Capital Regional District 2018
GPC BASIC+ Community
Greenhouse Gas (GHG)
Emissions Inventory Report

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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 Capital Regional District (CRD) for the 2007 (base year), 2010, 2012 and 2018 reporting years using the GPC Protocol. The CRD 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 CRD 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 2018 reporting year, and to present the CRD's 2018 community GHG emissions.

In 2018, the CRD's BASIC+ GHG emissions totaled 1,696,703 tCO_2. While this is a small decline of 1.1% from the 2007 base year GHG emissions, on an absolute basis, it is a decline of 14% on a per capita basis. Between 2007 and 2018, the CRD's population has grown 15% and thus this decline speaks to the efforts by the CRD and CRD local governments to reduce energy consumption and GHG emissions.

A summary of the 2018 GHG emissions is presented in Table E-1.

Table E-1 BASIC+ 2007 Base Year And 2018 Reporting Year GHG Emissions

Sector	Sub-Sector	2007 GHG Emissions (tCO_2e)	2018 GHG Emissions (tCO_2e)
Stationary Energy	Residential Buildings	403,409	338,796
	Commercial & Institutional Buildings	247,467	265,424
	Manufacturing Industries & Construction	0	0
	Energy Industries	418	7,658
	Agriculture, Forestry & Fishing activities	62,060	55,787
	Fugitive Emissions	993	1,510
Transportation	In-Boundary On-road Transportation	903,886	871,571
	Trans-Boundary On-road Transportation	13,858	7,578
	Waterborne Navigation	48,246	51,455
	Aviation	25,635	19,243
	Off-road Transportation	56,291	55,363
Waste	Solid Waste	111,234	71,219
	Biological Treatment of Waste	72	5,307
	Wastewater Treatment & Discharge	18,998	19,859
IPPU	IPPU	77,348	129,884
AFOLU	Land-Use Change	-259,033	-209,262
	Livestock	3,467	4,299
	Non-CO_2 Land Emission Sources	1,464	1,010
Change in GHG Emissions from Base Year		**1,715,814**	**1,696,703**
Total Per Capita GHG Emissions (tCO_2e / Capita)			**-14.4%**
Change GHG Emissions per Capita from Base Year		**4.9**	**4.2**
Change in GHG Emissions from Base Year			**-1.1%**

Data in the table above is depicted in Figure E-1, which includes land-use, and Figure E-2 which excludes land-use.

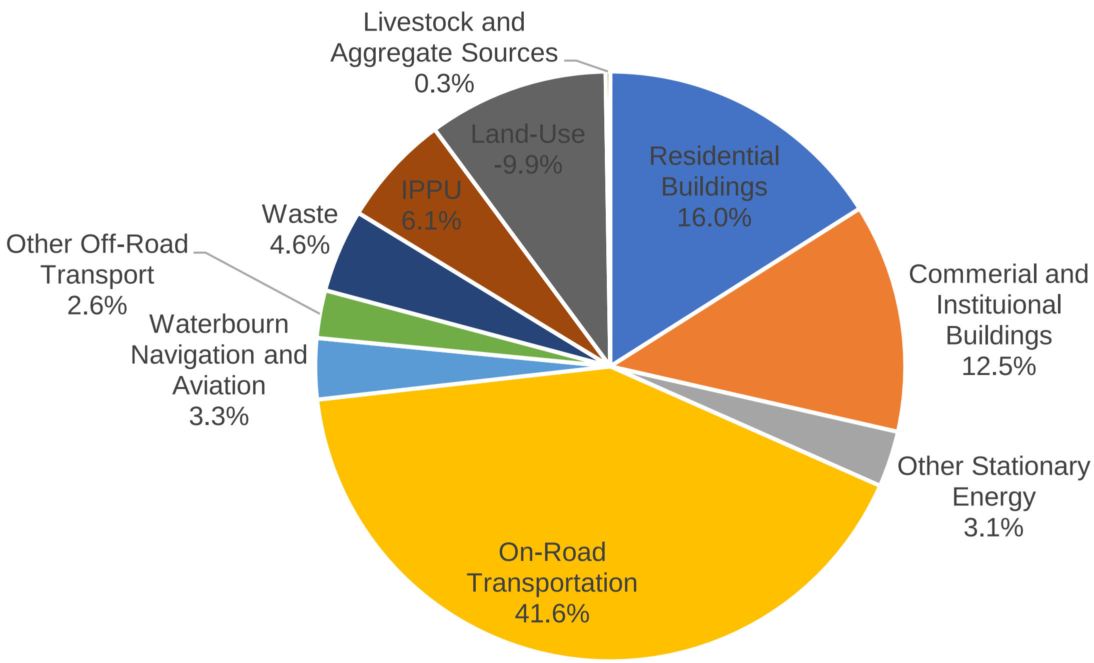

Figure E-1 CRD's 2018 BASIC+ GHG Emissions Profile (Including Land-Use)

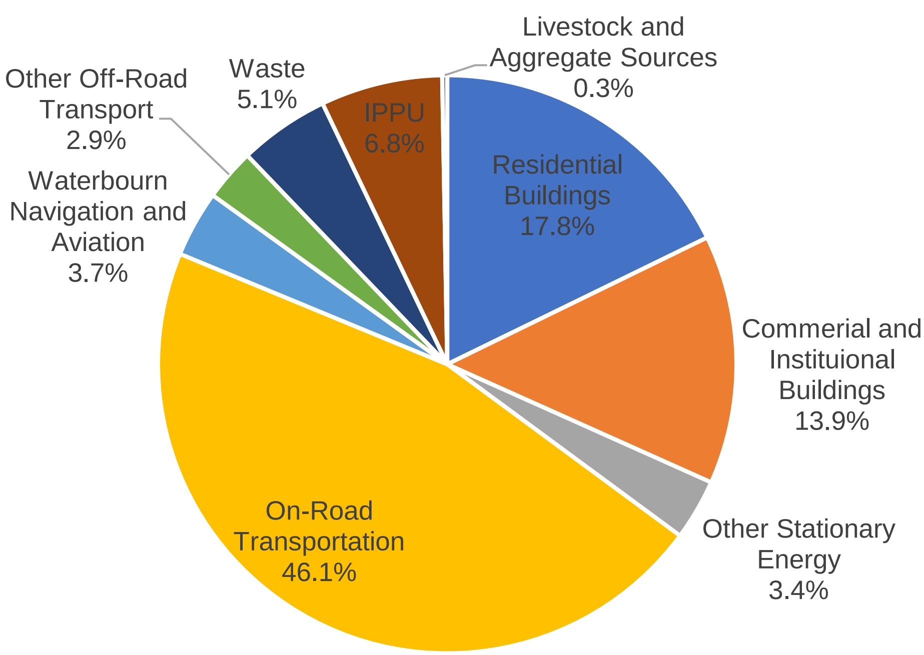

Figure E-2 CRD's 2018 BASIC+ GHG Emissions Profile (Excluding Land-Use)

Abbreviations

ACERT	Airport Carbon Emissions Reporting Tool
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
CRD	Capital Regional District
VIA	Victoria International Airport
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
GVHA	Greater Victoria Harbour Authority
GWP	global warming potentials
HFC	Hydrofluorocarbons
ICAO	International Civil Aviation Organization
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
MWh	megawatt hours
N_2O	nitrous oxides
NE	not estimated
NIR	National Inventory Report
NPRI	National Pollutant Release Inventory
NO	not occurring
PCP	Partnership for Climate Protection
PFC	Perfluorocarbons
SC	Other Scope 3
SF_6	sulfur hexafluoride
VIA	Victoria International Airport
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.
Base 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) • $200 of natural gas (a month of winter heating) • Enough electricity for three homes for a year (38,000 kWh)
Transboundary GHG emissions	Emissions from sources that cross the geographic boundary (GPC, 2014).

1.0 INTRODUCTION

1.1 CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS

There is increasing evidence that global climate change resulting from emissions of carbon dioxide and other greenhouse gases (GHGs) is having an impact on the global climate system. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), states the following consensus of scientific opinion about climate change and its causes and effects (IPCC, 2014):

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- Anthropogenic GHG emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in human-caused GHG concentrations.
- Continued emission of GHG will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive, and irreversible impacts for people and ecosystems.
- There is high agreement and much evidence that with current climate change mitigation policies and practices, global GHG emissions will increase over the next few decades.

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 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 CRD 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 in that it is an in-boundary inventory, the most recent version published is for 2012, 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 community 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		✓	✓
Wastewater		✓	✓
Emissions From Industrial Processes			✓

Reporting Sector	CEEI	GPC BASIC	GPC BASIC+
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 REPORT

The purpose of this document is to describe the quantification methodologies used by the CRD to calculate its BASIC+ GHG emissions for the 2018 reporting year.

