – Land-use: emissions sequestered (*reported, but not included in the total*) – Livestock – Aggregate sources and non-CO_2 emission sources on land
Scope 2	The GHG emissions occurring from using grid-supplied electricity, heating and/or cooling within the RDN's boundary: • Stationary fuel combustion: – Residential buildings – Commercial and institutional buildings and facilities • Transportation: – On-road
Scope 3	Other GHG emissions occurring outside of the RDN's limits as a result of the RDN's activities: • Stationary Energy: – Residential buildings – Commercial and institutional buildings and facilities • Transportation: – On-Road: Transboundary

3.4 GHG REPORTING

Where relevant, the GPC Protocol recommends using methodologies that align with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The GHG inventory is required to include all seven Kyoto Protocol GHGs occurring within the geographic boundary of a community.

Each GHG listed above has a different global warming potential (GWP) due to its ability to absorb and re-emit infrared radiation. This chemical property is recognized by the GWP set out by the IPCC Fifth

Assessment Report. A larger GWP value means the substance has a greater affinity to absorb and re-emit infrared radiation. The GWP of these GHGs are CO_2 = 1.0, CH_4 = 28, N_2O = 265 (IPCC, 2014).

Total GHG emissions are normally reported as CO_2e, whereby emissions of each of the GHGs are multiplied by their GWP and are reported as tonnes of CO_2e.

The GHG inventory results following the GPC Protocol reporting table format is presented in Section 5.0. The GPC Protocol reporting format is presented in Table 7 below which also indicates the reporting level (BASIC / BASIC+) for each source.

This report follows the GPC Basic + reporting scope.

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
I	**Stationary Energy Sources**		
I.1	**Residential Buildings**		
I.1.1	BASIC	1	Emissions from in-boundary fuel combustion
I.1.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.1.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.2	**Commercial and Institutional Buildings/Facilities**		
I.2.1	BASIC	1	Emissions from in-boundary fuel combustion
I.2.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.2.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.3	**Manufacturing Industry and Construction**		
I.3.1	BASIC	1	Emissions from in-boundary fuel combustion
I.3.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.3.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.4	**Energy Industries**		
I.4.1	BASIC	1	Emissions from in-boundary production of energy used in auxiliary operations
I.4.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.5	**Agriculture, Forestry, and Fishing Activities**		
I.5.1	BASIC	1	Emissions from in-boundary fuel combustion
I.5.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.5.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.7	**Fugitive Emissions from Mining, Processing, Storage, And Transportation of Coal**		
I.7.1	BASIC	1	In-boundary fugitive emissions

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
I.8	**Fugitive Emissions from Oil and Natural Gas Systems**		
I.8.1	BASIC	1	In-boundary fugitive emissions
II	**Transportation**		
II.1	**On-road Transportation**		
II.1.1	BASIC	1	Emissions from in-boundary transport
II.1.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.1.3	BASIC+	3	Emissions from transboundary journeys
II.2	**Railways**		
II.2.1	BASIC	1	Emissions from in-boundary transport
II.2.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.2.3	BASIC+	3	Emissions from transboundary journeys
II.3	**Waterborne Navigation**		
II.3.1	BASIC	1	Emissions from in-boundary transport
II.3.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.3.3	BASIC	3	Emissions from transboundary journeys
II.4	**Aviation**		
II.4.1	BASIC	1	Emissions from in-boundary transport
II.4.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.4.3	BASIC+	3	Emissions from transboundary journeys
II.5	**Off-road**		
II.5.1	BASIC	1	Emissions from in-boundary transport
II.5.2	BASIC	2	Emissions from consumption of grid-supplied energy
III	**Waste**		
III.1	**Solid Waste Disposal**		
III.1.1	BASIC	1	Emissions from waste generated and treated within the Community
III.1.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.2	**Biological Treatment of Waste**		
III.2.1	BASIC	1	Emissions from waste generated and treated within the Community
III.2.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.3	**Incineration and Open Burning**		

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
III.3.1	BASIC	1	Emissions from waste generated and treated within the Community
III.3.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.4	**Wastewater Treatment and Discharge**		
III.4.1	BASIC	1	Emissions from wastewater generated and treated within the Community
III.4.2	BASIC	3	Emissions from wastewater generated within but treated outside of the Community
IV	**Industrial Processes and Product Use (IPPU)**		
IV.1	BASIC+	1	In-boundary emissions from industrial processes
IV.2	BASIC+	1	In-boundary emissions from product use
V	**Agriculture, Forestry, and Other Land Use (AFOLU)**		
V.1	BASIC+	1	In-boundary emissions from livestock
V.1	BASIC+	1	In-boundary emissions from land
V.1	BASIC+	1	In-boundary emissions from other agriculture
VI	**Other Scope 3 Emissions**		
VI.1	BASIC / BASIC+	3	Other indirect emissions

4.0 GHG METHODOLOGIES BY SOURCE CATEGORY

The following sections describe the reporting source category, assumptions, activity data applied, and quantification methodology. The results of the analysis are presented in Section 5.0.

4.1 STATIONARY ENERGY

4.1.1 Overview

Stationery energy sources are one of the largest contributors to the RDN's GHG emissions. For the District, the Stationary Energy Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Residential buildings
  - Commercial and institutional buildings and facilities
  - Manufacturing industries and construction
  - Energy industries
  - Energy generation supplied to the grid
  - Agriculture, forestry and fishing activities
  - Fugitive emissions from oil and natural gas systems
- Scope 2 Emissions:
  - Emissions From The Consumption Of Grid-Supplied Electricity, Steam, Heating, And Cooling.
- Scope 3 Emissions:
  - Transmission And Distribution Losses Of Electricity, Steam, Heating, And Cooling.

4.1.2 Activity Data

BC Hydro and Fortis BC provided the Province of BC electricity and natural gas consumption data itemized by community in MWh and GJ, respectively. Based on the utility provider descriptions of the data, each is categorized as follows:

- Residential Buildings based on the BC Hydro and Fortis BC descriptor: "Residential"
- Commercial and Institutional Buildings/Facilities based on BC Hydro and Fortis BC descriptor: "Commercial"

Fortis BC also provided the number of natural gas connections.

The Province provided 2021 energy data to the RDN in draft form, and it may be subject to change.

2007-2019 residential fuel oil, propane and wood GHG and energy use estimates were derived by the Province using the 2010 BC Hydro Conservation Potential Review. This data was used to estimate the 2019-2021 reporting year GHG emissions for all RDN members and assumes that the consumption of

each fuel type increased directly with the number of annual heating degree days (HDD) for the RDN as reported by ECCC.

Fugitive emissions from the natural gas distribution network within the RDN is based on the Fortis fugitive emission factor for the 2020 reporting year for the Victoria Capital Regional District. This factor was used to estimate 2007-2021 fugitive emissions for residential natural gas use in the RDN and assumes a direct change with the number of reported natural gas connections (as reported by Fortis BC).

Harmac Gate Station (Fortis BC) and Harmac Pacific Operations reported their stationary combustion GHG emissions under the BC *Greenhouse Gas Industrial Reporting and Control Act.* This information was accessed though the Province of BC's website for industrial emissions.[3]

The Greater Nanaimo Pollution Control Centre captures biogas for reuse and flaring. The RDN landfill captures landfill fugitive gas and combusts it for energy generation and export to the BC electrical grid and flares the landfill gas captured, but not used. The biogas and landfill fugitive gas that is captured and used is reported in the Stationary Energy category and the remaining unused biogas / gas is flared and is reported under the Waste category. To support the quantification of these GHG emissions, the RDN provided the following data for each reporting year:

- Greater Nanaimo Pollution Control Centre biogas used.
- Greater Nanaimo Pollution Control Centre biogas flared.
- Average methane content of landfill gas
- Volume of landfill gas collected, flared and combusted to generate electricity.

Residential, commercial, and institutional building related off-road GHG emissions (e.g., residential lawn-mowers) included in the Stationary Energy Sector are based on the 2023 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the RDN on a per capita basis. Agriculture, forestry and fishing, and manufacturing industries and construction related off-road GHG emissions included in the Stationary Energy Sector are based on the 2023 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the RDN on the number of employees (using Statistics Canada data) in each of the reported sectors within the region.

4.1.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- The 2021 natural gas and electricity energy data was provided to the RDN in draft form and may be subject to change.
- The 2021 natural gas and electricity energy data did not include consumption values for the Electoral Areas, which had to be estimated. The estimate was derived by taking the total energy for the City of Nanaimo, City of Parksville, Town of Qualicum Beach, and the District of Lantzville for the 2020 and 2021 reporting years, calculating the change in energy consumption, and applying this factor to the

[3] Industrial facility greenhouse gas reporting - Province of British Columbia (gov.bc.ca)

2020 Electoral Area natural gas and electricity energy volumes. This process was completed separately for electricity and natural gas. This methodology also assumes similar patterns of energy use between rural and urban areas, which likely overestimates emissions from natural gas use in rural areas, where new connections to the natural gas grid are much less common than in urban areas.

- The City of Nanaimo natural gas commercial data included industrial natural gas consumption (from the Pulp Mill). Using the industrial GHG emissions data as provided by the Province, it is estimated that for the 2007 and 2021 reporting year ~27% and ~20%, respectively, of the City of Nanaimo's natural gas consumption is related to industrial activity. These values were used to deduct industrial natural gas consumption from the commercial natural gas consumption volumes for Nanaimo and reported under manufacturing industries.
- BC Hydro estimates that the combined energy losses- transmission and distribution- to be approximately 6.28% of supplied electricity. This value was used to calculate the Scope 3 emissions for each Stationary Energy Sub-Sector.
- Fortis BC provided the number of natural gas connections in the RDN, and the total fugitive emissions per connection for the 2020 reporting year at the Victoria Capital Regional District level. The 2020 value was used to derive 2007-2019 and 2021 estimates.
- The 2019-2021 propane, heating oil and wood GHG emissions were estimated using linear regression methods. The data used in the estimates included historical propane and wood energy data published in the 2007-2018 CEEIs, and heating degree days (HDD) published by Environment and Climate Change Canada.
- It was assumed that the high heat value (HHV) and the biogas efficiency factors as derived from the BC WCI.20-20 guidance are a reasonable reflection of the biogas being generated at the Greater Nanaimo Pollution Control Centre.

4.1.4 Data Quality Assessment

Table 8 presents the activity data quality assessment for the stationary energy sources.

Table 8 Stationary Energy Data Source Quality Assessment

Data	Quality Assessment Rating
Residential, Commercial and Industrial Electricity	Medium for Source Category; Low for Distribution between RDN Members
Residential, Commercial and Industrial Natural Gas	Medium for Source Category; Low for Distribution between RDN Members
Industrial GHG Emissions Data: • Harmac Gate Station - Fortis BC • Harmac Pacific Operations	High
Agriculture, Forestry & Fishing Activity GHG Emissions	Low
Manufacturing Industries & Construction GHG Emissions	Low

Data	Quality Assessment Rating
Fugitive Emissions	Medium
Transmission, Distribution & Line Losses	Medium
Off-Road Transportation Emissions	Low
Biogas & Landfill Gas Volumes Utilized / Flared	High

4.1.5 Residential & Commercial Buildings GHG Calculation Methodology

The Province of BC developed residential fuel oil, propane and wood GHG energy use estimates using heating degree days (HDD) the number and type of dwellings and the average dwelling consumption by authority and region contained in the BC Hydro Conservation Potential Review.

To calculate GHG emissions from electricity, natural gas, heating oil, propane, and wood, the total net annual energy values (where applicable, less transmission, distribution, and line losses of 6.28%) were multiplied by applicable emissions factors. These values were then multiplied by the pollutant's GWP to give total CO_2e emissions in tonnes.

These quantification methods are captured as follows:

$$\textbf{Energy}_{\text{Stationary Energy – Electricity}} = Electricity * (1 - Line\ Loss\ (\%))$$

$$\textbf{Energy}_{\text{Stationary Energy – Transmission, Distribution, and line Losses}} = Electricity * Line\ Loss\ (\%)$$

$$\textbf{Emissions}_{\text{Stationary Energy – Electricity}} = Fuel\ (MWh) * EF_{tCO2e}$$

$$\textbf{Emissions}_{\text{Stationary Energy – Natural Gas}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Propane}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Wood}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Heating Oil}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

The emission factors used in the 2021 reporting year are summarized in Table 9.

Table 9 Residential & Commercial Buildings Stationary Energy GHG Emission Factors

Emission Factor	Units	tCO_2e	Quality Assessment Rating
Electricity (BC Hydro)	tCO_2e / MWh	0.00970000	Medium

Emission Factor	Units	tCO_2e	Quality Assessment Rating
Natural Gas	tonne CO_2e / m^3	0.0019763	Medium
Propane	tonne CO_2e / L	0.0015443	Medium
Heating Oil	tonne CO_2e / GJ	0.0683516	Medium
Wood	tonne CO2e / kg	0.0004624	Medium

4.1.6 Industrial GHG Emissions

Harmac Gate Station (Fortis BC) and Harmac Pacific Operations reported their GHG emissions under the BC *Greenhouse Gas Industrial Reporting and Control Act.* This information was accessed though the Province of BC's website for industrial emissions. This reporting does not provide total energy use at these facilities and creates a risk of double-counting.

Because emissions from Harmac natural gas use are already included in the inventory through the Fortis BC natural gas data (under Commercial), they need to be subtracted from the natural gas values reported by Fortis to more accurately represent where natural gas consumption occurs and to avoid double counting. As this value could not be obtained from Harmac, an estimate was derived using publicly available data. To derive the 2007 value, the prior 2007 CEEI data (which did not include the industrial consumption volumes) and updated 2007 community energy data (which does include the industrial consumption volumes) were compared and a change in values derived. The data set that included industrial consumption volumes showed 29% higher natural gas use, which is assumed to be solely for Harmac Pacific Operations. The 2007 value ended up being reduced to 20% in 2021 to account for increasing rates of residential natural gas use in the City of Nanaimo (as a result of an increase in the number of dwellings being constructed). The 2021 value was derived using a change in the number of residential housing counts between 2007 and 2021, the change in Harmac's reported GHG emissions, and the change in natural gas consumption.

4.1.7 Biogas & Flaring GHG Emissions

The Greater Nanaimo Pollution Control Centre captures biogas for reuse and flaring. The biogas that is used is reported as a Stationary Energy source as it is used to heat the Greater Nanaimo Pollution Control Centre. To quantify these GHG emissions, the BC WCI.20-20 high heat value (HHV) and the biogas efficiency factors are used – this methodology is as follows.

$$\textbf{Emissions}_{Biogas} = Biogas\ Volume_{m3} * Biogas\ HHV\ (0.0281)_{GJ/m3} * EF_{tCO2e}$$

The biogas combustion emission factor is presented in Table 10.

Table 10 Biogas Combustion GHG Emission Factor

Emission Factor	Units	Emission Factor	Quality Assessment Rating
Biogas	tCO_2e/GJ Biogas	0.00494	Medium

The biogas that is combusted for heating is reported under the Stationary Energy category; the flared biogas is reported under the Solid Waste category. This is in accordance with the GPC Protocol.

The RDN landfill captures fugitive landfill gas, combusts it for energy generation and export to the BC electrical grid, and flares the landfill gas captured but not used. The landfill gas that is combusted for export into the electrical grid, under the GPC Protocol, it is deemed a reporting only GHG emissions source and is not included in the GHG inventory. This is to avoid double counting GHG emissions with other cities and energy consumers. The landfill gas that is flared is reported under the Solid Waste category. Both methodologies assume a combustion efficiency of 99.7%. To quantify GHG emissions related to landfill fugitive gas combustion, the following methodology is deployed.

$$Emissions_{Fugitive\ Landfill\ Gas} = LFG\ Volume_{m3} * LFG\ Methane\ Content_{Percent} * Density\ of\ methane\ at\ 25^{o}C\ and\ 1.0\ Atmosphere * Combustion\ Efficiency * GWP_{CH4}$$

4.2 TRANSPORTATION

4.2.1 Overview

Transportation covers all GHG emissions from combustion of fuels in journeys by on-road, railways, waterborne navigation, aviation, and off-road. GHG emissions are produced directly by the combustion of fuel, and indirectly using grid-supplied electricity. For the RDN, the Transportation Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - On-road: In Boundary
  - Waterborne
  - Aviation
  - Off-road
- Scope 2 Emissions:
  - Emissions from the consumption of grid-supplied electricity.
- Scope 3 Emissions:
  - On-road: Transboundary
  - Waterborne
  - Aviation
  - Off-road

4.2.2 Activity Data

The Insurance Corporation of BC (ICBC) provided 2007 and 2021 registered vehicle counts for the following classes: personal vehicles, electric vehicles, commercial vehicles, motorcycles, and motor homes for the City of Nanaimo, City of Parksville, Town of Qualicum Beach, and the District of Lantzville.[4] While some data is available for the electoral areas.

The Province of BC provided vehicle kilometer data for different vehicle classes at the Regional District level for the 2007 reporting year. ECCC provided Provincial level vehicle kilometer data and an annual estimate of fuel consumption by vehicle class for BC for the years 1990-2020.

Google Insights Explorer provided an estimate of the change in the transportation GHG emissions and transboundary split for the Regional District and the City of Nanaimo for the 2018-2021 reporting years.[5]

The RDN provided transit fuel volumes and estimated kilometers travelled (VKT) for busses. This data was used to estimate GHG emissions from buses serving the RDN.

The Nanaimo Airport provided off-road fuel consumption volumes. Passenger counts and aircraft movements were provided via annual reports from the Nanaimo Airport's website.

Transport Canada provided total domestic and international itinerant movements, by type of operation, airports with NAV CANADA flight service stations for the Nanaimo Airport. The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year. Historical data is not available.

The Nanaimo Port Authority provided the number of cruise ships serviced and total number of deep-sea ship traffic in their Port Authority Statistics.[6]

Through their annual reports[7], BC Ferries provided total fuel volumes consumed for all of BC Ferries operations and total passenger counts for Departure Bay and Duke Point.

The RDN provided total fuel consumption volumes consumed at the RDN landfill and an estimate of GHG emissions related to biosolids transportation. Other off-road transportation emissions are based on the 2023 NIR as prepared by Environment and Climate Change Canada. These GHG emissions are prorated on a per capita basis.

4.2.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the Transportation Sector GHG emissions:

- On-Road:

[4] https://public.tableau.com/app/profile/icbc/viz/VehiclePopulationIntroPage/VehiclePopulationData
[5] Nanaimo - Summary - Google Environmental Insights Explorer - Make Informed Decisions (sustainability.google)
[6] Cargo, Vessel and Passenger Volumes - 2013 to 2022 - Port of Nanaimo (npa.ca)
[7] Plans, Reports, Policies and Other Resources | BC Ferries

- The on-road transportation emissions for City of Nanaimo and the District of Lantzville are based on the number of registered vehicles for the 2020 reporting year and grown using the reported population change between 2020 and 2021. While the 2021 vehicle registration data is available, it is believed that the data is incorrect as it shows a 12% increase in vehicle registrations at the City of Nanaimo and an 11% increase in the District of Lantzville (a 14% increase at the RDN scale) between 2020 and 2021 which does not align with the change in the local government populations.
- Vehicle registration counts between 2007 and 2015greatly exceed population growth for the City of Parksville (87% increase in vehicle registrations vs 9% increase in population) and Town of Qualicum Beach (75% increase in vehicle registration vs 2% increase in population). As such, 2015-2021 vehicle populations were grown for these local governments using 2010 vehicle population data and census population data and then adjusted to align with the proportion of registered vehicle classes (e.g., gasoline-LDV) for each of the reporting years.
- Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the 2007 and 2021 on-road GHG emission estimates are based on the number of registrations from April 1 – March 31 and may not accurately represent the actual vehicle population for each given reporting year.
- ICBC does not fully report vehicle registration data for the RDN Electoral Areas. To estimate these GHG emissions, the 2010 Electoral Area vehicle counts (as available in the 2010 CEEI) were grown using the total change in population for each of the EAs and then adjusted to align with the proportion of registered vehicle classes (e.g., gasoline-LDV) at the RDN scale for each of the reporting years.
- ICBC' s publicly available vehicle registration data does not contain detailed vehicle and fuel class breakdowns for personal vehicles (it does release this data for commercial vehicles). To split out the data by class and fuel type, the vehicle classes were re-allocated based on the Victoria Capital Regional District's reported vehicle class breakdown in the 2021 GHG emissions report.
- The in-boundary and transboundary split was based on the Google Environmental Insights Explorer for the Regional District and the City of Nanaimo. The City of Nanaimo's split was applied to the other RDN members where data was not available. It should be noted that these values have no bearing on the total on-road transportation GHG emissions, but the allocation between Scope 1 and Scope 3.
- Diesel and natural gas GHG emissions from transit buses are pro-rated to RDN members based on the proportion of bus service kilometers traveled in each municipality within the RDN.
- ECCC and Google EIE data was used to grow 2007 VKT data for the different vehicle classes for the reporting years 2008-2021.

- Aviation
  - Aviation GHG emissions have been temporarily excluded from the GHG emissions inventory until the Nanaimo airport quantifies these emissions.
- Waterborne Navigation
  - The number of recreational boats was estimated based on the number of total number of pleasure craft and large vessels registered in the RDN as tracked by Transport Canada. Transport Canada does not track annual data, so the 2022 count is applied to all historical years.

Recreational vessel fuel consumption rates are based on the study entitled “Marine Vessel Air Emissions in BC and Washington State Outside of the Greater Victoria Regional District (GVRD) and FVRD for the Year 2000”. These GHG emissions are prorated based on the each RDN member population relative to the RDN population.

- BC Ferries GHG emissions were estimated and assigned to the RDN based on total annual passenger counts to Departure Bay and Duke Point. These assigned GHG emissions where then prorated to each RDN member population relative to the RDN population.
- Cruise ship emissions are based on the Greater Victoria Harbor Authority’s 2018 estimate of GHG emissions per cruise ship and the count as reported by the Nanaimo Port Authority. These GHG emissions were assigned to the City of Nanaimo as they occur within Nanaimo’s municipal boundary.
- Deep vessel shipment GHG emissions are based on the Port of Vancouver’s 2015 estimate of GHG emissions per cargo throughput and the count as reported by the Nanaimo Port Authority. These GHG emissions were assigned to the City of Nanaimo as they occur within Nanaimo’s municipal boundary.

4.2.4 Data Quality Assessment

Table 11 presents the activity data quality assessment for the transportation data sources.

Table 11 Transportation Data Quality Assessment

Data	Quality Assessment Rating
Split Between In-Boundary and Transboundary Traffic	Low
Vehicle Registry Data	Medium-Low
Vehicle Kilometers Travelled (VKT) Data	Medium-Low
Railway GHG Data	Low
Waterborne GHG Data	Low
Other Off-Road Transportation GHG Data	Low

4.2.5 Calculation Methodology

4.2.5.1 On-Road

The GPC Protocol identifies several methods for determining on-road emissions. The vehicle kilometers travelled (VKT) methodology was utilized to estimate the GHG emissions from on-road transportation (Scope 1) and transboundary transportation (Scope 3). The VKT uses the number and type of vehicles registered in a geopolitical boundary, the estimated fuel consumption rate of individual vehicles, and an estimate of the annual vehicle kilometres traveled (VKT) by various vehicle classes. To estimate the split between on-road in-boundary and transboundary traffic, data from the Google Insight Explorer was applied. The results of the survey as it applies to the RDN is presented in Table 12.

Table 12 RDN On-Road In-Boundary/Transboundary Split

Aspect	RDN	RDN Members
Estimated proportion of on-road in-boundary travel	86.9%	76.2%
Estimated proportion of on-road transboundary travel	13.1%	23.8%

To quantify the 2007 and 2020 reporting year on-road and transboundary GHG emissions, the following steps were taken:

1. Collect reported ICBC vehicle registration data for all RDN members for the 2010, 2007-2020 reporting years.
2. For the City of Nanaimo and the District of Lantzville grow the 2020 vehicle population based on the annual population change between 2020 and 2021.
3. For the City of Parksville, Town of Qualicum Beach and the EAs grow the 2010 vehicle population based on the annual average vehicle population change between 2010 and 2021 and adjust each members populations to align with the proportion of registered vehicle classes (e.g., gasoline-LDV) for each of the reporting years. For the EAs, the alignment of vehicle classes was based on the proportions seen in the City of Nanaimo, District of Lantzville, City of Parksville, and the Town of Qualicum Beach.
4. For all RDN members, grow the 2010 VKT data using ECCCs estimated change in vehicle class fuel consumption for BC. Since the data only went to 2020, use the Google data to estimate the change in VKTs for 2021 (Table 13).
5. Assign estimated vehicle fuel consumption rates (Table 13).
6. Estimate total fuel use by vehicle classification (Table 14).
7. Summate and allocate estimated fuel use, by vehicle class using the applicable in-boundary and transboundary split.
8. Pro-rate the diesel fuel use from busses.
9. Summate and allocate estimated bus fuel use using the applicable in-boundary and transboundary split.

Table 13 Estimated VKT And Fuel Efficiencies by Vehicle Class For Reporting Year

Vehicle Classification	Estimated VKT / Year (Average)	Estimated Fuel Efficiency (L/100 km)
Diesel-HDV	69,932	45.6
Diesel-LDT	26,283	11.8
Diesel-LDV	26,177	9.2
Diesel-ORVE	Not Estimated	45.6
Electric-HDV	14,271	30.0
Electric-LDT	36,686	20.0
Electric-LDV	12,328	20.0
Electric-ORVE	Not Estimated	30.0
Gasoline-HDV	14,271	54.1

Vehicle Classification	Estimated VKT / Year (Average)	Estimated Fuel Efficiency (L/100 km)
Gasoline-Hybrid-HDV	22,715	37.9
Gasoline-Hybrid-LDT	36,686	10.0
Gasoline-Hybrid-LDV	15,580	7.0
Gasoline-Hybrid-ORVE	Not Estimated	37.9
Gasoline-LDT	29,219	12.2
Gasoline-LDV	12,328	9.0
Gasoline-ORVE	Not Estimated	54.1
Hydrogen-Hybrid-LDV	15,580	Not Estimated
Hydrogen-LDV	33,439	Not Estimated
Hydrogen-LDT	36,686	Not Estimated
Motorcycle - Electric	18,026	17.0
Motorcycle - Non catalyst	18,026	9.9
Natural Gas-HDV	21,543	22.9
Natural Gas-LDT	10,328	8.3
Natural Gas-LDV	14,395	5.4
Natural Gas-ORVE	Not Estimated	22.9
Propane-HDV	14,420	22.9
Propane-Hybrid-LDV	14,395	13.1
Propane-LDT	10,239	12.6
Propane-LDV	17,065	8.2
Propane-ORVE	Not Estimated	22.9

Table 14 Total Registered Vehicles & Estimated Fuel Use For Reporting Year

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Diesel-HDV	2,357	64,292,677	Liters (L)
Diesel-LDT	5,867	15,408,681	Liters (L)
Diesel-LDV	4,803	12,098,680	Liters (L)
Diesel-ORVE	1,468	224,379	Liters (L)
Electric-HDV	13	46,163	kWh
Electric-LDT	8	56,493	kWh
Electric-LDV	780	1,890,935	kWh
Electric-ORVE	22	-	kWh
Gasoline-HDV	2,430	17,527,539	Liters (L)
Gasoline-Hybrid-HDV	-	-	Liters (L)

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Gasoline-Hybrid-LDT	351	1,253,522	Liters (L)
Gasoline-Hybrid-LDV	2,085	2,229,305	Liters (L)
Gasoline-Hybrid-ORVE	-	-	Liters (L)
Gasoline-LDT	26,355	91,573,329	Liters (L)
Gasoline-LDV	84,669	91,715,392	Liters (L)
Gasoline-ORVE	239	13,736	Liters (L)
Hydrogen-Hybrid-LDV	-	-	Liters (L)
Hydrogen-LDV	7	-	Liters (L)
Hydrogen-LDT	6	-	Liters (L)
Motorcycle - Electric	18	55,647	kWh
Motorcycle - Non catalyst	5,237	9,352,047	Liters (L)
Natural Gas-HDV	26	1,558,102	Kilogram (kg)
Natural Gas-LDT	10	8,792	Kilogram (kg)
Natural Gas-LDV	-	-	Kilogram (kg)
Natural Gas-ORVE	-	-	Kilogram (kg)
Propane-HDV	60	157,000	Liters (L)
Propane-Hybrid-LDV	-	-	Liters (L)
Propane-LDT	68	94,768	Liters (L)
Propane-LDV	14	8,449	Liters (L)
Propane-ORVE	41	-	Liters (L)
Total	**136,935**	**N/A**	**N/A**

Once the fuels were allocated amongst the vehicle classes and sectors, the GHG emissions were calculated accordingly. The GHG quantification method is captured, for all fuel types, is as follows:

$$\textbf{Emissions}_{\text{On-road}} = \text{In-Boundary Split \%} * ((\text{Vol. Fuel} * EF_{CO2}) + (\text{Vol. Fuel} * EF_{CH4} * GWP_{CH4}) + (\text{Vol. Fuel} * EF_{N2O} * GWP_{N2O}))$$

$$\textbf{Emissions}_{\text{Transboundary}} = \text{Transboundary Split \%} * ((\text{Vol. Fuel} * EF_{CO2}) + (\text{Vol. Fuel} * EF_{CH4} * GWP_{CH4}) + (\text{Vol. Fuel} * EF_{N2O} * GWP_{N2O}))$$

The emission factors used in the reporting year GHG inventory are from the 2020 B.C. Best Practices Methodology For Quantifying Greenhouse Gas Emissions. These are summarized in Table 15.