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 base 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:

- **GPC BASIC—**This level covers emissions Scopes 1 and 2, from stationary energy and transportation, as well as emissions Scopes 1 and 3 from waste. The BASIC level aligns with the Community Energy and Emissions Inventories (CEEI) that have been released in the past for local governments by the Province of BC.
- **GPC 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 emissions from Industrial Process and Product Use (IPPU), Agriculture, Forestry, and Other Land-Use (AFOLU), and transboundary transportation. The sources covered in BASIC+ also align with sources required for national reporting in IPCC guidelines.
- **GPC BASIC+ Scope 3 (SC)—** This inventory extends beyond the BASIC+ GHG inventory to include Other Scope 3 (SC) emissions such as GHG emissions from goods and services production and transportation.

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).

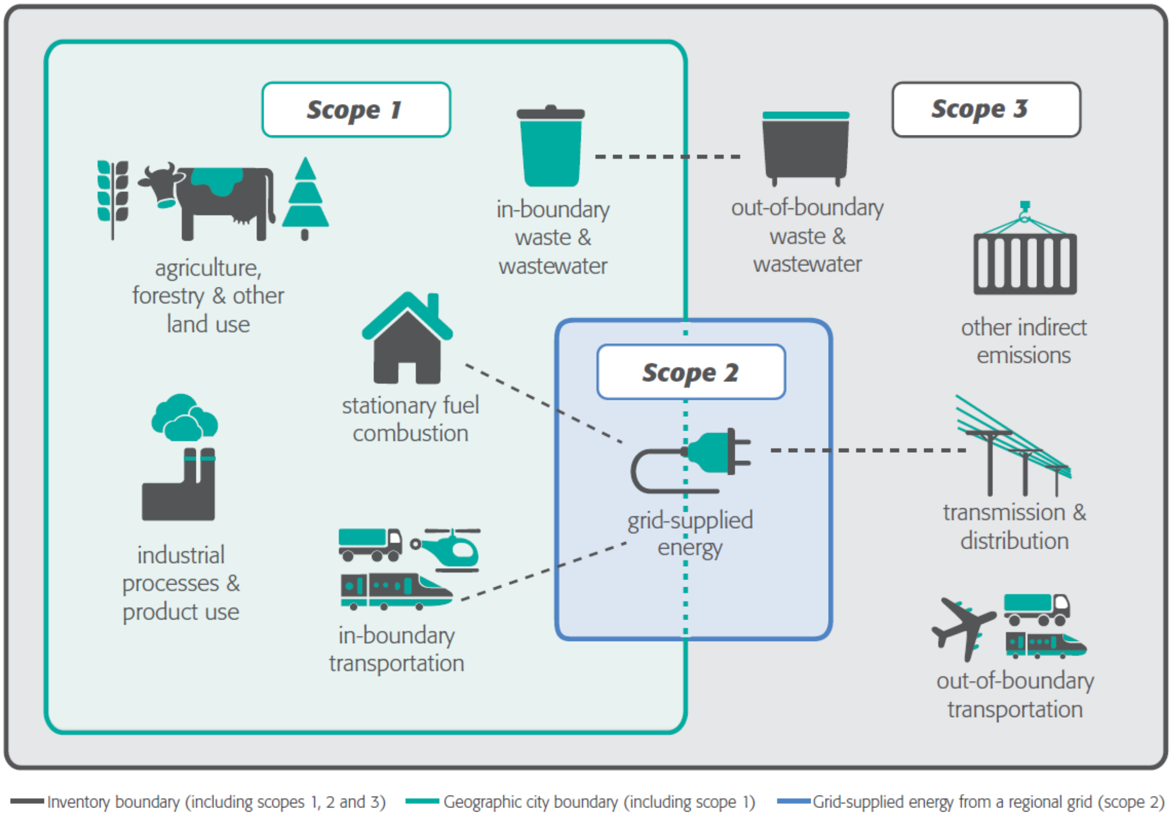

Figure 1 Sources and Boundaries of a Community's GHG Emissions (GPC 2014)

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

Stationery 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, such as off-road transportation emissions from construction equipment. 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, and natural gas distribution systems.

The Stationary Energy Sector includes the following Sub-Sectors:

- 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-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 included in the total GHG inventory 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
- Incineration and open burning
- Biological treatment of waste
- 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. 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 CRD, 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 factors that results in a material change in GHG emissions (i.e., +/-10%).	✓	
	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 CRD, 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	Site-specific emission factors
Medium (M)	Modeled activity data using robust assumptions	More general emission factors
Low (L)	Highly modeled or uncertain activity data	Default emission factors

3.0 GHG ASSESSMENT BOUNDARIES

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

3.1 SPATIAL BOUNDARIES

This GHG inventory is defined geographically by the CRD's jurisdictional boundaries. As shown in Figure 2, the CRD consists of 13 municipalities and 3 electoral areas. For the purposes of this report, only the CRD GHG emissions are presented. A breakdown of GHG emissions by each CRD municipality and electoral area has been presented in a separate report.

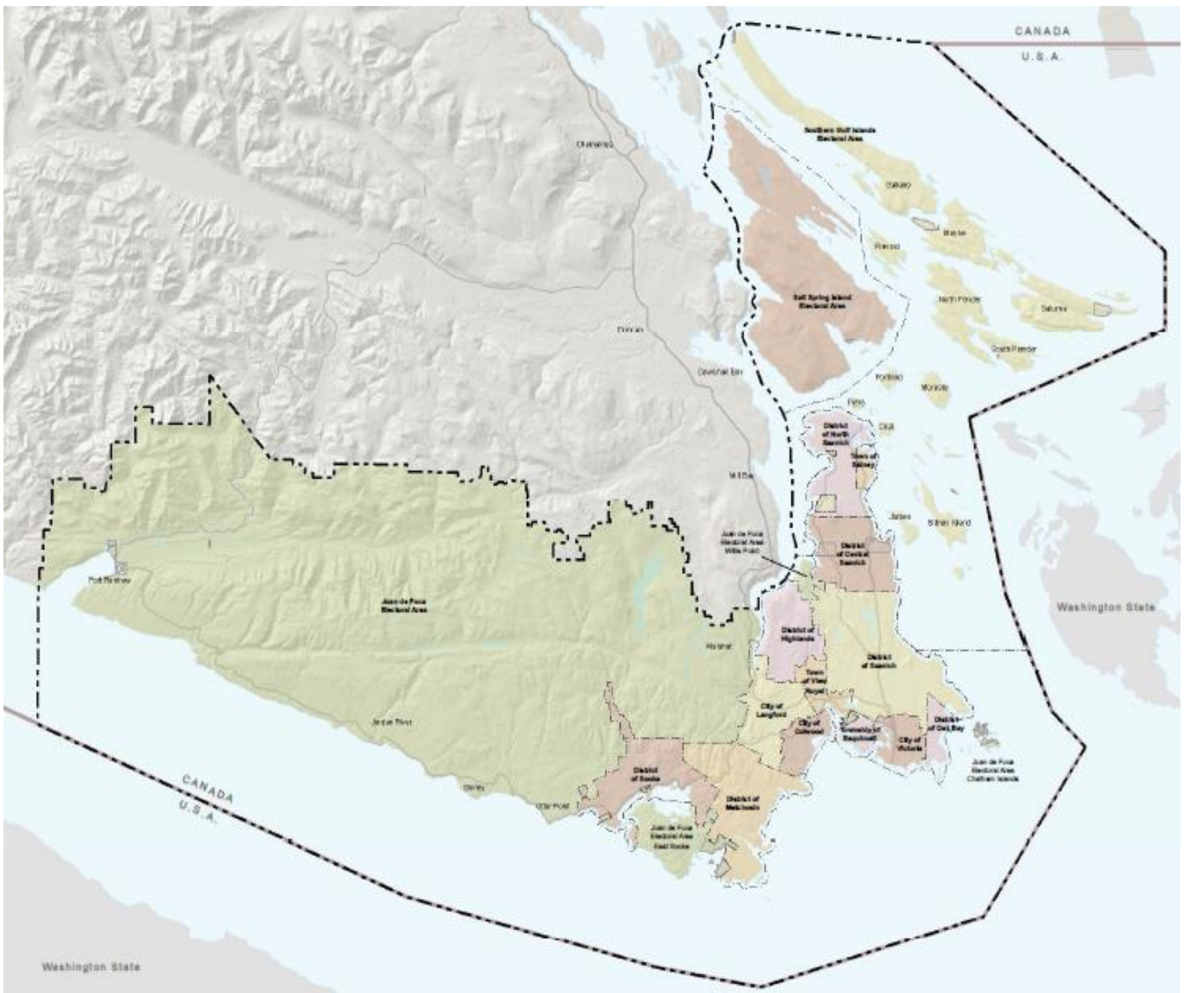

Figure 2 GHG Boundary

Table 4 Inventory Information

Inventory Boundary	Community / District Information
Name of Community / District	Capital Regional District
Municipality / Electoral Area	• District of Central Saanich • City of Colwood • Township of Esquimalt • District of Highlands • Juan de Fuca Electoral Area • City of Langford • District of Metchosin • District of North Saanich • District of Oak Bay • District of Saanich • Salt Spring Island Electoral Area • Town of Sidney • District of Sooke • City of Victoria • Town of View Royal • Southern Gulf Islands Electoral Area
Country	Canada
Inventory Year	2018
Geographic Boundary	See Figure 2
Land Area (km^2)	2,310.18
Resident population	405,983
GDP (US$)	Unknown at time of reporting
Composition of Economy	Government
Climate	Temperate, warm summer

3.2 TEMPORAL BOUNDARIES

3.2.1 2007 Base Year

Federal and provincial initiatives and legislation have been implemented to support local governments in acting to advance energy efficiency, promote energy conservation, and reduce GHG emissions. The CRD and its local governments have already been working to address sustainability and climate change through several initiatives over the past decade. The CRD's Regional Growth Strategy set a regional GHG reduction target) of 61% by 2038 (below 2007 levels).