Table 15 Vehicle GHG Emission Factors

Vehicle Class	Units	tCO_2e	Quality Assessment Rating
Gasoline-LDV	tonne CO_2e / L	0.00234581	Medium-Low
Gasoline-LDT	tonne CO_2e / L	0.0022579	Medium-Low
Gasoline-HDV	tonne CO_2e / L	0.0022851	Medium-Low
Gasoline-ORVE	tonne CO_2e / L	0.0022033	Medium-Low
Gasoline-Hybrid-LDV	tonne CO_2e / L	0.0023293	Medium-Low
Gasoline-Hybrid-LDT	tonne CO_2e / L	0.0022579	Medium-Low
Gasoline-Hybrid-HDV	tonne CO_2e / L	0.0022851	Medium-Low
Gasoline-Hybrid-ORVE	tonne CO_2e / L	0.0022579	Medium-Low
Electric-LDV	tonne CO_2e / kWh	0.0000097	Medium-Low
Electric-LDT	tonne CO_2e / kWh	0.0000097	Medium-Low
Electric-HDV	tonne CO_2e / kWh	0.0000097	Medium-Low
Electric-ORVE	tonne CO_2e / kWh	0.0000097	Medium-Low
Diesel-LDV	tonne CO_2e / L	0.0025786	Medium-Low
Diesel-LDT	tonne CO_2e / L	0.0025790	Medium-Low
Diesel-HDV	tonne CO_2e / L	0.0025629	Medium-Low
Diesel-ORVE	tonne CO_2e / L	0.0027757	Medium-Low
Hydrogen-Hybrid-LDV	tonne CO_2e / L	-	Medium-Low
Hydrogen-LDV	tonne CO_2e / L	-	Medium-Low
Hydrogen-LDT	tonne CO_2e / L	-	Medium-Low
Natural Gas-LDV	tonne CO_2e / kg	0.0002337	Medium-Low
Natural Gas-LDT	tonne CO_2e / kg	0.0002337	Medium-Low
Natural Gas-HDV	tonne CO_2e / kg	0.0002337	Medium-Low
Natural Gas-ORVE	tonne CO_2e / kg	0.0002337	Medium-Low
Propane-LDV	tonne CO_2e / L	0.0014495	Medium-Low
Propane-LDT	tonne CO_2e / L	0.0014495	Medium-Low
Propane-HDV	tonne CO_2e / L	0.0014495	Medium-Low
Propane-ORVE	tonne CO_2e / L	0.0014495	Medium-Low
Propane-Hybrid-LDV	tonne CO_2e / L	0.0014495	Medium-Low
Motorcycle - Non catalyst	tonne CO_2e / L	0.0022420	Medium-Low
Motorcycle - Electric	tonne CO_2e / L	0.0000097	Medium-Low

4.2.5.2 Waterborne Transportation

4.2.5.2.1 BC Ferries

Marine waterborne transportation emissions encompass GHG emissions from the use of the BC Ferries. GHG emissions from BC Ferries are estimated using total estimated fuel use for the 2021 reporting year, and provincially derived GHG emissions factors (Table 16).

Table 16 BC Ferries GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Ferry: Diesel	tonne CO_2e / L	0.0028777	Medium
Ferry: Natural Gas	tonne CO_2e / L	0.0014140	Medium

BC Ferries GHG emissions were assigned to the RDN based on total annual passenger counts to Departure Bay and Duke Point relative to the total number of passengers using BC Ferries for the reporting year. These assigned GHG emissions where then prorated to each RDN member population relative to the RDN population.

The GHG quantification method, that was applied to assigned and quantify GHG emissions to the RDN is as follows:

$$\textbf{Emissions}_{\textbf{Waterborne}} = (Passengers_{Total\ BC\ Ferries} * Passengers_{RDN}) *((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

4.2.5.2.2 Personal Watercraft

The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles; however, the registration system does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that 50% of the boats are sail (60% diesel; 40% gas) and 50% are power (25% diesel, 75% gas). To estimate the GHG emissions, the estimated annual fuel consumption rates from the Victoria Harbour Study “Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000” and BC based emission factors were applied (Table 17).

Table 17 Watercraft GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Marine Gasoline	tonne CO_2e / L	0.0022539	Medium-Low
Marine Diesel	tonne CO_2e / L	0.0026083	Medium-Low

The GHG quantification method, that was applied to personal watercraft was as follows:

$$\textbf{Emissions}_{\textbf{Waterborne}} = Total\ Boats * Fuel_{Percent} * ((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

4.2.5.2.3 Cruise Ship & Deep Sea Vessels

The GHG emissions from the operation of cruise ship and deep-sea vessels within the RDN's boundary was based on the number of reported vessels and cargo tonnages as reported by the Nanaimo Port Authority, and GHG emission estimates as reported by the Victoria Greater Harbor Authority and the Port of Vancouver. Only the container cargo tonnages were used and excluded logs and other forest products.

The GHG emission factors used to quantify these GHG emissions are presented in Table 18.

Table 18 Watercraft GHG Emission Factors

Aspect	Units	Emission Factor	Quality Assessment Rating
Cruise Ships	tCO_2e/Cruise Ship	49.9443	Medium-Low
Deep-Sea Vessels	tCO_2e /Tonne of Cargo	0.0070	Medium-Low

The GHG quantification method, that was applied to estimate these GHG emissions were as follows:

$$\textbf{Emissions}_{\textbf{Cruise Ships}} = Cruise\ Ships_{Total} * EF_{CO2e}$$

$$\textbf{Emissions}_{\textbf{Deep Sea Vessels}} = (Cargo_{Total} - Cargo_{Logs,\ Forest\ Products}) * EF_{CO2e}$$

4.2.5.3 Railways

The Island Rail Corridor is 225 kilometers in length to which approximately 52 kilometers of rail crosses through the RDN. To account for these GHG emissions from freight transport, the ECCC 2023 NIR estimates for railways in BC, and total kilometres of rail in BC (as reported by Statistics Canada) were used to derive a GHG per km of rail emission factor. This factor along with the estimated length of rail crossing the RDN was used to derive an estimate of GHG emissions. The factor derived is presented in Table 19.

Table 19 Railway GHG Emission Factor

Aspect	Units	Emission Factor	Quality Assessment Rating
Railway GHG Emissions	tCO_2e/km-Rail	30.09	Low

The GHG quantification method is as follows:

$$Emissions_{Railway} = Railway_{km} * EF_{tCO2e}$$

4.2.5.4 Off-Road

Currently, there is limited data available to estimate off-road GHG emissions. As such, a GHG emissions estimate for each off-road category was developed using Provincial emissions data from the 2023 NIR, and population and employment statistics from Statistics Canada.

Residential, commercial, and institutional building related off-road GHG emissions are based on the ECCC 2023 NIR estimates for BC and were pro-rated to the RDN on a per capita basis.

Agriculture, forestry and fishing related off-road GHG emissions are based on the ECCC 2023 NIR estimates for BC and were pro-rated to the RDN on a per hectare of agricultural land basis.

Manufacturing industries and construction, and manufacturing, mining and construction related off-road GHG emissions are based on the ECCC 2023 NIR estimates for BC and were pro-rated to the RDN based on the number of employees in each of the reported sectors.

Other off-road GHG emissions are based on the ECCC 2023 NIR estimates for BC and were pro-rated to the RDN on a per capita basis. These GHG emissions were reported in the Transportation Other Off-Road Sub-Sector.

The GHG quantification method is presented below:

$$Emissions_{Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Population_{BC}) * Current\ Reporting\ Year\ Population_{RDN}$$

$$Emissions_{Agriculture,\ Forestry\ And\ Fishing} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Lands\ in\ Agriculture_{HA}) * RDN\ Lands\ in\ Agriculture_{HA}$$

$$Emissions_{Manufacturing\ Industries\ And\ Construction\ \&\ Manufacturing,\ Mining\ and\ Construction\ Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Employment\ Statistics_{BC}) * Current\ Reporting\ Year\ Employment\ Statistics_{RDN}$$

$$Emissions_{Other\ Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Population_{BC}) * Current\ Reporting\ Year\ Population_{RDN}$$

4.3 WASTE

Cities produce GHG emissions because of the disposal and management of solid waste, incineration and open burning of waste, the biological treatment of waste, and through wastewater treatment and discharge. Waste does not directly consume energy, but releases GHG emissions because of decomposition, burning, incineration, and other management methods.

For the RDN, the Waste Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 3: Emissions:
  - Solid waste disposal
  - Biological treatment of waste
  - Incineration and opening burning
  - Wastewater treatment and discharge

There are no incineration activities, but there are open burning activities.

4.3.1 Activity Data

The RDN provided the following data sources:

- Total fugitive landfill fugitive GHG emissions
- Total organic material sent for treatment
- Total volume of wastewater treated for the following wastewater treatment plants:
  - Greater Nanaimo Pollution Control Centre
  - French Creek Pollution Control Centre
  - Nanoose Bay Pollution Control Centre
  - Duke Point Pollution Control Centre
- Annual average BOD and TKN for each of the wastewater treatment plants
- Volume of landfill gas flared

4.3.2 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- The assignment of fugitive GHG emissions from the landfill based on a per capita basis. While there is waste entering the landfill from outside of the RDN, is currently not tracked. As such, for conservativeness, all landfill fugitive emissions are allocated to RDN members.
- Composting GHG emissions are estimated based on the total tonnage estimated by the RDN. It is assumed that all compost, other than the City of Courtenay's waste steam, is treated aerobically.
- It is assumed that all residential dwellings in the Electoral Areas backyard compost.
- It is assumed that the wastewater influent volumes include any septage received.
- It is assumed that the Electoral Areas without wastewater treatment have septic tanks.
- Open burning GHG emissions are estimated using a 2015 particulate matter emissions inventory that was prepared for the Comox Valley. The GHG emissions are adjusted to 2007 and 2021 using population data.

4.3.3 Data Quality Assessment

Table 20 presents the activity data quality assessment for the waste data sources.

Table 20 Waste Data Quality Assessment

Data	Quality Assessment Rating
Landfill fugitive methane and flaring data	Medium-High
Landfill tonnages sent to landfill by RDN member data	Medium-Low
Wastewater volume data	High
Wastewater BOD and TKN data	High
Wastewater septic system data	Medium-Low
Composting waste data (compost and biosolids)	Medium
Incineration and open burning data	Low

4.3.4 Calculation Methodology

4.3.4.1 Solid Waste

The RDN provided fugitive landfill GHG emissions estimates and solid waste tonnage by RDN member. The GHG emissions were allocated based on solid waste tonnage sent to the landfill by RDN member. To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification method was deployed:

$$Emissions_{Fugitive\ Landfill} = Waste_{Total} * (Population_{RDN\ Member} / Population_{RDN}) * EF_{CH4} * GWP_{CH4}$$

4.3.4.2 Biological Treatment of Solid Waste

The RDN provided composting data which is assumed to be treated aerobically. The composting emission factor used in the estimation of GHG emissions was derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5, Chapter 4: Biological Treatment of Solid Waste) (Table 21).

Table 21 Composting Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Composting: Anerobic	tCO_2e / kg waste	0.00019150	Low
Composting: Aerobic	tCO_2e / kg waste	0.00002800	Low

To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification methods was deployed:

$$Emissions_{Anaerobic\ Waste} = Compost\ Waste_{Total} * EF_{CH4} * GWP_{CH4}$$

4.3.4.3 Waste Incineration And Open Burning

Thera are no incineration activities occurring within the RDN.

Open burning GHG emissions are estimated using a 2015 factor of tonnes combusted per household. For the purposes of estimation, it is assumed that all open burning occurs in the Electoral Areas of the RDN. The GHG emissions are adjusted to 2007 and 2021 using population data.

The emission factor used in the estimation of GHG emissions was derived from 2001 US EPA GHG methodology quantification guidance document (Chapter 16, Open Burning). It is assumed that the material being burned is evenly split amongst leaf species, forest residues, and weeds. The emission factor is presented in Table 22.

Table 22 Open Burning Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Open Burning	tCO_2e / tonne waste	0.04622430	Medium-Low

To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification methods was deployed:

$$Emissions_{Open\ Burning} = Burned\ Waste_{Total} * EF_{CO2}$$

4.3.4.4 Wastewater Treatment And Discharge: Treatment Systems

Wastewater is currently treated prior to discharge. To estimate GHG emissions, the total wastewater volumes (m^3), the average biological oxygen demand (BOD) and the average Total Kjeldal Nitrogen (TKN) in treated wastewater area used. IPCC default wastewater methane (CH_4) producing capacity (0.6 kg CH_4/kg BOD) and methane correction factor (MCF) (0.1 – unit less) were used to estimate CH_4 from the wastewater. To estimate N_2O from the wastewater, the Total Kjeldal Nitrogen (TKN) annual average in conjunction with the total wastewater volumes to calculate the total TKN in the wastewater. The IPCC default conversion value of 0.01 kg N_2O-N/kg sewage-N was used to estimate N_2O from the wastewater. These factors used are for treated wastewater being deposited into deep or moving waters. It is likely that ocean sequesters more CH_4 than what has been estimated.

To quantify GHG emissions from the wastewater treatment, the following GHG quantification method is deployed:

$$Emissions_{Wastewater\ CH4} = ((Wastewater_{m3} * (BOD_{ml/L} / 1000) * (0.018_{kg\ CH4/kg\ BOD} * 0.01)) / 1000) * GWP_{CH4}$$

$$Emissions_{Wastewater\ N2O} = ((Wastewater_{m3} * (TKN_{ml/L} / 1000) * 0.01_{kg\ N2O\text{-}N/kg\ sewage\text{-}N}) / 1000) * GWP_{N2O}$$

4.3.4.5 Wastewater Treatment And Discharge: Septic Systems

There are several households within the RDN are on septic systems. The number of homes not receiving wastewater treatment, based on service area, was used to estimate the fugitive wastewater GHG emissions from septic systems. The method is presented as follows:

$$Emissions_{Septic} = Homes_{Septic} * Population_{Septic} * EF$$

The emission factor derived from septic GHG emissions research by the Water Environment Research Foundation is presented in Table 23.

Table 23 Septic System Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Septic Systems	tCO_2e / capita / year	0.0010302	Medium-Low

4.4 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

4.4.1 Overview

Emissions from the IPPU Sector are only required for BASIC+ GHG reporting under the GPC Protocol. This Sector encompasses GHG emissions produced from industrial processes that chemically or physically transform materials and using products by industry and end-consumers (e.g., refrigerants, foams, and aerosol cans) (GPC, 2014).

For the RDN, the IPPU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Product use

No significant GHG emissions from Industrial Processes, like the release of chemicals and refrigerants because of manufacturing or processing of materials, are reported to be occurring and thus the notation key for “Not Occurring” has been used to indicate this. It should be noted that the reporting threshold for the BC government is 10,000 tCO_2e so it is possible that there are small industrial GHG emissions sources occurring within the RDN, but there is no data to support a conclusion.

4.4.2 Activity Data

The IPPU data was derived from the ECCC 2023 NIR.

4.4.3 Data Quality Assessment

Table 24 presents the activity data quality assessment for the IPPU data sources.

Table 24 IPPU Data Quality Assessment

Data	Quality Assessment Rating
Industrial process emissions data	Low
Industrial product use emissions data	Low

4.4.4 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- The product use emissions are based on the 2023 NIR product use GHG emissions as prepared by Environment and Climate Change Canada. These are applied to the RDN on a per capita basis.
- The NIR uses the Tier 1 methodology to estimate these emissions and thus uncertainty around their accuracy remains quite high.

4.4.5 Calculation Methodology

4.4.5.1 Product Use Emissions

For the 2021 reporting year, only the emissions estimated were production and consumption of halocarbons, SF_6 and NF_3 were estimated for the province. To estimate product use GHG emissions for the RDN, the ECCC 2023 NIR estimates for BC were pro-rated to the RDN based on the number of employees in the manufacturing, construction, and mining, quarrying and oil and gas extraction sectors.

The GHG quantification method is presented below:

$$\textbf{\textit{Emissions}}_{\textit{Product Use}} = (\textit{NIR Product Use GHG Emissions}_{BC} / \textit{Employment Population}_{BC}) * \textit{Current Reporting Year Population}_{\textit{RDN Manufacturing, Construction And Mining, Quarrying And Oil And Gas Extraction Employee Count}}$$

4.5 AGRICULTURE, FORESTRY, AND OTHER LAND USE (AFOLU)

4.5.1 Overview

The AFOLU Sector includes emissions from livestock, land-use, and all other agricultural activities occurring within a community's boundaries. For the RDN, the AFOLU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Land (*reported, but not included in the GHG totals*)

- Livestock
- Aggregate Sources and Non-CO_2 Emissions Sources On Land

4.5.2 Activity Data

The 2005, 2010, 2015 and 2020 Agriculture and Agri-Food Canada semi-decadal land use time series remotely sensed imagery datasets were used to estimate land-cover change between 2007 and 2021. The RDN provided jurisdictional boundary geospatial datasets.

Livestock counts were derived using Statistics Canada data.

Aggregate sources and non-CO_2 emissions sources on land were estimated using GHG emissions data from the 2023 NIR, and land-use data from the 2021 Statistics Canada Census of Agriculture, to create a GHG emissions per hectare value.

4.5.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- It is conservatively assumed that all cropland is used for livestock and agricultural purposes.
- Infrequent and small source open burning may be occurring, but there is no data to estimate this emissions source.
- The land cover change analysis requires a consistent land-use category attribution and spatial data. Landsat spatial data was available for the 2005, 2010, 2015 and 2020 reporting years. Since annual data was not available, the change between land cover data years (2007-2021) for all areas was averaged and may not represent actual changes in each year.

4.5.4 Data Quality Assessment

Table 25 presents the activity data quality assessment for the AFOLU data sources.

Table 25 AFOLU Data Quality Assessment

Data	Quality Assessment
Land-use data	High
Urea application GHG data	Low
Direct, indirect, and manure nitrous oxide (N_2O) GHG data	Low
Livestock data	Medium

4.5.5 Calculation Methodology

4.5.5.1 Land Use

Remotely sensed imagery was used to estimate land-cover changes during the 2007-2021 reporting periods. Using the remotely sensed imagery an annual average land-use change between land classes (e.g., cropland, forestland, etc.) was determined and applied to BC-based emission factors to estimate GHG emissions resulting from changes between land-uses for the reporting year.

The spatial data sources representing land cover in this analysis did not categorize lands by the 6 IPCC land-use categories. To align with the IPCC land classification definitions (as required by the GPC Protocol), the following data categories were re-assigned to the most appropriate IPCC land class.

Table 26 IPCC Land Use Classification Cross-References

Data Label	Definition	IPCC Land Use Classification
Settlement	Urban and rural residential, commercial, industrial, transportation or other built infrastructure use	Settlement
Settlement Forest	Settlement areas mostly or entirely covered by tree canopy	Settlement
Vegetated Settlement	Settlement areas with observable vegetation such as lawns, golf courses, and settlement areas with 30-50% tree canopy	Settlement
High Reflectance Settlement	Settlement areas with high spectral reflectance such as pavement, buildings, or other surfaces with little to no observable vegetation	Settlement
Very High Reflectance Settlement	Settlement areas with very high spectral reflectance such as pavement, buildings, or other surfaces with no observable vegetation	Settlement
Roads	Primary, secondary, and tertiary roads	Settlement
Water	Open water	Other
Forest	Land covered by trees with a canopy cover >10% and a minimum height of 5m, or capable of growing to those measurements within 50 years	Forest Land
Forest Wetland	Wetland with forest cover (canopy cover over 10% and minimum height 5m, or capable of growing to those measurements within 50 years)	Wetlands
Forest Regenerating after Harvest <20 years	Forest regenerating from tree harvesting activity that took place less than 20 years prior	Forest Land
Forest Wetland Regenerating after Harvest <20 years	Wetland with forest cover regenerating from tree harvesting activity that took place less than 20 years prior	Wetlands

Data Label	Definition	IPCC Land Use Classification
Forest Regenerating after Fire <20 years	Forest Regenerating after a fire less than 20 years prior	Forest Land
Forest Regenerating after Harvest 20-29 years	Forest regenerating from tree harvesting activity that took place 20 to 29 years prior (this class is identified beginning in 2010)	Forest Land
Forest Wetland Regenerating after Harvest 20-29 years	Wetland with forest cover regenerating from tree harvesting activity that took place 20 to 29 years prior	Wetlands
Cropland	Annual and perennial cropland	Cropland
Annual Cropland	Annual cropland (identified beginning in 2015)	Cropland
Land Converted to Cropland	Cropland that did not appear to be cropland 10 years prior (this class is identified beginning in 2010)	Cropland
Land Converted to Annual Cropland	Annual cropland that did not appear to be cropland 10 years prior (this class is identified beginning in 2015)	Cropland
Grassland Managed	Natural grass and shrubs used for cattle grazing	Grassland
Grassland Unmanaged	Natural grass and shrubs with no discerned human intervention (e.g., perpetual meadows, tundra)	Grassland
Wetland	Wetland with vegetation at or above the surface of the water	Wetlands
Newly-Detected Settlement <10 years	Settlement (21) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Settlement Forest <10 years	Settlement Forest (24) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Vegetated Settlement <10 years	Vegetated Settlement (28) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected High Reflectance Settlement <10 years	High Reflectance Settlement (22) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Very High Reflectance Settlement <10 years	Very High Reflectance Settlement (29) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Other Land	Rock, beaches, ice, barren land	Other
Snow and Ice	Snow and Ice on mountains (this class is identified only in 2020)	Other

The analysis resulted in an estimate of an annual average change in hectares' value for each land class. Once the land use change values were determined for the reporting year, BC-based and IPCC emission factors were applied to estimate reported and disclosed (not-reported) GHG emissions from land use (Table 27).

Table 27 Land-Use Change Emission Factors

Land-Use Classification	Emission Factor	Units	Quality Assessment Rating
Forestland	224.1	tCO_2e / ha	Low
Shrubland/Scrubland	112.0	tCO_2e / ha	Low
Grasslands	205.7	tCO_2e / ha	Low
Wetlands	471.5	tCO_2e / ha	Low
Cropland	239.8	tCO_2e / ha	Low
Settlements	0	tCO_2e / ha	Low
Other	0	tCO_2e / ha	Low
Forestland	1.8	tCO_2e / ha / year	Low
Shrubland/Scrubland	0.1	tCO_2e / ha / year	Low
Grasslands	2.6	tCO_2e / ha / year	Low
Wetlands	3.3	tCO_2e / ha / year	Low
Croplands	0.4	tCO_2e / ha / year	Low
Settlements	0	tCO_2e / ha / year	Low
Other	0	tCO_2e / ha / year	Low

The GHG quantification methods for land use change is presented below:

$$\textbf{Emissions}_{\textbf{Lands Not Converted}} = Land\ Type_{ha} * EF_{Sequester}$$

$$\textbf{Emissions}_{\textbf{Lands Converted}} = Land\ Type_{ha} * (EF_{Release} / (Current\ Land\ Reporting_{Year} - Last\ Land\ Reporting_{Year} + 1))$$

4.5.5.2 Emissions from Livestock

Emissions from Livestock includes enteric fermentation and manure management emission sources. IPCC derived emission factors were used to estimate this emissions source (Table 28).

Table 28 Livestock Emission Factors

Animal	Enteric Methane (tCO_2e / head / year)	Methane from Wastes (tCO_2e / head / year)	Quality Assessment Rating
Dairy Breeding Herd	2.875	0.325	Medium

Animal	Enteric Methane (tCO_2e / head / year)	Methane from Wastes (tCO_2e / head / year)	Quality Assessment Rating
Beef Herd	1.200	0.069	Medium
Cattle: Others>1, Dairy Heifers	1.200	0.150	Medium
Cattle: Others<1	0.820	0.074	Medium
Pigs	0.038	0.075	Medium
Breeding Sheep	0.200	0.005	Medium
Other Sheep	0.200	0.005	Medium
Lambs < 1 year	0.080	0.002	Medium
Goats	0.125	0.003	Medium
Sheep / Lamb / Goat	0.151	0.004	Medium
Horses	0.450	0.035	Medium
Deer (Stags & Hinds)	0.260	0.007	Medium
Deer (Calves)	0.130	0.003	Medium
Poultry	-	0.002	Medium

The GHG quantification methods to estimate livestock emissions is presented below:

$$\textbf{Emissions}_{\text{Livestock}} = \text{Livestock Type}_{\text{Head}} * (EF_{\text{Enteric Methane}} + EF_{\text{Methane From Waste}})$$

4.5.5.3 Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land

Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land includes direct N_2O emissions from agricultural soil management and indirect N_2O emissions from applied nitrogen. To estimate these GHG emissions, the total area of farmland for BC is used in conjunction with 2023 NIR data to develop a tCO_2e / ha value. This is then be applied to the total crop land in hectares to derive a GHG emissions estimate.

The GHG quantification method is presented below:

$$\textbf{Emissions}_{\text{Direct \& Indirect N2O}} = ((BC_{\text{Direct N2O Emissions}} + BC_{\text{Indirect N2O Emissions}} + BC_{\text{Indirect N2O Manure Management Emissions}}) / BC_{\text{Land In Crops ha}}) * \text{RDN Cropland}_{ha}$$

$$\textbf{Emissions}_{\text{Urea Application}} = \text{RDN Cropland}_{ha} * 0.06\ tCO_2e / ha$$

5.0 2021 GHG REPORTING YEAR RESULTS

This section presents the 2021 reporting year GHG emissions for the RDN.

5.1 SUMMARY

Total BASIC, and BASIC+ emissions for the RDN for the 2021 reporting year are presented in Figure 3 below.

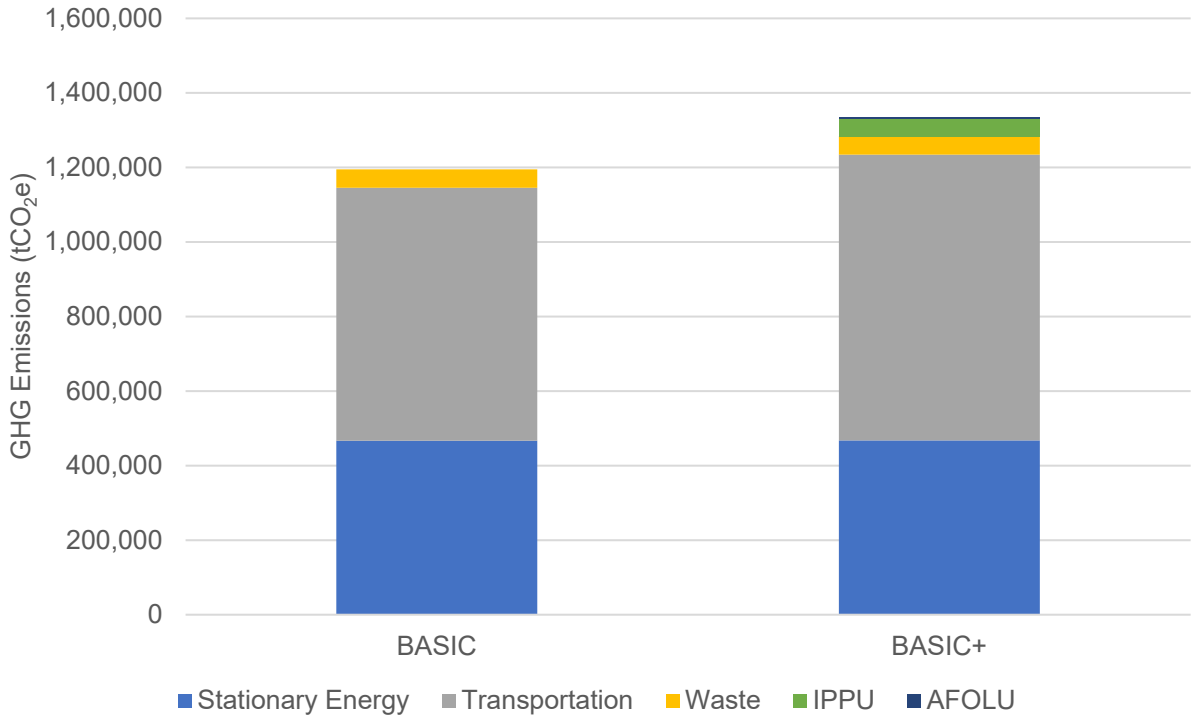

Figure 3 2021 GHG Emissions Summary by GPC Reporting Level

Emissions by reporting level are presented in Table 29 below which shows a difference in emissions under the GPC Protocol's BASIC, and BASIC+ reporting levels. This is due to the inclusion of additional sources in BASIC+ which are very significant for almost any growing community. These additional emissions include transboundary emissions, industrial and product use emissions, and emissions from land-use change. Under the GPC Protocol, emissions included within each higher reporting level are cumulative from lower levels.