To maintain consistency with the current reporting year, and as required by the GPC Protocol, the CRD 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, adjusted for the 2007 reporting year, are the same.

Table 5 summaries the original 2007 and the updated 2007 base year.

Table 5 Original And Updated BASIC+ Base Year

Aspect	Quantification Protocol	2007 GHG Base Year (tCO_2e)
Original Base Year	CEEI Protocol	1,563,000
Updated Base Year	GPC Protocol BASIC+	1,715,814

3.2.2 GHG Reduction Target

Recognizing the role that the CRD plays in achieving a significant and immediate reduction in global GHG emissions, the CRD has set a regional GHG reduction target of 61% (from 2007 levels) by 2038. With the CRD's 2007 base year GHG emissions being 1,715,814 tCO_2e, a 39% reduction would require a reduction of approximately 669,168 tCO_2e. On a per capita basis, this amounts to reducing emissions from approximately 4.2 tCO_2e per person in 2018 to 2.6 tCO_2e per person by 2038.

In February 2019, the CRD declared a climate emergency and committed to regional carbon neutrality.

3.2.3 2018 GHG Boundary

This inventory covers all GHG emissions for the 2018 reporting year. Where 2018 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 is currently applying GWPs from the fourth IPCC report in light of the fact that there are updated GWPs in available in the fifth IPCC report. On this basis, the CRD is applying GWPs from the fourth IPCC report.
- **Stationary Energy: Residential, Commercial and Institutional Buildings**. Propane, 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, 2010 and 2012 CEEIs, and heating degree days (HDD) published by Environment Canada. This approach was also applied to the estimate of heating oil for all local governments, except the City of Victoria and District of Saanich. For the District of Saanich and the City of Victoria, heating oil GHG emissions were estimated based on the number of known tanks, average heated floor areas and fuel volume intensity.
- **Stationary Energy: Fugitives**. Fortis BC provided total fugitive emissions for the 2018 reporting year at the CRD level. Since no historical numbers were provided, the 2018 value was applied to the 2007 base year as well.

- **Transportation: On-Road**. The Province of BC provided Insurance Corporation of BC (ICBC) vehicle registration data from April 1, 2018 – March 31, 2019. When compared to local government population trends, there appears to be a high degree of uncertainty as to the accuracy of the 2018 vehicle registration data in terms of total registered vehicles. Without having reliable historical (e.g. 2011-2017) and current (2019) data to compare this dataset against, the reasonableness of the data was too uncertain to be applied in the estimation of GHG emissions for the 2018 reporting year. Therefore, to estimate on-road energy and GHG emissions for the 2018 reporting year, 2010 vehicle populations were grown in proportion to the reported changes in local government populations. Each of the local government vehicle profiles were then adjusted to match the proportion of vehicle classes reported in the 2018 ICBC data.
- **Transportation: Aviation.** 2018 aviation GHG emissions were estimated using 2015 aircraft flight profiles (the last available data), and the total number of aircraft movements reported in 2018.
- **Transportation: Waterborne Recreational Watercraft.** GHG emissions from recreational watercraft and US/Canada ferries were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors.
- **Transportation: Cruise Ships.** The Greater Victoria Harbour Authority (GVHA) reported on cruise ship emissions for the 2010 and 2018 reporting years but did not provide an estimate for 2007. As a result, the 2010 GHG emissions estimate and number of cruise ship visits to Ogden Point was used to create a proxy to estimate 2007 cruise ship emissions. The GVHA reported 163 visits in 2007.
- **Waste: Solid Waste.** To quantify GHG emissions from the Hartland Landfill, the CRD utilized the waste-in-place (WIP) method which is accepted under the GPC Protocol. The WIP assigns landfill emissions based on total waste deposited during that year. It counts GHGs emitted that year, regardless of when the waste was disposed. Except for the City of Victoria, who claims 31% of the CRD's landfill GHG emission, the remaining landfill GHG emissions were allocated to each local government on a per capita basis. Using this allocation method, the CRD members may over, or underestimate associated solid waste GHG emissions as the current year landfill GHG emissions are based upon cumulative waste over time, and each member may have contributed more waste in past years than the current year (and vice versa).
- **AFOLU: Aggregate Sources And Non-CO_2 Emission Sources On Land.** These emissions are based on the 2019 NIR as prepared by ECCC and the total area of farmland BC in 2016 as reported by Statistics Canada. These GHG emissions were assigned to each local government on a per hectare (ha) of cropland basis.

  AFOLU: Land-Use. The land cover change analysis requires a consistent land-use category attribution and spatial resolution for the 2007 base and 2018 reporting years. For the land use change analysis, land cover data was available for the 2007, 2011 and 2017 years for only part of the CRD. There was limited land-use datasets for the Juan de Fuca, Salt Spring Island and Gulf Islands and this data was only available for 2007 and 2011. Unfortunately, no more recent or higher quality data source was available to represent the land cover consistently for all three years. Furthermore, since annual data was not available, the change between land cover data years (2007-2011, 2011-2017) was averaged and may not represent actual changes in each year.

3.3 GHG EMISSION SOURCES AND SCOPES

The following table summarizes the CRD'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 CRD's limits: • Stationary fuel combustion: – Residential buildings – Agriculture, forestry, and fishing activities – Commercial and institutional buildings, and facilities – Energy industries – Fugitive emissions from oil and natural gas systems • Transportation: – On-road: In Boundary – Waterborne Navigation – Off-road • Waste: – Solid waste disposal – Biological treatment of solid waste – Wastewater treatment and discharge • Industrial processes and product use (IPPU): – Product use • Agriculture, Forestry, and Other Land Use (AFOLU): – Land-use – 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 CRD'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 CRD's limits as a result of the CRD's activities: • Stationary Energy: – Transmission, Distribution, and Line Losses • Transportation: – Aviation – On-Road: Transboundary – Waterborne Navigation

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. 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)

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 Fourth 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 = 25, N_2O = 298 (IPCC, 2006).

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.

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**		

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
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
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**		

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
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**		
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 CRD's GHG emissions. For the District, the Stationary Energy Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Residential buildings
  - Agriculture, forestry, and fishing activities
  - Commercial and institutional buildings, and facilities
  - Energy industries
  - 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.

There are GHG emissions from construction of buildings and infrastructure as the CRD region grows and changes. However, these GHG emissions have not been quantified due to a lack of available data. Environment Canada does estimate BC GHG emissions for manufacturing industries, mining and construction, but these GHG emission sources are not disaggregated and cannot reasonably be applied to the CRD (there is no mining and limited manufacturing activities). As a result, the notation "Not Estimated (NE)" is reported.

4.1.2 Scope 2: Market Based Method

As per the GPC Protocol, cities can report on Scope 2 GHG emissions using either the market-based, or the location-based method. A market-based method utilizes utility-specific grid emission intensity factor, whereas a location-based method uses a regional or Provincial average grid emission intensity factor. At present, the fuel mix and GHG emissions data relative to the CRD's energy consumption is not available. As such, the CRD is defaulting to the BC Provincial electricity grid consumption intensity factor of 0.01067 tCO_2e/MWh reported by the BC Government in the 2019 B.C. Best Practices Methodology For Quantifying Greenhouse Gas Emissions document.

4.1.3 Activity Data

BC Hydro and Fortis BC provided the Province of BC electricity and natural gas consumption data 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 descriptors: "Commercial", and "CSMI"

The Province developed 2007, 2010 and 2012 residential fuel oil, propane and wood GHG energy use estimates from the number and type of dwellings and the average dwelling consumption by authority and region from the BC Hydro Conservation Potential Review. This data was used to estimate the reporting year GHG emissions for all CRD members except for the District of Saanich and the City of Victoria who provided fuel oil estimates for residential and commercial buildings.

Fortis BC provided the fugitive emission estimate.

The CRD provided landfill gas energy generation data from the Hartland landfill.

Applicable, off-road GHG emissions included in the Stationary Energy Sector are based on the 2020 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the CRD on a per capita basis.

4.1.4 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2018 GHG emissions:

- Prior to releasing the electricity and natural gas consumption data, the Province completes a series of quality assurance and control checks which has resulted in the re-allocation of energy between local governments. This data is then published on the Province's website. When the published 2007-2018 natural gas data was trended, several unexplained data anomalies and trends were identified for several local governments in the CRD. As these data anomalies and trends could not readily be explained, the raw natural gas data sets were acquired from FortisBC, reviewed and compared to the published data. In the 2007 and 2010 reporting years, the published data was under reporting natural gas volumes by upwards of 17% at the CRD level and had several large allocations between the City of Victoria and other local governments in 2012. Based on the issues with the published data, and on the basis the annual raw natural gas consumption trends align with the reported 2018 consumption data and align with historical raw data provided to the City of Victoria and the District of Saanich for their energy and GHG emissions inventories, the raw FortisBC dataset was used to estimate GHG emissions.
- A similar issue was noted for the Juan de Fuca electoral area and electricity data for the 2007, 2010 and 2012 reporting years (i.e., the under reporting of energy consumption) in the published data. As such, the raw electricity data from BC Hydro was used to estimate GHG emissions.

- BC Hydro estimates that the combined energy losses- transmission and distribution- to be approximately 6.28%. This value was used to calculate the Scope 3 emissions for each Stationary Energy Sub-Sector. It is assumed that this is accurate.
- Fortis BC provided total fugitive emissions for the 2018 reporting year at the CRD level. Since no historical numbers were provided, the 2018 value was applied to the 2007 base year as well.
- Propane and wood GHG emissions were estimated using linear regression methods. The data used in the estimate included historical propane and wood energy data published in the 2007, 2010 and 2012 CEEIs, and heating degree days (HDD) published by Environment Canada.
- Fuel oil consumption values for the District of Saanich and the City of Victoria were derived by each local government and provided to the CRD. For the remaining local governments, fuel oi values were estimated using linear regression methods. The data used in the estimate included historical fuel oil data published in the 2007, 2010 and 2012 CEEIs, and heating degree days (HDD) published by Environment Canada.

4.1.5 Calculation Methodology

The Province of BC developed residential fuel oil, propane and wood GHG energy use estimates for the 2007, 2010 and 2012 reporting years, using the number and type of dwellings and the average dwelling consumption by authority and region contained in the BC Hydro Conservation Potential Review. Actual electricity and natural gas consumption values were subtracted from the total energy use, with the remainder assumed to be heating oil, propane, or wood. To estimate the 2018 propane, fuel oil and wood energy use, historical 2007, 2010 and 2012 values and the number of heating degree days (HDD) were linearly regressed to estimate future propane and wood energy use using reporting year HDD values. these values were prorated to each local government based on the 2012 consumption estimates. This resulted in the development of the following equations:

- Propane (L) = 163,133 + 87.38 * HDD
- Wood (GJ) = 557,864 + 191.39 * HDD
- Fuel Oil (GJ) = 1,728,690 + 127.49 * HDD

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 7.5%) 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:

Energy *Stationary Energy – Electricity =* *Electricity * (1 – Line Loss (%)*

Energy *Stationary Energy – Transmission, Distribution, and line Losses =* *Electricity * Line Loss (%)*

Emissions *Stationary Energy – Electricity* = *Fuel (MWh) * EF_{tCO2e}*

$$Emissions_{Stationary\ Energy - Natural\ Gas} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Propane} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Wood} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Heating\ Oil} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

The emission factors used in the 2018 reporting year are from the 2020 NIR. These are summarized in Table 8.

Table 8 Stationary Energy GHG Emission Factors

Emission Factor	Units	CO_2	CH_4	N_2O	tCO_2e
Electricity (BC Hydro)	tCO_2e / MWh				0.0106700
Natural Gas	tonne CO_2e / m^3	0.0019260	0.0000000	0.0000000	0.0019374
Propane	tonne CO_2e / L	0.0015150	0.0000000	0.0000001	0.0015478
Heating Oil	tonne CO_2e / GJ	0.0681200	0.0000007	0.0000008	0.0683759
Wood	tonne CO2e / kg	-	0.0000150	0.0000002	0.0004227

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 CRD, 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 Province of BC provided 2007, 2010 and 2018 ICBC vehicle registration data.

BC Transit provided total diesel and gasoline fuel use. This data was used to estimate GHG emissions from busses serving the CRD.

The 2017 CRD Origin Destination Travel Survey was used to estimate on-road in-boundary and transboundary split for registered vehicles and busses. The CRD Origin Destination Travel Survey is based on travel patterns observed in the Capital Regional District (CRD) level.

Aviation GHG emissions from the Victoria International Airport were estimated using 2015 aircraft flight profiles, and the total number of aircraft movements reported in 2018. These data sets were provided by the Victoria International Airport.

Victoria harbour aviation GHG emissions were estimated using Victoria harbor aircraft movement statistics, estimated taxi times, and estimated fuel use for the DHC-6 Twin Otter type of plane. This data was taken from Statistics Canada.

Marine watercraft GHG emissions were estimated using published BC Ferries fuel statistics. GHG emissions from the Coho Ferry, the Victoria Clipper Ferry, personal and commercial watercraft, were estimated based on a Study entitled “Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000”. The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year.

The Greater Victoria Harbour Authority provided an estimate of cruise ship emissions.

Other off-road transportation emissions are based on the 2020 NIR as prepared by Environment and Climate Change Canada.

4.2.3 Assumptions and Disclosures

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

- The Insurance Corporation of BC (ICBC) provided the number of vehicle registrations from April 1, 2006 – March 31, 2010 to the Province of BC. This data was checked and processed by the Province and used in the historical CEEI inventories. This same data set is used to estimate the GHG emissions for 2007, 2010 and 2012 inventories and forms the basis of the 2018 estimate. The 2012 vehicle registration data, although available, was not used due to concerns around data quality. This is the same reason the Province of BC decided to remove the transportation data from the 2012 CEEIs. As the summary of vehicle registrations is not based on the calendar year, the local government vehicle profiles may not accurately reflect the actual vehicle profiles for each reporting year.

- The Insurance Corporation of BC (ICBC) provided the number of registrations from April 1, 2018 – March 31, 2019 to the Province of BC. When compared to local government population trends, there appears to be a high degree of uncertainty as to the accuracy of the 2018 vehicle registration data in terms of total registered vehicles. Without having historical (e.g. 2011-2017) and current (2019) data to compare this dataset against, the reasonableness of the data was too uncertain to be applied in the estimation of GHG emissions for the 2018 reporting year. To estimate on-road energy and GHG emissions for the 2018 reporting year, the 2010 vehicle populations were grown in proportion to the reported changes in local government populations. Each of the local government vehicle profiles were then adjusted to match the proportion of vehicle classes reported in the 2018 ICBC data.
- In cases where vehicle registration counts were 10 or less, the Province assigned a value of "<10" rather than report the actual number. In these cases, the inventory assumes there was 10 vehicles of that particular classification. This is likely to result in an over-estimation of GHG emissions, but it will be immaterial to the overall GHG inventory.
- Vehicle fuel consumption rates and Vehicle Kilometer Travelled (VKT) were taken from the activity data summary for British Columbia on-road transportation from the 2018 National Inventory Report (1990-2018) as prepared by Environment Canada. Based on the clear diesel and clear gasoline consumption values reported by the Province of BC for the Victoria region, the VKT and fuel efficiency values are reasonable and result in a similar estimate of fuel consumption for the Region.
- Gasoline and diesel GHG emissions from BC Transit busses are pro-rated to the CRD based on the proportion of population in the CRD relative to the Province of BC. A more accurate estimation method would be to prorate fuel use based on total bus service kilometers in the CRD. However, this data is not available, and thus the method applied provides the best estimate at the time of reporting.
- It is assumed that the 2015 aircraft flight profiles at the Victoria International Airport are representative of the 2018 reporting year.
- Statistics Canada stopped collecting Victoria Harbor aircraft movement data in 2016. To estimate 2018 marine aviation GHG emissions, the 2016 Victoria data was applied and adjusted using the change in aircraft traffic between the 2016 and 2018 reporting years at the Victoria International Airport. It is assumed that the activity at both airports would be corelated, but not causational.
- The aviation GHG emissions are prorated based on the total Victoria population relative to the CRD population.
- As there is currently no publicly available energy or GHG related information on the operation of the Coho and the Victoria Clipper Ferries, it was assumed that the GHG emissions for these ferries calculated in 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".
- The Greater Victoria Harbour Authority (GVHA) reported on cruise ship emissions for the 2010 and 2018 reporting years but did not provide an estimate for 2007. As a result, the 2010 GHG emissions estimate and number of cruise ship visits to Ogden Point was used to create a proxy to estimate 2007 cruise ship emissions. The GVHA reported 163 visits in 2007. It is assumed these estimations of GHG emissions are reasonable.
- The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year; however, it does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that the watercraft would have been similar to those in the referenced study.