Table 29 Breakdown of the RDN's 2021 GHG Emissions in GPC Reporting Format

GHG Emissions Source (by Sector)		Total GHGs (metric tonnes CO_2e)					
		Scope 1	Scope 2	Scope 3	BASIC	BASIC+	BASIC+ S3
Stationary Energy	Energy use (all emissions except I.4.4)	452,361	14,338	961	466,699	467,660	467,660
	Energy generation supplied to the grid (I.4.4)	43					
Transportation	(all II emissions)	678,764	20	87,913	678,784	766,697	766,697
Waste	Waste generated in the Community (III.X.1 and III.X.2)	49,335		0	49,335	49,335	49,335
	Waste generated outside community (III.X.3)	NO					
IPPU	(all IV emissions)	46,361				46,361	46,361
AFOLU	(all V emissions)	4,293				4,293	4,293
Other Scope 3 (S3)	(all VI emissions)			NE			NE
TOTAL		**1,231,114**	**14,358**	**88,874**	**1,194,818**	**1,334,345**	**1,334,345**

NOTES:
Notation Keys: IE = Included Elsewhere; NE = Not Estimated; NO = Not Occurring.
Cells in green are required for BASIC reporting.
Cells in green and blue are required for BASIC+ reporting.
Cells in purple are for disclosure purposes only but are not included in the summary totals as required by the GPC Protocol.
Cells in orange are not required for BASIC or BASIC+ reporting

Table 30 presents the breakdown of the RDN's BASIC+ GHG emissions by Sector and Sub-Sector.

Table 30 Breakdown of the RDN's 2021 BASIC+ GHG Emissions in the GPC Protocol Reporting Format

GPC ref No.	GHG Emissions Source (by Sector and Sub-Sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
I	**Stationary Energy**				
I.1	Residential buildings	168,337	9,213	617	178,168
I.2	Commercial and institutional buildings and facilities	71,028	5,125	343	76,497
I.3	Manufacturing industries and construction	162,486	IE	IE	162,486
I.4.1/2/3	Energy industries	688	IE	IE	688
I.4.4	Energy generation supplied to the grid	43			
I.5	Agriculture, forestry, and fishing activities	48,671	IE	IE	48,671
I.6	Non-specified sources	IE	IE	IE	IE
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			NO
I.8	Fugitive emissions from oil and natural gas systems	1,151			1,151
Sub-Total	(community induced framework only)	**452,361**	**14,338**	**961**	**467,660**
II	**Transportation**				
II.1	On-road transportation	633,016	20	87,913	720,948
II.2	Railways	1,602	IE	IE	1,602
II.3	Waterborne navigation	9,122	IE	IE	9,122
II.4	Aviation	NE	NE	NE	NE
II.5	Off-road transportation	35,024	IE	IE	35,024
Sub-total	(community induced framework only)	**678,764**	**20**	**87,913**	**766,697**
III	**Waste**				
III.1.1/2	Solid waste generated in the Community	43,188		NO	43,188
III.2.1/2	Biological waste generated in the Community	3,112		NO	3,112
III.3.1/2	Incinerated and burned waste generated in the Community	147		NO	147
III.4.1/2	Wastewater generated in the Community	2,887		IE	2,887
III.1.3	Solid waste generated outside the Community	IE			
III.2.3	Biological waste generated outside the Community	NO			

Table 30 Breakdown of the RDN's 2021 BASIC+ GHG Emissions in the GPC Protocol Reporting Format

GPC ref No.	GHG Emissions Source (by Sector and Sub-Sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
III.3.3	Incinerated and burned waste generated outside community	NO			
III.4.3	Wastewater generated outside the Community	NO			
Sub-total	(community induced framework only)	**49,335**		**0**	**49,335**
IV	**Industrial Processes and Product Uses**				
IV.1	Emissions from industrial processes occurring in the Community boundary	IE			IE
IV.2	Emissions from product use occurring within the Community boundary	46,361			46,361
Sub-Total	(community induced framework only)	**46,361**			**46,361**
V	**Agriculture, Forestry, and Other Land Use**				
V.1	Emissions from livestock	4,184			4,184
V.2	Emissions from land (not included in total)	-265,745			-265,745
V.3	Emissions from aggregate sources and non-CO_2 emission sources on land	109			109
Sub-Total	(community induced framework only)	**4,293**			**4,293**
VI	**Other Scope 3**				
VI.1	Other Scope 3			NE	NE
Total	(community induced framework only)	**1,231,114**	**14,358**	**88,874**	**1,334,345**

NOTES:
Cells in green are required for BASIC reporting.
Cells in green and blue are required for BASIC+ reporting.
Cells in purple are for disclosure purposes only but are not included in the summary totals as required by the GPC Protocol.
Cells in orange are not required for BASIC or BASIC+ reporting

5.2 TOTAL GHG EMISSIONS

Under the BASIC+ method, the RDN's GHG emissions totaled 1,334,345 tCO_2e. On a per capita basis, this works out to 7.8 tCO_2e per person (Table 31).

Table 31 Total Energy and GHG Emissions Per Person by Sector

Sector	Sub-Sector	Energy (GJ)	GHG Emissions (tCO_2e)	GJ Per Capita	tCO_2e Per Capita
Stationary Energy	Residential Buildings	7,107,515	178,168	41.3	1.0
	Commercial & Institutional Buildings	3,285,598	76,497	19.1	0.4
	Manufacturing Industries & Construction	3,741,417	162,486	21.8	0.9
	Agriculture, Forestry & Fishing activities	-	688	-	0.0
	Non-Specified Sources	678,243	48,671	3.9	0.3
	Fugitive Emissions	-	1,151	-	0.0
Transportation	In-Boundary On-road Transportation	9,714,320	633,033	56.5	3.7
	Trans-Boundary On-road Transportation	1,349,118	87,915	7.8	0.5
	Waterborne Navigation	123,118	9,122	0.7	0.1
	Aviation	NE	NE	-	-
	Railways	22,329	1,602	0.1	0.0
	Off-road Transportation	487,763	35,024	2.8	0.2
Waste	Solid Waste		43,188		0.3
	Biological Treatment of Waste		3,112		0.0
	Waste Incineration & Open Burning		147		0.0
	Wastewater Treatment & Discharge		2,887		0.0
IPPU	Product Use		46,361		0.3
AFOLU	Land-Use: Emissions Sequestered		(275,068)		(1.6)
	Land-Use: Emissions Release		9,322		0.1
	Livestock		4,184		0.0
	Non-CO_2 Land Emission Sources		109		0.0
Total		**26,509,421**	**1,334,345**	**154.1**	**7.8**

Total GHG emissions for 2021 are 1,334,345 tCO_2e and have increased 1.7% from the 2007 reporting year. Scope 1 and 2 Emissions are 92.3% and 1.1% of the total GHG inventory. Scope 1 emissions are the GHG emissions that result from the combustion of fuel in sources within the RDN's boundaries, primarily from Stationary Energy and Transportation. Scope 1 GHG emissions also include IPPU and some AFOLU GHG emissions. Scope 2 emissions result from the use of electricity supplied to the RDN which includes emissions associated with the generation of electricity and other forms of energy (e.g., heat and steam). Scope 2 emissions are low compared to other geographies, due to the predominance of hydroelectric generation technologies in the BC. Scope 3 emissions are emissions from electricity line losses, transboundary traffic, and emissions associated with the RDN that are occurring outside of the RDN's boundaries. For 2021, Scope 3 GHG emissions make up 6.7% of the GHG inventory. This breakdown by emission scope is depicted in Figure 4.

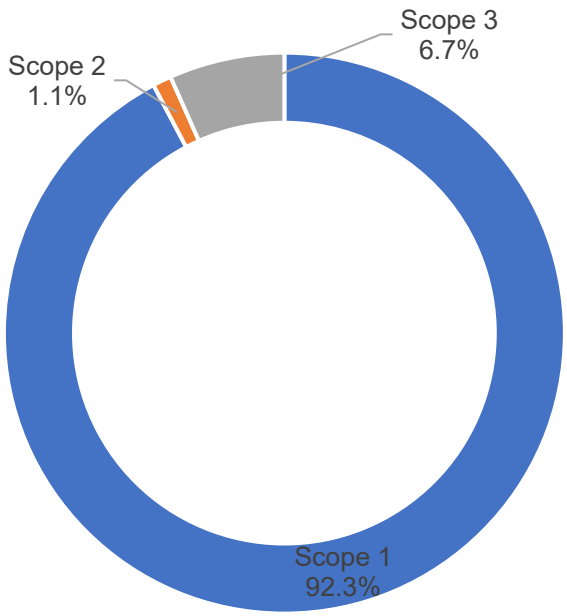

Figure 4 RDN BASIC+ GHG Emissions by Emissions Scope

A breakdown of GHG emissions by reporting scope for the 2007 and 2021 reporting years are presented in Table 32 below.

Table 32 Change in GHG Emissions Between 2007 & 2021 Reporting Years

Emissions Scope	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)	Change
Scope 1	1,165,200	1,231,114	5.7%
Scope 2	49,710	14,358	-71.1%
Scope 3	97,104	88,874	-8.5%
Total	**1,312,013**	**1,334,345**	**1.7%**

5.3 SECTORAL GHG EMISSIONS ANALYSIS

5.3.1 Stationary Energy

Stationary energy sources are one of the largest contributors to the RDN's GHG emissions. In 2021, excluding sequestered GHG emissions, it contributed 35.0% of the community's GHG emissions. In general, stationary energy emissions include the energy to run manufacturing processes and other industrial activities (e.g., compressor stations), energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within these residences and facilities. Fugitive methane emissions from natural gas pipelines and other distribution facilities, and related off-road GHG emissions, are also reported in this Sector. The table below shows the breakdown of energy use in the stationary energy reporting category.

Table 33 summarizes the energy and GHG emissions for the 2021 reporting year.

Table 33 2021 Energy and GHG Emissions by Stationary Energy Sector

Sector	Electricity (tCO_2e)	Natural Gas (tCO_2e)	Heating Oil (tCO_2e)	Propane (tCO_2e)	Wood (tCO_2e)	Other Sources (tCO_2e)	**Total GHG Emissions (tCO_2e)**	**Total Energy (GJ)**
Residential Buildings	9,830	78,835	53,735	8,274	24,192	3,302	**178,168**	**7,107,515**
Commercial & Institutional Buildings	5,469	46,519	-			24,509	**76,497**	**3,285,598**
Manufacturing Industries & Construction		135,634				26,852	**162,486**	**3,741,417**
Agriculture, Forestry & Fishing activities						688	**688**	
Non-Specified Sources						48,671	**48,671**	**678,243**
Fugitive Emissions						1,151	**1,151**	
Total GHG Emissions (tCO_2e)	**15,299**	**260,988**	**53,735**	**8,274**	**24,192**	**105,173**	**467,660**	
Total Energy (GJ)	**5,677,878**	**5,831,415**	**786,150**	**135,600**	**941,738**	**1,439,992**		**14,812,773**

It can be seen in Figure 5 that natural gas use contributed to 55.8% of the RDN's total Stationary Energy GHG emissions.

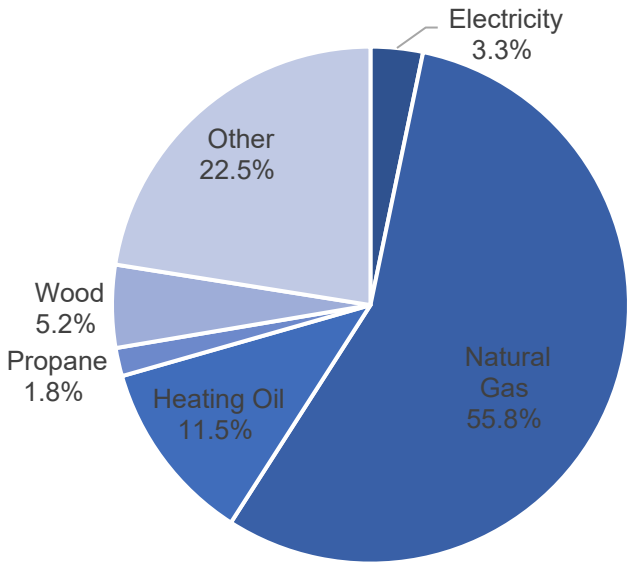

Figure 5 Stationary Energy GHG Emissions Contribution to the GHG Inventory

Figure 6 shows that the stationary GHG emissions largely arise from the operation of residential and commercial buildings.

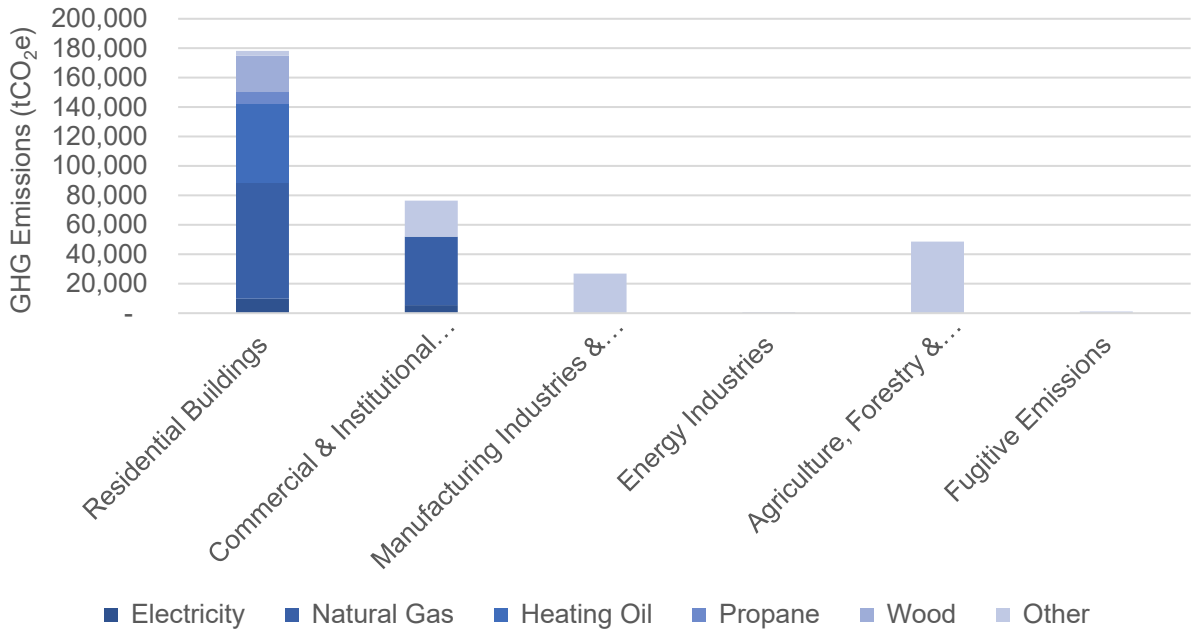

Figure 6 Total Stationary Energy Use By Sub-Sector

Stationary energy consumption has increased 17.5% since the 2007 reporting year while emissions only increased approximately 25% of that (Table 34). Much of the associated increase in GHG emissions has been offset by a significantly lower electricity emission factor in 2021 (as compared to 2007).