- No railway GHG emissions are occurring in the CRD.
- The off-road transportation emissions are based on the 2020 NIR as prepared by Environment and Climate Change Canada. This is deemed to be the best available data.

4.2.4 Calculation Methodology

4.2.4.1 On-Road

The GPC Protocol identifies several methods for determining on-road emissions. The vehicle kilometers travelled (VKT) methodology and fuel sales methods were 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. ICBC provided the number of registered vehicles in the CRD by style and by fuel type for 2018. To estimate the split between on-road in-boundary and transboundary traffic, data from the 2017 CRD Origin Destination Survey was applied. The results of the survey as it applies to the CRD is presented in Table 9.

Table 9 CRD On-Road In-Boundary/Transboundary Split

Aspect	By Vehicle
Estimated proportion of on-road in-boundary travel	99.1%
Estimated proportion of on-road transboundary travel	0.9%

The Province of BC screened the 2007, 2010, 2012 and 2018 ICBC datasets to pull out only CRD registered vehicles, and to eliminate duplicates. Any changes to a vehicle's insurance policy in a reporting year can create another occurrence of the vehicle in the same dataset. As such, if a vehicle record included a change of location during a quarter, the vehicle was assigned to the location where it was insured for the greatest portion of the quarter. The objective of this screening is to increase the accuracy of the GHG estimate. Once complete the Province of BC, identified vehicle characteristics using Identification Number (VIN) and other data fields to assign a fuel class and vehicle sector. This data was provided to the CRD to estimate energy and GHG emissions.

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

1. Change any vehicle registration counts with the reference of "<10" to 10.
2. Grow the 2010 local government vehicle populations based on population changes at the local government level.
3. Use the 2018 ICBC data to derive vehicle profiles (e.g. 37% LDT, 36% LDT, etc.) for each local government.
4. Apply these values to the grown 2010 data to derive 2018 vehicle populations for each local government.
5. Assign estimated NRCan vehicle fuel consumption rates and estimated VKT to each vehicle class (Table 10).

6. Estimate total fuel use by vehicle classification.
7. Summate and allocate estimated fuel use, by vehicle class using the applicable in-boundary and transboundary split.
8. Pro-rate the gasoline and diesel fuel use from busses.
9. Summate and allocate estimated bus fuel use using the applicable in-boundary and transboundary split.
10. Compare fuel estimated fuel volumes to the regional fuel sales volumes reported by the CRD. Adjust the VKTs as needed to make sure that the fuel estimate is at least above the fuel sales volumes reported in the region.

Table 10 Estimated VKT And Fuel Efficiencies by Vehicle Class For Reporting Year

Vehicle Classification	Estimated VKT / Year	Estimated Fuel Efficiency (L/100 km)
Diesel-HDV	27,972	45.6
Diesel-LDT	14,351	11.8
Diesel-LDV	16,384	9.2
Gasoline-HDV	10,883	54.1
Gasoline-Hybrid-LDT	11,717	12.2
Gasoline-Hybrid-LDV	12,840	9.0
Gasoline-LDT	11,717	12.2
Gasoline-LDV	12,840	9.0
Motorcycle - Non catalyst	1,973	9.9
Propane-LDT	29,237	13.1
Electric-LDV	19,733	20.0
Electric-LDT	19,733	20.0

Table 11 Total Registered Vehicles & Estimated Fuel Use For Reporting Year

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Diesel-HDV	2,621	35,049,591	Liters (L)
Diesel-LDT	8,950	15,183,037	Liters (L)
Diesel-LDV	2,271	3,411,652	Liters (L)
Electric-LDV	1,571	6,201,969	kWh
Electric-LDT	106	420,283	kWh
Gasoline-HDV	2,485	14,640,078	Liters (L)
Gasoline-Hybrid-LDT	1,072	1,527,195	Liters (L)
Gasoline-Hybrid-LDV	3,273	3,790,489	Liters (L)
Gasoline-LDT	121,631	173,279,769	Liters (L)

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Gasoline-LDV	120,615	139,685,291	Liters (L)
Motorcycle - Non catalyst	4,523	885,376	Liters (L)
Propane-LDT	76	291,534	Liters (L)
Total	**269,196**	**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:

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

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

The emission factors used in the reporting year GHG inventory are from the 2020 NIR. These are summarized in Table 12.

Table 12 Vehicle GHG Emission Factors

Vehicle Class	Units	CO_2	CH_4	N_2O	tCO_2e
Electricity (BC Hydro)	tonne / MWh	-	-	-	0.0106700
Diesel-LDV	tonne / L	0.0026810	0.0000001	0.0000002	0.0027478
Diesel-LDT	tonne / L	0.0026810	0.0000001	0.0000002	0.0027483
Diesel-HDV	tonne / L	0.0026810	0.0000001	0.0000002	0.0027287
Diesel-ORVE	tonne / L	0.0026810	0.0000001	0.0000000	0.0026894
Gasoline-LDV	tonne / L	0.0023070	0.0000001	0.0000002	0.0023761
Gasoline-LDT	tonne / L	0.0023070	0.0000001	0.0000002	0.0023761
Gasoline-HDV	tonne / L	0.0023070	0.0000001	0.0000002	0.0023683
Gasoline-HYBRID-LDV	tonne / L	0.0027380	0.0000130	0.0000005	0.0032031
Gasoline-HYBRID-LDT	tonne / L	0.0027380	0.0000130	0.0000005	0.0032031
Gasoline-ORVE	tonne / L	0.0027380	0.0000130	0.0000005	0.0032031
Propane-LDV	tonne / L	0.0015150	0.0000006	0.0000000	0.0015393
Propane-LDT	tonne / L	0.0015150	0.0000006	0.0000000	0.0015393
Propane-HDV	tonne / L	0.0015150	0.0000006	0.0000000	0.0015393
Natural Gas-LDV	tonne / kg	0.0000019	0.0090000	0.0000600	0.2428819
Natural Gas-LDT	tonne / kg	0.0000019	0.0090000	0.0000600	0.2428819
Natural Gas-HDV	tonne / kg	0.0000019	0.0090000	0.0000600	0.2428819

Vehicle Class	Units	CO_2	CH_4	N_2O	tCO_2e
Natural Gas-ORVE	tonne / kg	0.0000019	0.0090000	0.0000600	0.2428819
Motorcycle - Non-catalyst	tonne / L	0.0023160	0.0000023	0.0000000	0.0023878

4.2.4.2 Aviation: Victoria International Airport

The Victoria International Airport (VIA) estimated its 2015 airplane GHG emissions following the ACI ACERT standard. This includes GHG emissions from aircraft and GHG emissions from auxiliary power units (APU). APUs provides electricity to the aircraft prior to the engine start up. Within the ACERT model, it is assumed all aircraft have APUs and the duration of the APU operation (of five minutes per aircraft) was generically applied to every landing take-off (LTO) cycles. It should also be noted that the EIA has quantified aircraft GHG emissions from planes up to 3,000 ft. to avoid double counting with other airports and cities. This is consistent with the ACERT standard.

The CRD's 2018 aviation emissions estimate is based on the 2015 aircraft flight profiles, which included the estimated landing and takeoff (LTO) and auxiliary power unit (APU) fuel use, and an estimated percentage allocation of total flights to the following aviation class groupings (Table 13). The total reported flight movements for the reporting year (121,152) provided by the VIA and the aircraft flight profile data was used to estimate aviation GHG emissions for the reporting year at the VIA.

Table 13 Aircraft Type, Estimated Percentage of Total Reported Movements, And Estimated Fuel Use

Aviation Class	Aircraft Type	Estimated Percentage of Annual Movements	Estimated LTO Fuel Use by Aircraft Type (kg)	Estimated APU Fuel Use by Aircraft Type (kg/min)
Jet	Large: 2-aisle, long-haul	0.01%	1,853	4.00
	Medium: 2-aisle, medium-haul	0.01%	1,321	4.00
	Small: 1-aisle, small/medium haul	7.95%	565	1.78
	Regional: 1-aisle, short-haul	0.01%	315	1.78
	Business: 2-eng business jets	0.01%	41	1.78
Turboprop	Turboprop (all engines)	22.29%	46	1.78
Piston	Piston (all engines)	66.30%	41	0.00
Helicopter	Helicopter small (1 engine/turbine)	1.72%	13	0.00
	Helicopter large (2 engine/turbine)	1.72%	8	0.00

Calculating fuel use for each aviation class applied the following equation:

***Fuel Use** Per Aviation Class = Number of Aircraft Movements * (LTO Fuel Use + (APU Fuel Use * 15 minutes))*

The GHG quantification method, that was applied to each aviation class, is as follows:

***Emissions** Per Aviation Class* = *(Vol. Fuel * Aviation Class EF_{CO2}) + (Vol. Fuel * Aviation Class EF_{CH4} * GWP_{CH4}) + (Vol. Fuel * Aviation Class EF_{N2O} * GWP_{N2O}))*

The ACERT GHG calculator used by the VIA utilized emission factors from the 2020 NIR. Actual airplane emission factors are from the International Civil Aviation Organization (ICAO) GHG database. These are summarized in Table 14.