Table 34 Stationary Energy—Energy and GHG Emissions Trends

Sector	Change in GJ: 2007 & 2021	Change in tCO_2e: 2007 & 2021
Residential Buildings	11.3%	-0.2%
Commercial & Institutional Buildings	0.4%	-13.6%
Manufacturing Industries & Construction	51.2%	23.8%
Energy Industries	-	48.9%
Agriculture, Forestry & Fishing activities	43.6%	39.8%
Fugitives	-	97.4%
Total	**17.5%**	**7.7%**

5.3.2 Transportation

Transportation covers all emissions from combustion of fuels in journeys by road, rail, water, and air, including inter-community and international travel. For the 2021 reporting year, transportation GHG emissions accounted for 57.5% of the RDN GHG inventory with the bulk of transportation GHG emissions resulting from the on-road transportation sub-sector (93.9%). The transportation GHG emissions are produced directly by the combustion of fuel or indirectly because of the use of grid-supplied electricity. Unlike stationary emission sectors, transit is mobile and can pose challenges in both accurately calculating emissions and allocating them to the cities linked to the transit activity. The following sections summarize energy and GHG emissions by on-road transportation, which is then followed by off-road transportation (marine, aviation, and other).

Table 35 summarizes the on-road energy and GHG emissions for the 2021 reporting year.

Table 35 2021 On-Road Transportation Energy And GHG Emissions by Fuel Type

Fuel Type	Number of Registered Vehicles	Total Fuel Use	Fuel Use Units	Energy (GJ)	GHG Emissions (tCO_2e)
Electricity	841	2,514,146	kWh	7,377	20
Gasoline	121,367	250,235,118	Liters (L)	7,405,624	483,850
Diesel	14,494	119,731,177	Liters (L)	3,559,504	236,335
Propane	184	310,474	Liters (L)	6,643	377
Hydrogen	13	-	Liters (L)	-	-
Natural Gas	36	1,678,836	Kilograms (kg)	84,289	366
Total	**136,935**	**N/A**	**N/A**	**11,063,438**	**720,948**

Overall, GHG emissions from on-road transportation has declined by 6.8% compared to the 2007 reporting year – this is largely due to improved vehicle fuel efficiency and the lingering impacts that COVID-19 restrictions had on community movement which has resulted in people driving less.

Figure 7 provides a breakdown of GHG emisisons by vehicle classification. More than 70% of the on-road GHG emissions come from light duty vehciles and trucks.

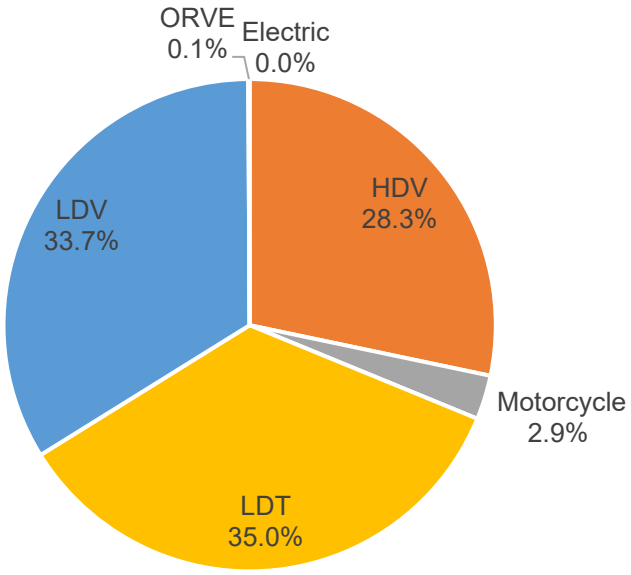

Figure 7 Breakdown of On-Road GHG Emissions by Vehicle Type

Table 36 summarizes the waterborne, and off-road transportation energy and emissions by fuel type. These GHG emissions contribute to 6.0% of the total transportation GHG emissions and 3.4% to the total inventory, after excluding for land use sequestration (Figure 8).

Table 36 2021 Aviation, Waterborne, and Off-Road Transportation Energy and Emissions by Fuel Type

Fuel Type	Total	Units	Energy (GJ)	GHG Emissions (tCO_2e)
Marine Gasoline	2,981	Liters (L)	103	7
Marine Diesel	3,121,908	Liters (L)	120,755	8,984
Marine Natural Gas	58,140	Liters (L)	2,259	131
Railway Diesel	577,268	Liters (L)	22,329	1,602
Aviation Jet Fuel	-	Liters (L)	-	-
Other Off-Road Transportation Diesel	12,618,042	Liters (L)	487,763	35,024
Total	**N/A**	**N/A**	**633,210**	**45,748**

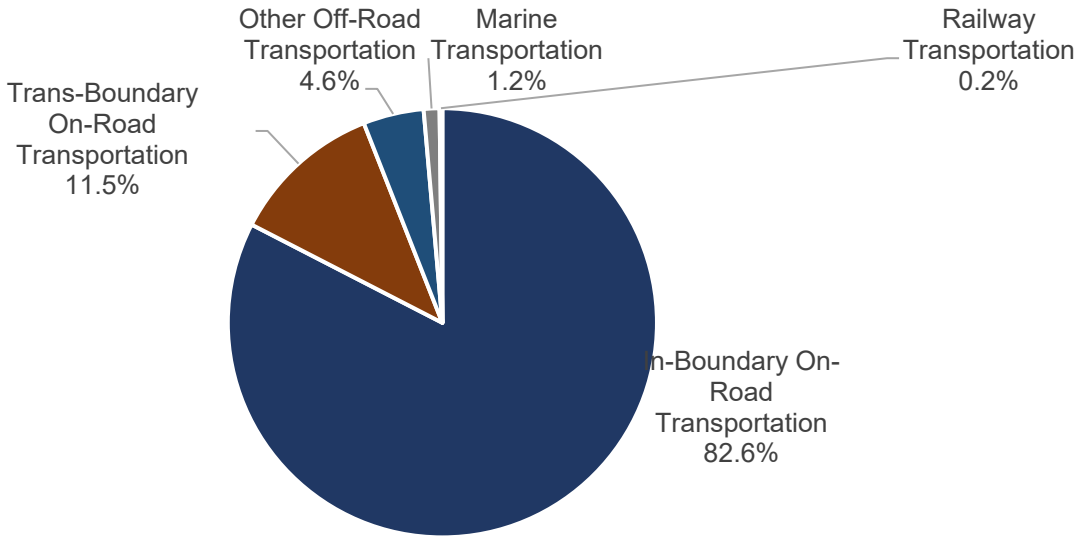

Figure 8 Summary of Transportation GHG Emissions by Sub-Sector

5.3.3 Waste

Communities produce solid waste, compost, and wastewater. Waste does not directly consume energy, but when deposited into landfills, or left exposed to the atmosphere, it decomposes and releases methane (CH_4) gas which is a potent GHG. The GHG emissions from the solid waste, composting, and wastewater facilities for the reporting year is summarized in the following table. For the 2021 reporting year, waste emissions contributed 3.7% to the GHG inventory after excluding sequestration GHG emissions. A breakdown of the Waste Sub-Sector GHG emissions is presented in Table 37.

Table 37 Summary of Waste Sub-Sector GHG Emissions

Sector	2021 GHG Emissions (tCO_2e)	GHG Emissions Per Capita (tCO_2e / Capita)	Change from Reporting year (2007)
Wastewater Treatment & Discharge	2,887	0.02	46.9%
Biological Treatment of Solid Waste	3,112	0.02	100%
Waste Incineration & Open Burning	147	0.00	17%
Solid Waste	43,188	0.25	-4.7%
Total	**49,335**	**0.29**	**4.1%**

For the 2021 reporting year, in scope GHG emissions from waste have increased by 4.1% compared to the 2007 reporting year. Fluctuations in waste will occur over the reporting periods as waste is driven by both the population, as well as economic prosperity in the region. The Solid Waste Sub-Sector contributes more than 85% of total waste GHG emissions (Figure 9). To reduce the amount of waste

landfilled, and thus GHG emissions, the RDN and its members are making a significant effort to reduce waste going to landfills through organics diversion and recycling.

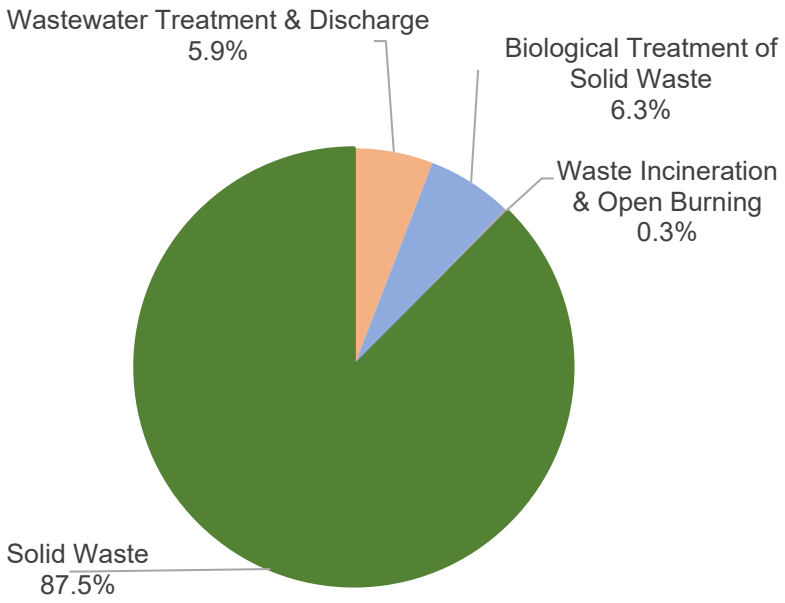

Figure 9 2021 GHG Emissions from Waste (tCO_2e)

5.3.4 Industrial Processes and Product Use (IPPU)

Reporting on IPPU GHG emissions is required for BASIC+ reporting only. Industrial GHG emissions are produced from a wide variety of non-energy related industrial activities which are typically releases from industrial processes that chemically or physically transform materials. During these processes, many different GHGs can be produced. It is not clear if there are industrial GHG emissions occurring within the RDN's boundaries and thus a "Not Estimated" notation is used in the GPC tables.

Also included in the IPPU Sector is Product Use GHG emissions. Certain products used by industry and end-consumers, such as refrigerants, foams or aerosol cans, also contain GHGs which can be released during use and disposal and thus, as with best-practice, must be accounted for. For the reporting year, only the emissions estimated were production and consumption of halocarbons, SF_6 and NF_3 were estimated for the RDN on the basis that other GHG emissions sources identified in the NIR are not likely to be occurring in the RDN. The sources of these GHG emissions are typically fridges, heat pumps, and air conditioners.

Between the 2007 and 2021 reporting years, IPPU GHG emissions have increased by 127.4% (Table 38). The increase in GHG emissions is largely related to ECCC's estimate of GHG emissions for BC which is allocated to the RDN on a per capita basis.

Table 38 Product Use GHG Emissions for the 2007 and 2021 Reporting Years

Sub-Sector	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)	Change
Product Use Emissions	20,338	46,631	127.4%

5.3.5 Agriculture, Forestry, and Other Land Use

The AFOLU Sector includes GHG emissions from livestock, land use, and all other agricultural activities occurring within the RDN's boundaries.

The following information is provided for disclosure purposes only. Using remotely sensed imagery, land cover data was used to estimate land use changes between the reporting years. In 2021, the RDN's greenspace is estimated to have sequestered and stored 284,748 tCO_2e (Table 39), and released 9,322 tCO_2e for a net reduction of 265,745 tCO_2e. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and ecosystem sequestration, these GHG emissions have been excluded from the RDN's GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed.

Table 39 Summary of Land Area & GHG Emissions By Land Use Sector

Land Use Sector	Average Area in Hectares (ha)	GHG Emissions Sequestered (tCO_2e)	GHG Emissions Released (tCO_2e)
Settlement Forest	5,455	(4,105)	-
Vegetated Settlement	4,052	(2,135)	-
Forest Regenerating after Fire <20 years	306	(1,573)	-
Forest Regenerating after Harvest <20 years	53,999	(32,302)	-
Forest Wetland Regenerating after Harvest <20 years	77	(36)	-
Wetland	529	(1,745)	-
Forest	124,448	(225,263)	-
Cropland	1,976	(797)	-
Forest Wetland	2,090	(6,899)	-
Grassland Unmanaged	527	(213)	-
High Reflectance Settlement	1,009	-	1,261
Other Land	320	-	-

Land Use Sector	Average Area in Hectares (ha)	GHG Emissions Sequestered (tCO_2e)	GHG Emissions Released (tCO_2e)
Roads	5,453	-	1,096
Very High Reflectance Settlement	551	-	1,054
Water	108,112	-	-
Settlement	3,796	-	5,912
Total	**312,701**	**(275,068)**	**9,322**

Figure 10 presents the land use classes by proportion of total area. It shows that the majority of lands within the RDN are forested.

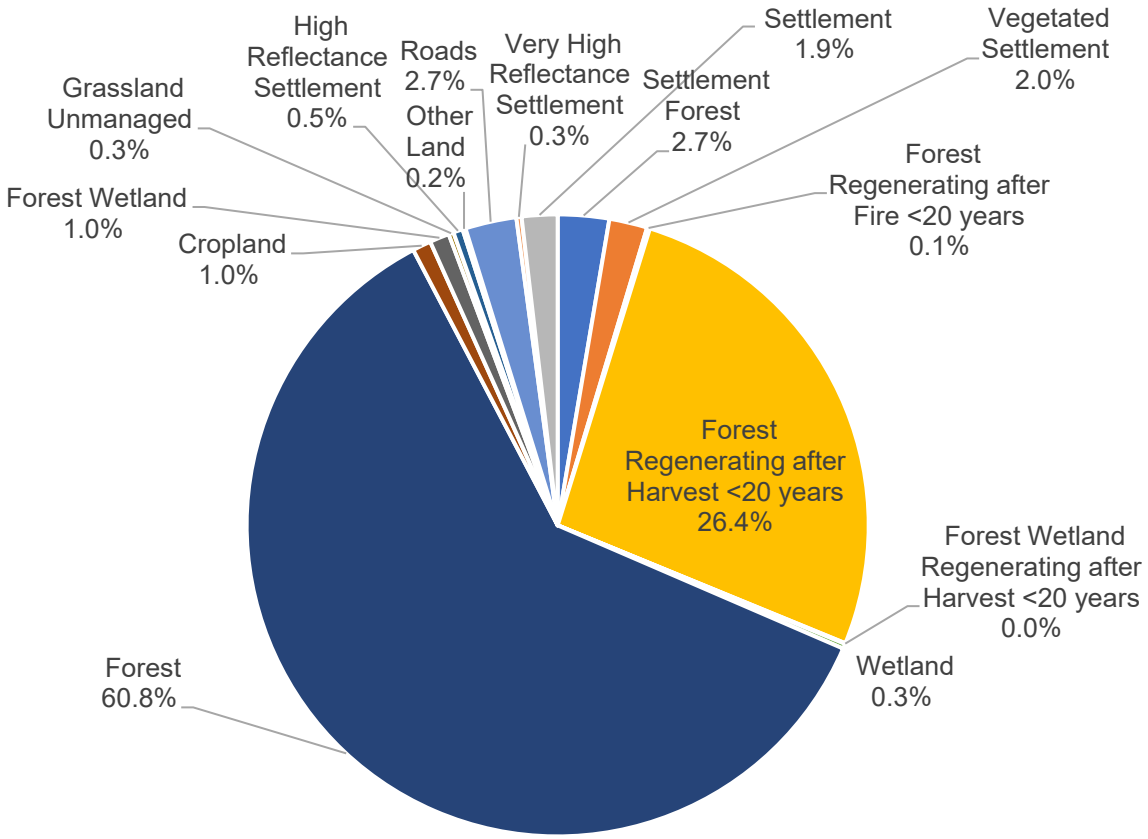

Figure 10 Breakdown of Land Classes

5.3.5.1 Livestock and Other Agriculture

In addition to land use change, GHG emissions from the AFOLU Sector are produced through a variety of non-land use pathways, including livestock (enteric fermentation and manure management), and aggregate sources and non-CO_2 emission sources on land (e.g., fertilizer application). Under this Sector, the RDN reports on GHG emissions from the following sources, and Sub-Sectors:

- Scope 1 GHG Emissions:
  - Livestock:
    - Methane (CH_4) Emissions from Enteric Fermentation
    - Methane (CH_4) Emissions from Manure Management
    - Direct Nitrous Oxide (N_2O) GHG Emissions
  - Aggregate Sources and Non-CO_2 Emissions Sources on Land
    - Direct Nitrous Oxide (N_2O) Emissions from Agricultural Soil Management
    - Indirect Nitrous Oxide (N_2O) Emissions from Applied Nitrogen

The GHG emissions from this source is presented in Table 40. Livestock GHG emissions have increased as a result of increasing livestock populations. Other land use GHG emissions sources have declined as the area of cropland in the RDN has also declined since the 2007 base year and this emission source is primarily driven by cropping activities (e.g., tilling, fertilizer application)

Table 40 Summary of Livestock and Aggregate Sources and Non-CO_2 Emissions Sources On Land Change GHG Emissions Between 2007 and 2021

Land Type	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)	Change From 2007
Livestock	3,818	4,184	9.6%
Aggregate Sources and Non-CO_2 Emissions Sources On Land	109	109	-0.1%
Total	**3,927**	**4,293**	**9.3%**

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance and Quality Control (QA/QC) procedures are applied to add confidence that all measurements and calculations have been made correctly and to reduce uncertainty in data. Examples include:

- Checking the validity of all data before it is processed, including emission factors.
- Performing recalculations to reduce the possibility of mathematical errors.
- Recording and explaining any adjustments made to the raw data.
- Documenting quantification methods, assumptions, emission factors and data quality

With respect to the GHG inventory, the data was subject to various quality assurance and quality control checks throughout the collection, analysis, and reporting phases. Specifically, the following procedures were followed:

- Upon receipt of data from the RDN, the data was checked for completeness (e.g., all months of data are present), relevancy (e.g., the correct calendar year is presented), and reasonableness (e.g., comparing similar transportation data sets). Incorrect or incomplete datasets were queried directly with the data provider.
- Where estimates were used (e.g., fuel oil consumption), all possible data sources were considered for their accuracy and relevance to the community before a final method and data source was selected.
- All manual data transfers were double-checked for data transfer accuracy.
- The inventory was compared to other third-party inventories (e.g., CEEI) to assess for reasonableness of the estimates.
- The inventory underwent internal RDN reviews to confirm assumptions, data and reasonableness of the estimates.

7.0 RECOMMENDATIONS

To remain accurate and reflective of the current community conditions, the RDN should revise and improve its GHG emissions inventory either annually or in line with capital planning cycles (i.e., every 3-4 years), focusing on these general aspects:

- Improving activity data collection and management, including Sector and Sub-Sector allocations.
- Performing recalculations, where applicable, and tracking GHG emissions over time.
- Reviewing methodologies and data to assess for opportunities to improve the estimates.
- Assessing changes to boundaries, methodologies, assumptions, or data that may be material and require a reporting year restatement.

The next section provides a summary of specific GHG inventory improvement recommendations.

7.1 INVENTORY ASSUMPTIONS, ASSESSMENT, AND RECOMMENDATIONS

In the preparation of the 2021 GHG emissions inventory, there are several assumptions were made in the analysis that will have some influence on accuracy of the RDN's estimate of GHG emissions. Most emission sources have been calculated with a high level of confidence, due to the presence of utility records, and direct energy and emissions data being provided by stakeholders. Data sources and assumptions with medium to high uncertainty are presented in Table 41 which summarizes the main assumptions, possible impacts on the data, and recommended improvement. It is recommended that the RDN prioritize improvements that are likely to have a material (>5%) influence on the GHG inventory estimate.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	The 2021 natural gas and electricity energy data was provided to the RDN in draft form and may be subject to change. Furthermore, the 2021 data did not include an estimate for the Electoral Areas and had to be estimated.	Immaterial impact on the GHG inventory (<5%)	Update the GHG inventory when the 2021 data is published by the province.
Stationary Energy	The energy utility providers provide energy in lump sum amounts for: residential, commercial, and industrial. As	Immaterial impact on the GHG inventory (<5%)	Work with the utility provider to get a more detailed breakdown of energy use by sub-sector. Reach out to the

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	such, energy consumption from industrial operations had to be estimated and removed from the total.		industrial entities to see if they would be amendable to sharing their energy consumption data.
Stationary Energy	Propane, fuel oil and wood GHG emissions are estimated by the province using an energy balance model. This does not likely represent actual fuel consumption within the RDN.	Immaterial impact on the GHG inventory (<10%)	Consider completing a residential energy labelling program. With such a program, an energy and fuel profile for buildings could be developed so that a reasonable estimate of other fuel use be determined.
Stationary Energy	Manufacturing, mining construction and agricultural off-road emissions were estimated using the 2023 NIR estimates for BC.	Immaterial impact on the GHG inventory (<10%)	Work with local industry to support GHG emission reporting.
Stationary Energy	FortisBC provided a total estimate of fugitive emissions for the CRD region for 2020; however, this did not include upstream fugitive emissions as suggested as best practice by the GPC Protocol.	Immaterial impact on the GHG inventory (<1%)	Work with FortisBC to refine this estimate.
Transportation	ICBC has not been collecting off-road vehicle data so this source could not be estimated.	Possible material impact on the GHG inventory (>10%)	Work with ICBC to begin collecting this data regionally.
Transportation	There appears to be a data quality issue with vehicle registration data in 2021 for all local governments in the RDN, and possibly data issues for Qualicum Beach and Parksville in general. There is also limited data on the EAs.	Possible material impact on the GHG inventory (>10%)	Work with ICBC and the Province to access vehicle registry data by postal code.
Transportation	Vehicle kilometers travelled (VKT) was estimated.	Possible material impact on the GHG inventory (>10%)	Advocate for ICBC to collect and share odometer data. Alternatively, complete an origin destination study that includes collecting annual travel distances by mode.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Transportation	The GHG emissions from recreational watercraft were estimated based on an average boat count at a harbor. The energy split is based on a publicly available year 2000 study.	Immaterial impact on the GHG inventory (<5%)	Work with the harbors to deploy a database tracking the types of boats entering the harbor.
Transportation	Cruise ships and deep-sea vessel GHG emissions were estimated using third party emission factors.	Immaterial impact on the GHG inventory (<5%)	Work with the Nanaimo Port Authority to derive a localized estimate of GHG emissions.
Transportation	BC Ferries fuel consumption was estimated based on total passengers.	Immaterial impact on the GHG inventory (<5%)	Work with BC Ferries to improve this estimate and/or get actual fuel volumes for the routes servicing the RDN.
Transportation	The Nanaimo airport air traffic GHG emissions were excluded to allow the airport time to develop an estimate.	Immaterial impact on the GHG inventory (<5%)	Work with the Airport to derive a localized estimate of GHG emissions.
Transportation	Seaplane GHG emissions and movements were not estimated.	Immaterial impact on the GHG inventory (<1%)	Work with Sea Plane organizations to derive a localized estimate of GHG emissions.
Transportation	Rail GHG emissions were estimated using 2022 EC NIR data and total km of rail.	Immaterial impact on the GHG inventory (<1%)	No recommendations currently.
Waste	The number of homes on septic was estimated using the number of homes not being serviced.	Immaterial impact on the GHG inventory (<1%)	No recommendations currently.
Waste	Incineration and open burning GHG emissions were estimated and are based on data in a 2015 air quality report.	Immaterial impact on the GHG inventory (<1%)	Complete an air quality study on open burning and incineration GHG emissions.
IPPU	Product use emissions were estimated on a per capita basis using the 2023 NIR estimates. The product use emissions were estimated by the NIR using an IPCC Tier 1	Immaterial impact on the GHG inventory (<5%)	No recommendations currently.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	approach and thus will have high uncertainty.		
AFOLU	GHG estimates for land use change are based on a period of years (2007-2021) and thus were averaged for each period. As there was no annual data, land use change for the reporting year was estimated using the average value between the data years. Furthermore, there were issues with the spatial data (not being consistent, granular enough for analysis, and not all land-classes considered).	Possibly a material impact on the GHG inventory (>10%)	Work with the planning department to track land-use change annually so that a more refined estimate can be made. Work with the GIS department to gather and process LIDAR data for the region. Aim to collect this data every 3-5 years. This is a secondary priority to the recommended improvement below.
AFOLU	The land-use sequestration and storage GHG emission factors are taken from the literature, for BC ecozones, and may not reflect the productivity, or lack thereof, of land uses in the RDN. The land-change emission factors for changes between land types were derived by the Province. These are average values by ecozone and are based on a 20-year horizon. Since land-use change in the RDN is typically related to development, it was assumed that the loss of emissions is immediate which may overestimate GHG emission losses. In both emission factor applications, the use of non-site emission factors may result in an over or underestimate of GHG emissions.	Possibly a material impact on the GHG inventory (>10%)	Work with the Province and the post-secondary institutions to derive refined sequestration emission factors.

8.0 REFERENCES

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Appendix A

The following tables summarize RDN Member GHG Emissions by sector for the 2007, 2010, 2012, 2015-2021 reporting years. Also included is a comparison of the 2007 CEEI GHG emissions inventories as prepared by the Province.

October 2, 2023

Table A1. RDN GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	161,287	178,457	196,828	212,780	183,481	190,923	211,670	200,128	210,385	226,342	178,168
Commercial & Institutional Buildings	69,716	88,577	73,328	77,691	77,095	83,135	96,440	89,649	97,543	100,096	76,497
Manufacturing Industries & Construction	6,574	131,220	95,707	97,130	158,110	166,234	176,038	158,935	155,668	163,923	162,486
Energy Industries	-	462	464	594	350	497	511	546	589	631	688
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	12,482	34,815	28,292	30,103	43,110	40,748	47,480	56,431	53,931	47,611	48,671
Fugitive Emissions	-	583	915	950	1,012	1,040	1,076	1,115	1,167	1,151	1,151
In-Boundary On-road Transportation	527,905	680,030	693,881	657,296	668,681	671,436	689,437	692,958	710,533	713,459	633,033
Trans-Boundary On-road Transportation	-	93,773	95,683	90,638	92,208	92,587	95,070	94,377	99,190	80,509	87,915
Waterborne Navigation	-	6,518	7,690	8,289	9,647	11,209	9,009	10,118	9,094	7,211	9,122
Aviation	-	-	-	-	-	-	-	-	-	-	-
Railway	-	1,248	1,264	1,564	1,413	1,373	1,554	1,653	1,716	1,620	1,602
Off-road Transportation	-	24,215	21,240	20,278	24,294	29,965	32,718	33,615	33,299	35,352	35,024
Solid Waste	51,146	45,315	52,783	-	46,981	-	-	51,175	49,191	46,537	43,188
Biological Treatment of Waste	-	394	400	412	2,147	-	-	2,210	2,681	3,102	3,112
Incineration & Open Burning	-	126	129	132	135	136	137	140	142	145	147
Wastewater Treatment & Discharge	-	1,965	1,934	-	2,729	2,051	2,756	2,448	2,211	2,655	2,887
IPPU	-	20,388	31,645	34,690	40,225	43,321	42,669	46,640	46,640	46,782	46,361
Land-Use Change	83,158	(294,814)	(288,585)	(284,433)	(278,204)	(276,127)	(274,051)	(271,975)	(269,898)	(267,822)	(265,745)
Livestock	5,628	3,818	3,818	3,904	4,034	4,078	4,099	4,120	4,141	4,163	4,184
Non-CO2 Land Emission Sources	-	109	104	105	114	119	117	128	123	133	109
Total	**834,738**	**1,312,013**	**1,306,103**	**1,236,558**	**1,355,765**	**1,338,852**	**1,410,781**	**1,446,385**	**1,478,247**	**1,481,420**	**1,334,345**

Table A2. City of Nanaimo GHG Emissions Summary (all units are tCO_2e)
The 2010 CEEI data is also provided for Nanaimo as the City set 2010 as the baseline year.