These GHG emissions were reported in the Scope 3 category as directed by the GPC Protocol.

Table 14 Aviation GHG Emission Factors

Airplane Type	Units	CO_2	CH_4	N_2O	tCO_2e
Jet	tCO_2e/kg fuel	0.0031380	0.0000001	0.0000003	0.0032254
Turbo Propeller	tCO_2e/kg fuel	0.0031380	0.0000001	0.0000003	0.0032254
Piston	tCO_2e/kg fuel	0.0032530	0.0000031	0.0000003	0.0034154
Helicopter	tCO_2e/kg fuel	0.0031380	0.0000001	0.0000003	0.0032254

4.2.4.3 Aviation: Victoria Harbour

Victoria harbor aviation emissions were estimated using 2016 NAV Canada airplane movement statistics, estimated taxi times, and estimated fuel use for the DHC-6 Twin Otter type of plane (Table 15).

Table 15 Aircraft Type, Estimated Percentage of Total Reported Movements, And Estimated Fuel Use

Aviation Class	Aircraft Type	Estimated Percentage of Annual Movements	Estimated LTO Fuel Use by Aircraft Type (kg)	Estimated APU Fuel Use by Aircraft Type (kg/min)
Turboprop	DHC-6 Twin Otter	100%	56	0.00

Statistics Canada stopped collecting Victoria Harbor aircraft movement data in 2016. To estimate 2018 Victoria harbor aviation GHG emissions, the 2016 data was applied and adjusted using the change in aircraft traffic between the 2016 and 2018 reporting years at the Victoria International Airport. This resulted in an estimated 29,979 movements.

Calculating aviation fuel use in the Victoria harbor for applied the following equation:

***Fuel Use** Per Aviation Class* = *Number of Aircraft Movements * (LTO Fuel Use + (APU Fuel Use * 15 minutes))*

The GHG quantification method is as follows:

$$\textit{Emissions}_{\textit{Per Aviation Class}} = \textit{CRD Population} * ((\textit{Vol. Fuel} * \textit{Aviation Class } EF_{CO2}) + (\textit{Vol. Fuel} * \textit{Aviation Class } EF_{CH4} * GWP_{CH4}) + (\textit{Vol. Fuel} * \textit{Aviation Class } EF_{N2O} * GWP_{N2O}))$$

The airplane emission factors are from the International Civil Aviation Organization (ICAO) GHG database. These are summarized in Table 16.

Table 16 Marine Aviation GHG Emission Factors

Airplane Type	Units	CO_2	CH_4	N_2O	tCO_2e
Turbo Propeller	tCO_2e/kg fuel	0.0031380	0.0000001	0.0000003	0.0032254

These GHG emissions were reported in the Scope 3 category as directed by the GPC Protocol.

4.2.4.4 Waterborne Transportation

4.2.4.4.1 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 reported fuel use 120,200,000 liters of diesel for the 2018 reporting year, and a provincially derived GHG emissions factor (Table 17).

Table 17 BC Ferries GHG Emission Factors

Aspect	Units	CO_2	CH_4	N_2O	tCO_2e
Ferry (Diesel)	tonne CO_2e / L	0.0025820	0.0000002	0.0000011	0.0029136

As BC Ferries operate outside of the CRD's boundary, the GHG emissions were allocated to Scope 3 based on the proportion of the CRD population relative to the total Vancouver Island and Mainland / Southwest populations.

4.2.4.4.2 Other Watercraft

The GHG emissions from the Coho Ferry, the Victoria Clipper Ferry, and personal and commercial watercraft were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors and the Transport Canada Vessel Registration System. As there is currently no publicly available energy or GHG related information on the operation of the Coho and the Victoria Clipper Ferries, it was assumed that the GHG emissions for these ferries calculated in the Study entitled "Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000" is still valid for 2018. The GHG emissions for these ferries are summarized in Table 18.

Table 18 Coho and the Victoria Clipper Ferries Estimated GHG Emissions

Aspect	Units	CO_2	CH_4	N_2O	tCO_2e
Coho Ferries	Tonnes	1,160.00	0.10	0.40	1,281.70
Victoria Clipper	Tonnes	1,895.00	0.10	0.80	2,135.90

Cruise ship GHG emissions were estimated by the Greater Victoria Harbour Authority.[1] The Greater Victoria Harbour Authority (GVHA) reported on cruise ship emissions for the 2010 and 2018 reporting years but did not derive an estimate for 2007. As a result, the 2010 GHG emissions estimate and number of cruise ship visits to Ogden Point was used to create a proxy to estimate 2007 cruise ship emissions. The GVHA reported 163 visits in 2007.

The GHG quantification method to estimate 2007 GHG emissions from the Odgen Point cruise ship terminal was as follows:

$$Emissions_{Waterborne} = (GVHA\ Reported\ Emissions_{2010} / Cruise\ Ship\ Visits_{2010}) * Cruise\ Ship\ Visits_{2007}$$

The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles which was 2,163 vessels all registered boats in Victoria; however, the registration system does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that the watercraft would have been similar to those in the referenced study. To estimate the personal / watercraft GHG emissions, the breakdown of vessels and total fuel use by category were used to estimate what the current population and fuel use might be in the reporting year. To do this, the following steps were taken.

1. Calculate the percentage of the population and per unit fuel use of the year 2000 population (Table 19).
1. Take the total number of registered vessels, and the percentage breakdown of the year 2000 population, and apply the per unit fuel use factor to determine the total gasoline and diesel fuel use (Table 20).
2. Using 2020 NIR emission factors estimate the GHG emissions from other watercraft.

Table 19 Year 2000 Other Watercraft Population Breakdown And Estimated Fuel Use

Type of Watercraft from Year 2000 Study	Year 2000 Study Vancouver Island Population	Percentage of Population	Fuel Use (m^3/Year)	Fuel Use Per Unit (m^3/Year)
Inboard: 4 stroke - gasoline	1,689	0.19%	175	0.10
Inboard: Diesel	199	0.02%	62	0.31
Outboard: 2 stroke - gasoline	23,494	2.66%	1,632	0.07
Outboard: 4 stroke - gasoline	622	0.07%	7	0.01
Stemdrive: 2 stroke - gasoline	68	0.01%	8	0.12
Stemdrive: 4 stroke - gasoline	6,576	0.74%	535	0.08

[1] https://gvha.ca/wp-content/uploads/2019/10/EmissionsInventory-2019.pdf

Type of Watercraft from Year 2000 Study	Year 2000 Study Vancouver Island Population	Percentage of Population	Fuel Use (m^3/Year)	Fuel Use Per Unit (m^3/Year)
Stemdrive: Diesel	784	0.09%	216	0.28
Personal Watercraft: 2 stroke - gasoline	848,492	96.00%	342	0.00
Sailboat Auxiliary Inboard: 4 stroke - gasoline	428	0.05%	1	0.00
Sailboat Auxiliary Inboard: Diesel	1,088	0.12%	6	0.01
Sailboat Auxiliary Outboard: 2 stroke - gasoline	396	0.04%	1	0.00
Sailboat Auxiliary Outboard: Diesel	1	0.00%	0	0.01

Table 20 Reporting Year Other Watercraft Population Breakdown and Estimated Fuel Use

Type of Watercraft	Estimated Breakdown of Currently Registered Vessels	Estimated Fuel Use (L/year)
Inboard: 4 stroke - gasoline	4	428.3
Inboard: Diesel	0	151.7
Outboard: 2 stroke - gasoline	57	3,994.0
Outboard: 4 stroke - gasoline	2	17.1
Stemdrive: 2 stroke - gasoline	0	19.6
Stemdrive: 4 stroke - gasoline	16	1,309.3
Stemdrive: Diesel	2	528.6
Personal Watercraft: 2 stroke - gasoline	2,058	837.0
Sailboat Auxiliary Inboard: 4 stroke - gasoline	1	1.2
Sailboat Auxiliary Inboard: Diesel	3	14.7
Sailboat Auxiliary Outboard: 2 stroke - gasoline	1	1.2
Sailboat Auxiliary Outboard: Diesel	0	0.0

To calculate the GHG emissions, for the other watercraft, provincially derived GHG emissions factors were used (Table 21).