Sector	2007 CEEI	2007 Updated	2010 CEEI	2010 Updated	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	87,833	96,379	83,188	112,374	124,275	104,360	110,415	124,759	118,418	124,501	134,096	104,980
Commercial & Institutional Buildings	55,888	67,863	51,456	52,050	54,949	55,113	59,753	70,600	64,976	71,252	72,476	54,666
Manufacturing Industries & Construction	-	121,934	-	89,285	90,094	148,564	156,632	164,699	145,190	142,935	153,839	152,259
Energy Industries		462	-	464	594	350	497	511	546	589	631	688
Non-Specified Sources		-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities		1,418	-	1,111	1,152	1,584	1,475	1,694	1,983	1,866	1,621	1,631
Fugitive Emissions		402	-	668	700	748	773	801	835	862	851	851
In-Boundary On-road Transportation	300,360	347,484	316,230	348,319	339,455	362,697	370,809	388,446	384,932	403,366	390,352	350,030
Trans-Boundary On-road Transportation		100,403	-	100,644	98,082	104,798	107,142	112,238	116,681	110,953	111,303	103,111
Waterborne Navigation		5,759	-	6,967	7,522	8,948	10,494	8,933	9,390	8,389	6,831	8,524
Aviation		-	-	-	-	-	-	-	-	-	-	-
Railway		367	-	371	460	415	403	457	486	504	476	471

Sector	2007 CEEI	2007 Updated	2010 CEEI	2010 Updated	2012	2015	2016	2017	2018	2019	2020	2021
Off-road Transportation		13,958	-	12,305	11,800	14,346	17,753	19,431	20,000	19,856	21,067	20,788
Solid Waste	29,135	26,315	32,921	30,532	-	27,591	-	-	30,393	29,269	27,751	25,737
Biological Treatment of Waste		-	-	-	-	963	-	-	1,025	1,374	1,641	1,585
Incineration & Open Burning		-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge		1,094	-	1,129	-	1,589	1,329	1,847	1,414	1,181	1,730	1,875
IPPU		12,623	-	19,593	21,340	24,292	26,008	25,780	28,356	28,356	28,619	28,533
Land-Use Change		(4,616)	-	(4,558)	(4,519)	(4,461)	(4,441)	(4,422)	(4,402)	(4,383)	(4,363)	(4,344)
Livestock		-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources		4		4	4	4	4	4	5	4	5	4
Total	**473,216**	**796,465**	**483,795**	**775,817**	**750,427**	**856,363**	**863,489**	**920,200**	**924,629**	**945,259**	**953,288**	**855,732**

Table A3. Town of Qualicum Beach GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	11,311	12,333	10,389	10,724	9,876	10,082	10,680	10,036	10,651	11,577	8,572
Commercial & Institutional Buildings	3,250	4,048	3,995	4,227	4,005	4,106	4,555	4,339	4,561	4,380	3,638
Manufacturing Industries & Construction	-	990	685	773	1,133	1,165	1,343	1,588	1,434	1,105	1,090
Energy Industries	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	316	239	242	317	291	328	377	347	295	290
Fugitive Emissions	-	67	58	59	63	63	64	64	69	68	68
In-Boundary On-road Transportation	28,863	25,187	25,892	24,830	26,767	27,740	29,690	29,612	30,665	29,339	26,199
Trans-Boundary On-road Transportation	-	7,277	7,481	7,174	7,734	8,015	8,579	8,976	8,435	8,366	7,718
Waterborne Navigation	-	110	102	107	97	100	11	100	96	51	80
Aviation	-	-	-	-	-	-	-	-	-	-	-
Railway	-	-	-	-	-	-	-	-	-	-	-
Off-road Transportation	-	1,483	1,260	1,180	1,384	1,715	1,850	1,867	1,824	1,923	1,903
Solid Waste	3,083	2,775	3,180	-	2,691	-	-	2,894	2,732	2,550	2,349
Biological Treatment of Waste	-	-	-	-	229	-	-	227	226	243	263
Incineration & Open Burning	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge	-	275	233	-	325	201	252	300	313	268	280
IPPU	-	828	1,285	1,466	1,891	2,101	2,001	2,113	2,113	2,045	1,954
Land-Use Change	-	(1,351)	(1,337)	(1,329)	(1,315)	(1,311)	(1,307)	(1,302)	(1,298)	(1,293)	(1,289)
Livestock	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources	-	1	1	1	1	1	1	1	1	1	1
Total	**46,507**	**55,691**	**54,800**	**50,782**	**56,512**	**55,580**	**59,353**	**62,494**	**63,468**	**62,210**	**54,406**

Table A4. District of Lantzville GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	3,114	3,567	3,367	3,571	3,089	3,150	3,393	3,152	3,336	3,700	2,646
Commercial & Institutional Buildings	401	496	497	552	503	526	618	626	670	716	556
Manufacturing Industries & Construction	-	572	395	435	595	600	707	854	789	623	630
Energy Industries	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	140	110	115	159	149	172	202	190	166	168
Fugitive Emissions	-	10	11	12	12	12	12	12	13	13	13
In-Boundary On-road Transportation	16,321	16,980	16,906	16,561	18,832	20,109	20,457	20,576	21,441	20,973	20,822
Trans-Boundary On-road Transportation	-	4,906	4,885	4,785	5,441	5,810	5,911	6,237	5,898	5,980	6,134
Waterborne Navigation	-	47	44	44	40	41	4	42	40	21	33
Aviation	-	-	-	-	-	-	-	-	-	-	-
Railway	-	-	-	-	-	-	-	-	-	-	-
Off-road Transportation	-	637	543	490	569	704	756	776	756	800	791
Solid Waste	1,331	1,184	1,371	-	1,123	-	-	1,183	1,136	1,056	978
Biological Treatment of Waste	-	-	-	-	96	-	-	93	94	100	109
Incineration & Open Burning	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge	-	20	20	-	27	22	31	23	19	28	30
IPPU	-	478	742	825	993	1,082	1,052	1,136	1,136	1,125	1,101
Land-Use Change	-	(3,267)	(3,227)	(3,200)	(3,160)	(3,147)	(3,133)	(3,120)	(3,107)	(3,093)	(3,080)
Livestock	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources	-	0	0	0	0	0	0	0	0	0	0
Total	**21,167**	**29,037**	**28,893**	**27,390**	**31,478**	**32,206**	**33,113**	**34,912**	**35,518**	**35,303**	**34,012**

Table A5. City of Parksville GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	15,168	16,462	15,694	16,189	14,903	15,239	16,435	15,712	16,618	17,903	14,154
Commercial & Institutional Buildings	7,001	10,371	10,580	11,130	10,620	11,395	12,414	11,835	12,579	12,648	10,748
Manufacturing Industries & Construction	-	1,689	1,168	1,280	1,737	1,747	2,063	2,500	2,316	1,834	1,860
Energy Industries		-	-	-	-	-	-	-	-	-	-
Non-Specified Sources		-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities		294	237	250	354	334	387	459	437	384	391
Fugitive Emissions		92	98	99	105	107	110	113	123	122	122
In-Boundary On-road Transportation	35,606	32,535	32,829	32,881	37,635	39,658	43,096	42,925	44,666	42,747	38,392
Trans-Boundary On-road Transportation		9,401	9,486	9,501	10,874	11,459	12,452	13,012	12,286	12,189	11,309
Waterborne Navigation		145	140	150	137	141	15	144	140	75	120
Aviation		-	-	-	-	-	-	-	-	-	-
Railway		156	158	196	177	172	195	207	215	203	201
Off-road Transportation		1,955	1,729	1,660	1,948	2,419	2,637	2,696	2,663	2,814	2,846

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Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Solid Waste	4,047	3,655	4,248	-	3,766	-	-	4,124	3,945	3,722	3,438
Biological Treatment of Waste		-	-	-	320	-	-	323	327	354	385
Incineration & Open Burning		-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge		407	344	-	480	296	372	443	463	395	414
IPPU		1,412	2,192	2,428	2,899	3,150	3,073	3,326	3,326	3,304	3,242
Land-Use Change		(511)	(501)	(494)	(484)	(480)	(477)	(473)	(470)	(466)	(463)
Livestock		-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources		1	1	1	1	1	1	1	1	1	1
Total	**61,822**	**78,574**	**78,903**	**75,763**	**85,956**	**86,118**	**93,251**	**97,821**	**100,104**	**98,695**	**87,623**

Table A6. Electoral Areas (All) GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021
Residential Buildings	43,863	49,716	55,005	58,022	51,254	52,038	56,404	52,810	55,279	59,066	47,815
Commercial & Institutional Buildings	3,176	5,799	6,206	6,833	6,854	7,355	8,253	7,872	8,481	9,876	6,888
Manufacturing Industries & Construction	-	6,036	4,174	4,549	6,081	6,090	7,226	8,802	8,195	6,522	6,647
Energy Industries	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	32,647	26,595	28,345	40,696	38,500	44,899	53,411	51,091	45,144	46,191
Fugitive Emissions	-	11	79	80	84	86	88	91	100	98	98
In-Boundary On-road Transportation	146,729	178,154	188,620	166,543	144,389	134,437	126,955	126,147	134,906	134,397	121,456
Trans-Boundary On-road Transportation	-	51,476	54,500	48,121	41,720	38,844	36,683	38,238	37,108	38,321	35,778
Waterborne Navigation	-	457	437	466	425	431	46	443	430	233	365
Aviation	-	-	-	-	-	-	-	-	-	-	-
Railway	-	725	734	909	821	798	903	960	997	941	931
Off-road Transportation	-	6,182	5,402	5,149	6,047	7,374	8,044	8,275	8,199	8,747	8,697
Solid Waste	13,550	11,386	13,452	-	11,811	-	-	12,582	12,110	11,459	10,686
Biological Treatment of Waste	-	394	400	412	540	-	-	543	660	764	770
Incineration & Open Burning	-	126	129	132	135	136	137	140	142	145	147
Wastewater Treatment & Discharge	-	169	209	-	309	203	253	266	234	234	287
IPPU	-	5,047	7,833	8,630	10,150	10,980	10,763	11,709	11,709	11,689	11,530
Land-Use Change	-	(285,069)	(278,962)	(274,891)	(268,784)	(266,748)	(264,713)	(262,677)	(260,641)	(258,606)	(256,570)
Livestock	-	3,818	3,818	3,904	4,034	4,078	4,099	4,120	4,141	4,163	4,184
Non-CO2 Land Emission Sources	-	102	98	99	107	112	111	121	116	126	104
Total	**207,318**	**352,245**	**367,691**	**332,196**	**325,456**	**301,459**	**304,864**	**326,530**	**333,899**	**331,924**	**302,572**

Appendix B

The following table presents adjusted RDN Member CEEI equivalent GHG emissions summaries for the 2021 reporting year.

Table B1. RDN 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	7,061,500	174,866
Commercial & Institutional Buildings	2,944,062	51,988
Manufacturing Industries & Construction	3,741,417	135,634
In-Boundary On-road Transportation	9,714,320	633,033
Trans-Boundary On-road Transportation	1,349,118	87,915
Solid Waste	-	43,188
Biological Treatment of Waste	-	3,112
Total	**24,810,417**	**1,129,736**

Table B2. City of Nanaimo 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	3,765,869	103,020
Commercial & Institutional Buildings	2,017,324	38,625
Manufacturing Industries & Construction	3,598,905	135,634
In-Boundary On-road Transportation	5,380,672	350,030
Trans-Boundary On-road Transportation	1,585,029	103,111
Solid Waste	-	25,737
Biological Treatment of Waste	-	1,585
Total	**16,347,799**	**757,742**

Table B3. Town of Qualicum Beach 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	374,764	8,393
Commercial & Institutional Buildings	126,950	2,695
Manufacturing Industries & Construction	15,194	-
In-Boundary On-road Transportation	403,001	26,199
Trans-Boundary On-road Transportation	118,715	7,718
Solid Waste	-	2,349
Biological Treatment of Waste	-	263
Total	**1,038,625**	**47,616**

Table B4. District of Lantzville 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	150,212	2,572
Commercial & Institutional Buildings	21,698	373
Manufacturing Industries & Construction	8,773	-
In-Boundary On-road Transportation	314,857	20,822
Trans-Boundary On-road Transportation	92,750	6,134
Solid Waste	-	978
Biological Treatment of Waste	-	109
Total	**588,290**	**30,988**

Table B5. City of Parksville of Lantzville 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	539,269	13,886
Commercial & Institutional Buildings	358,352	8,246
Manufacturing Industries & Construction	25,917	-
In-Boundary On-road Transportation	589,797	38,392
Trans-Boundary On-road Transportation	173,741	11,309
Solid Waste	-	3,438
Biological Treatment of Waste	-	385
Total	**1,687,076**	**75,656**

Table B6. Electoral Areas (All) 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	2,231,387	46,995
Commercial & Institutional Buildings	419,738	2,049
Manufacturing Industries & Construction	92,628	-
In-Boundary On-road Transportation	1,857,651	121,456
Trans-Boundary On-road Transportation	547,224	35,778
Solid Waste	-	10,686
Biological Treatment of Waste	-	770
Total	**5,148,627**	**217,734**

Table B7. Electoral Area: A 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	343,250	7,229
Commercial & Institutional Buildings	64,567	315
Manufacturing Industries & Construction	17,547	-
In-Boundary On-road Transportation	325,675	21,274
Trans-Boundary On-road Transportation	95,937	6,267
Solid Waste	-	1,882
Biological Treatment of Waste	-	136
Total	**846,975**	**37,102**

Table B8. Electoral Area: B 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	323,493	6,813
Commercial & Institutional Buildings	60,851	297
Manufacturing Industries & Construction	9,155	-
In-Boundary On-road Transportation	195,415	12,796
Trans-Boundary On-road Transportation	57,565	3,769
Solid Waste	-	1,121
Biological Treatment of Waste	-	81
Total	**646,480**	**24,878**

Table B9. Electoral Area: C 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	136,074	2,866
Commercial & Institutional Buildings	25,596	125
Manufacturing Industries & Construction	8,074	-
In-Boundary On-road Transportation	145,286	9,507
Trans-Boundary On-road Transportation	42,798	2,801
Solid Waste	-	824
Biological Treatment of Waste	-	59
Total	**357,829**	**16,181**

Table B10. Electoral Area: E 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	353,075	7,436
Commercial & Institutional Buildings	66,416	324
Manufacturing Industries & Construction	13,711	-
In-Boundary On-road Transportation	294,879	19,229
Trans-Boundary On-road Transportation	86,865	5,664
Solid Waste	-	1,689
Biological Treatment of Waste	-	122
Total	**814,946**	**34,464**

Table B11. Electoral Area: F 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	409,596	8,626
Commercial & Institutional Buildings	77,048	376
Manufacturing Industries & Construction	19,411	-
In-Boundary On-road Transportation	356,451	23,363
Trans-Boundary On-road Transportation	105,003	6,882
Solid Waste	-	2,066
Biological Treatment of Waste	-	149
Total	**967,509**	**41,463**

Table B12. Electoral Area: G 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	399,243	8,408
Commercial & Institutional Buildings	75,100	367
Manufacturing Industries & Construction	15,978	-
In-Boundary On-road Transportation	352,055	23,029
Trans-Boundary On-road Transportation	103,708	6,784
Solid Waste	-	2,034
Biological Treatment of Waste	-	147
Total	**946,084**	**40,769**

Table B13. Electoral Area: H 2021 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	266,655	5,616
Commercial & Institutional Buildings	50,160	245
Manufacturing Industries & Construction	8,752	-
In-Boundary On-road Transportation	187,890	12,258
Trans-Boundary On-road Transportation	55,348	3,611
Solid Waste	-	1,071
Biological Treatment of Waste	-	77
Total	**568,805**	**22,878**