Table 21 Watercraft GHG Emission Factors

Aspect	Units	CO_2	CH_4	N_2O	tCO_2e
Marine Gasoline	tonne CO2e / L	0.0022000	0.0000013	0.0000001	0.0022522
Marine Diesel	tonne CO2e / L	0.0025820	0.0000002	0.0000011	0.0029136

The GHG quantification method, that was applied to the BC Ferries and other watercraft was as follows:

Emissions $_{Waterborne}$ **=** *(CRD Population / Vancouver Island; Mainland; Southwest Population) * ((Vol. Fuel * EF_{CO2}) + (Vol. Fuel * EF_{CH4} * GWP_{CH4}) + (Vol. Fuel * EF_{N2O} * GWP_{N2O}))*

4.2.4.5 Off-Road

Currently, there is limited data available to estimate off-road GHG emissions. As such, a GHG emissions per capita estimate for each off-road category was developed using Provincial emissions data from the 2020 NIR, and BC's population from Statistics Canada. To develop each off-road factor, the total BC GHG emissions for each reporting category was divided by the BC population for the NIR reporting year (2018). Each derived per-capita value was applied to the current reporting year CRD population (2018) to estimate off-road GHG emissions.

The NIR currently reports the following off-road emissions:

- Total BC off-road agriculture and forestry GHG emissions
- Total BC off-road commercial and institutional GHG emissions
- Total BC off-road residential GHG emissions
- Total BC other off-road GHG emissions

Total BC off-road manufacturing, mining, and construction GHG emissions were not included on the basis that manufacturing and mining GHG emission could not be split out.

Other than other off-road GHG emissions, which is reported in the Off-Road Transportation Sub-Sector, the remaining off-road GHG emissions are reported in the Stationary Energy Sector as required by the GPC Protocol.

The GHG quantification method is presented below:

Emissions $_{Off\text{-}Road}$ **=** *(NIR Off-Road GHG Emissions $_{BC}$ / BC Population $_{BC}$) * Current Reporting Year Population $_{CRD}$*

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

- Scope 3: Emissions:
  - Solid waste disposal

- Biological treatment of waste
- Wastewater treatment and discharge

4.3.1 Activity Data

The CRD provided landfill gas volumes, energy and GHG related data for the Hartland landfill (fugitives and flaring), total CRD wastewater volumes, average biological oxygen demand (BOD) and Total Kjeldal Nitrogen (TKN) annual average values (mg/L) from the wastewater for all relevant outfalls. The wastewater volumes are based on total budgeted sewer costs.

Some GHG emissions from incineration and open burning are likely to be occurring in the CRD but cannot readily be estimated. This the notation key for "Not Estimated" has been used to indicate this.

4.3.2 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2018 GHG emissions:

- To quantify GHG emissions from the Hartland Landfill, the CRD utilized the waste-in-place method which is accepted under the GPC Protocol. The Waste-in-place (WIP) assigns landfill emissions based on total waste deposited during that year. It counts GHGs emitted that year, regardless of when the waste was disposed. GHG emissions from the Hartland Landfill for the reporting year are allocated based upon the percentage of Community waste, relative to total waste received at to the Hartland Landfill. It is assumed that the GHG emissions data provided is reasonably accurate and the method deployed correct.
- It is assumed that the landfill gas has a constant higher heating value (HHV) of 0.01865 (GJ/m^3).
- Composting GHG emissions are estimated based on the total tonnage estimated by the CRD. It is assumed that all compost is treated aerobically.
- Wastewater is not currently treated. As such, IPCC wastewater methane (CH_4) producing capacity and CH_4 correction default factors were used. These factors used are for untreated wastewater being deposited into deep or moving waters. It is likely that ocean sequesters more CH_4 than is estimated.
- It is likely that GHG emissions from incineration and open burning are occurring on an infrequent and controlled (property by property) basis, but without available data the GHG emissions cannot be reasonably quantified.

4.3.3 Calculation Methodology

4.3.3.1 Solid Waste

The Hartland Landfill has a landfill gas (LFG) collection and destruction system at the Hartland Landfill to which the LFG is either combusted in a flare, or in an engine to generate electricity which is exported to the grid. The GHG emissions associated with energy generation are reported as a reporting only GHG emission under Stationary Energy: Energy Industries Reporting Only and are not included in the total GHG emissions estimate. The GHG emissions associated with flaring of the landfill gas are reported under Stationary Energy: Energy Industries Scope 1.

The GHG quantification method for Stationary Energy: Energy Industries is as follows:

$$\textbf{Emissions}_{\text{Stationary Energy: Energy Industries}} = (\text{LFG Consumed}_{m3} * HHV_{LFG} * EF_{RNG\ CH4} * GWP_{CH4}) + (\text{LFG Consumed}_{m3} * HHV_{LFG} * EF_{RNG\ N2O} * GWP_{N2O})$$

The fugitive landfill GHG emissions estimates were generated by the CRD using the waste-in-place (WIP) method which is accepted under the GPC Protocol. The WIP assigns landfill emissions based on emissions during that year. It counts GHGs emitted that year, regardless of when the waste was disposed.

4.3.3.2 Biological Treatment of Solid Waste

The CRD provided 2018 composting data which is assumed to be treated aerobically at the Hartland Landfill. 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 22).

Table 22 Composting Emission Factor

Emission Factor	Units	CO_2	CH_4	N_2O	tCO_2e
Composting	tCO_2e / kg waste	-	0.0000010	-	0.0000250

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

$$\textbf{Emissions}_{\text{Anaerobic Waste}} = \text{Compost Waste}_{\text{Total}} * EF_{CH4} * GWP_{CH4}$$

4.3.3.3 Wastewater Treatment And Discharge

Wastewater is not currently treated on Vancouver Island and is sent to ocean-based outfalls. The CRD provided the 2018 wastewater volumes (m^3), the average biological oxygen demand (BOD) and the average Total Kjeldal Nitrogen (TKN) in wastewater. 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 untreated 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:

$$Emissions_{Wastewater\ CH4} = ((Wastewater_{m3} * (BOD_{ml/L} / 1000) * (0.06_{kg\ CH4/kg\ BOD} * 0.01)) / 1000) * GWP_{CH4}$$

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

4.4 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 CRD, the IPPU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Product use

No GHG emissions from Industrial Processes are known to be occurring and thus the notation key for "Not Occurring" has been used to indicate this.

4.4.2 Activity Data

As there is limited data available on Product Use GHG emissions, the GHG Emissions estimate was derived on a per capita basis using the 2020 NIR GHG data for the Province of BC and BC population data for the reporting year.

4.4.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2018 GHG emissions:

- The product use emissions are based on the 2020 NIR product use GHG emissions as prepared by Environment and Climate Change Canada.
- The NIR uses the Tier 1 methodology to estimate these emissions and thus uncertainty around their accuracy remains quite high.

4.4.4 Calculation Methodology

4.4.4.1 Product Use Emissions

For the 2018 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 CRD, a per capita estimate was developed using the Provincial emissions data from the 2020 NIR, and BC's NIR reporting year population from Statistics Canada. This value was applied to the 2018 reporting year CRD population to estimate the total product use emissions.

The GHG quantification method is presented below:

***Emissions** Product Use = (NIR Product Use GHG Emissions BC / NIR Population BC) * Current Reporting Year Population*

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 CRD, the AFOLU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Land
  - Livestock
  - Aggregate Sources And Non-CO_2 Emissions Sources On Land

4.5.2 Activity Data

The CRD provided remotely sensed imagery to estimate land-cover change. This data included:

- Habitat Acquisition Trust (HAT) Land Cover Mapping
- Annual Crop Inventory (ACI), Agriculture Canada
- Satellite Imagery interpretation, CRD
- Vegetation Resources Inventory (VRI), British Columbia Government.
- Earth Observation for Sustainable Development of Forests (EOSD) Land Cover Classification, Service Natural Resources Canada

Livestock and aggregate sources and non-CO_2 emissions sources on land were estimated using GHG emissions data from the 2020 NIR, and land-use data from the 2016 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 2018 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 resolution for the 2007 base and 2018 reporting years. For the land use change analysis, land cover data was available for the 2007, 2011 and 2017 years for only part of the CRD. There was limited land-use datasets for the Juan de Fuca, Salt Spring Island and Gulf Islands and this data was only available for 2007 and 2011. Unfortunately, no more recent or higher quality data source was available to represent the land cover consistently for all three years. Furthermore, since annual data was not available, the change between land cover data years (2007-2011, 2011-2017) was averaged and may not represent actual changes in each year.

4.5.4 Calculation Methodology

4.5.4.1 Land Use

Remotely sensed imagery was used to estimate land-cover changes during the 2007-2018 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 following table identifies the data sources used for the reporting years for each of the study area's geographies.

Table 23 Spatial Data Sources Representing Land Cover For The CRD Study Area

<table>
<tr><th colspan="2"></th><th colspan="3">CRD Study Area Geography</th></tr>
<tr><th colspan="2"></th><th>CRD Core</th><th>Gulf Islands</th><th>Juan de Fuca Region</th></tr>
<tr><td rowspan="3">Reporting Year</td><td>2007</td><td>2005 HAT Land Cover Mapping</td><td>2001 EOSD Land Cover Classification</td><td>2011 HAT Land Cover Mapping[2]</td></tr>
<tr><td>2011</td><td>2011 HAT Land Cover Mapping</td><td>2001 EOSD Land Cover Classification + 2011 ACI 'Settlement'</td><td>2011 HAT Land Cover Mapping[2] + 2011 ACI 'Settlement'</td></tr>
<tr><td>2017</td><td>2011 HAT Land Cover Mapping + 'Settlement' satellite image interpretation[1]</td><td>2001 EOSD Land Cover Classification + 2017 ACI 'Settlement'</td><td>2011 HAT Land Cover Mapping[2] + 2017 ACI 'Settlement'</td></tr>
</table>

Notes:

[1] Settlements land cover category is a combination of i) municipality provided building footprint as acquired mostly from digitizing roofline from satellite and orthoimagery, ii) new roads (ParcelMap BC parcel with parcel start dates > 2011 and parcel class = 'road') and iii) and theoretical building footprints (average building footprint areas as buffered centroids of new ParcelMap BC parcel with start dates > 2011 with a residential parcel class)

[2] The 2011 land cover classification was interpreted mostly from 2005 imagery in the Juan de Fuca region making it more suitable for the 2007 reporting year.

The spatial data sources representing land cover in this analysis include more categories than 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 24 IPCC Land Use Classification Cross-References

IPCC Land Cover	EOSD Land Cover	HAT Land Cover	Annual Crop Inventory
Cropland	Annual Cropland, Perennial Cropland And Pasture	Agricultural Fields	-
Forest	Broadleaf Dense, Broadleaf Open, Coniferous Dense, Coniferous Open, Coniferous Sparse,	Tree	-
Grassland	Grassland , Herb, Shrub Low	Grass, Herb	-
Settlement	Developed	Pavement/Building	Developed
Wetland	Wetland - Herb , Wetland - Shrub , Wetland - Treed	Riparian Tree, Riparian Herb, Pond	-
Other	Water, Exposed Land	Shadow, Ocean, Lake, River, Sand/Gravel Shoreline, Bedrock Shoreline, Exposed Soil, Exposed Bedrock	-

The analysis resulted 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 the GHG emissions from land use (Table 25).

Table 25 Land-Use Change Emission Factors

Sector	Emission Factor	Units
Forestland	556.33	tCO_2e / ha
Grasslands	205.70	tCO_2e / ha
Wetlands	471.50	tCO_2e / ha
Cropland	239.80	tCO_2e / ha

Sector	Emission Factor	Units
Settlements	0.00	tCO_2e / ha
Other	0.00	tCO_2e / ha
Forestland	(0.66)	tCO_2e / ha / year
Grasslands	(8.05)	tCO_2e / ha / year
Wetlands	(6.50)	tCO_2e / ha / year
Croplands	(9.79)	tCO_2e / ha / year
Settlements	0.00	tCO_2e / ha / year
Other	0.00	tCO_2e / ha / year

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

$$Emissions_{Lands\ Not\ Converted} = Land\ Type_{ha} * EF_{Sequester}$$

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

4.5.4.2 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 was used in conjunction with 2020 NIR data to develop a tCO_2e / ha value estimate for:

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

To calculate GHG emissions from urea application, the calculated total crop land in hectares for the reporting year was applied against an IPCC GHG emissions factor of 0.20 tCO_2e / ha. This emission factor is also applied in the 2020 NIR.

The GHG quantification method is presented below:

$$Emissions_{Direct\ \&\ Indirect\ N2O} = ((BC_{Direct\ N2O\ Emissions} + BC_{Indirect\ N2O\ Emissions} + BC_{Indirect\ N2O\ Manure\ Management\ Emissions})\ /\ BC_{Land\ In\ Crops\ ha})) * CRD\ Cropland_{ha}$$

$$Emissions_{Urea\ Application} = CRD\ Cropland_{ha} * 0.66\ tCO_2e\ /\ ha$$

5.0 2018 GHG REPORTING YEAR RESULTS

5.1 OVERVIEW

This section presents the 2018 reporting year GHG emissions for the CRD. The following table classifies each of the GPC Protocol GHG emission categories by scope and reporting level. Note that these are cumulative.

Table 26 GHG Emissions Reporting Breakdown by GPC Reporting Method

GHG Emissions Scope	BASIC Reporting Level	BASIC+ Reporting Level
Scope 1	• Emissions from in boundary fuel combustion • In boundary fugitive emissions • Emissions from in boundary transport	Everything in the box at left, plus in-boundary emissions from: • Industrial process and product use • Livestock • Land use • Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land
Scope 2	• Emissions from consumption of grid-supplied energy	• Emissions from consumption of grid-supplied energy
Scope 3	• Emissions from solid waste, and composting generated within but treated outside of the GHG boundaries	Everything in the box at left, plus: • Transmission, distribution, and line losses from grid-supplied energy • Emissions from transboundary journeys
Outside of Reporting Scopes & GPC Protocol	• Upstream fuel emission extraction, processing, and transport • Food and drink imports • Construction materials (imports) • Other supply chain emissions • Vehicle fuel exports	

5.2 SUMMARY

Total BASIC, and BASIC+ emissions for the CRD for the 2018 reporting year are presented in the Figure 3 below.

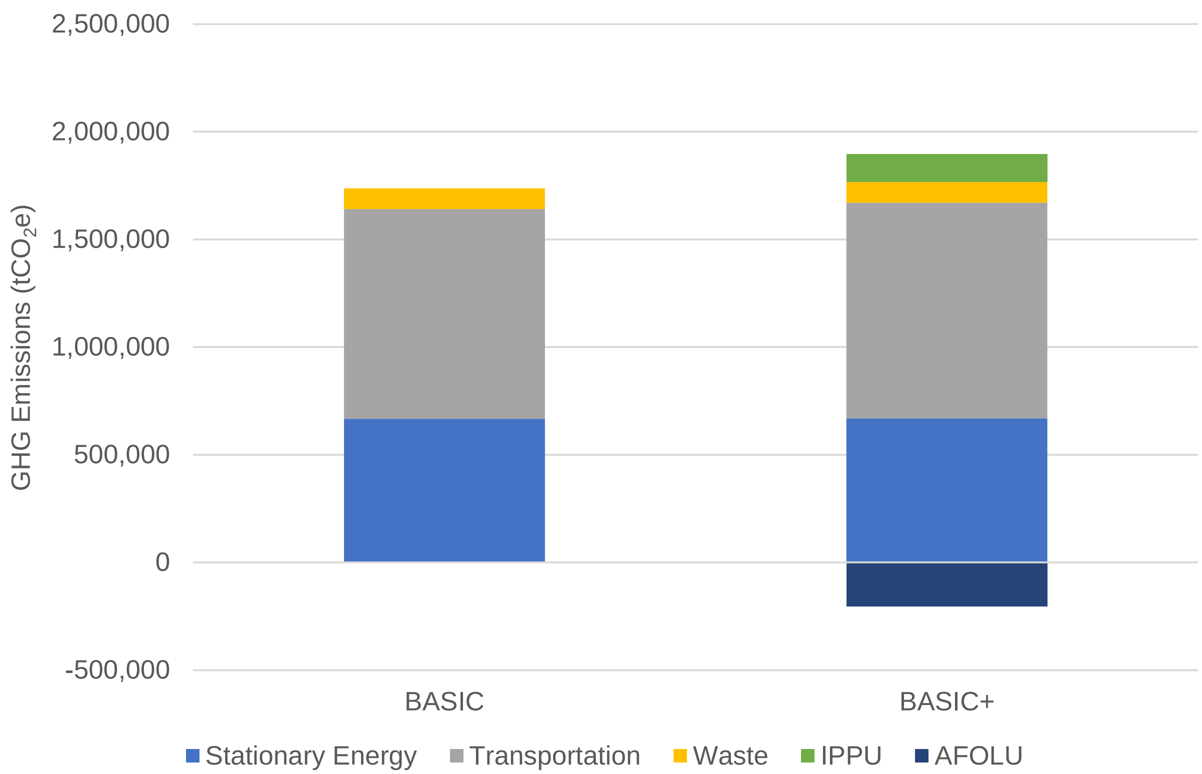

Figure 3 2018 GHG Emissions Summary by GPC Reporting Level

Emission by reporting level are presented in the Table 27 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 27 Breakdown of the CRD's 2018 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)	634,906	32,117	2,152	667,023	669,175	669,175
	Energy generation supplied to the grid (I.4.4)	8,147					
Transportation	(all II emissions)	978,309	80	26,821	978,389	1,005,210	1,005,210
Waste	Waste generated in the Community (III.X.1 and III.X.2)	96,386		0	96,386	96,386	96,386
	Waste generated outside community (III.X.3)	NO					
IPPU	(all IV emissions)	129,884				129,884	129,884
AFOLU	(all V emissions)	-203,952				-203,952	-203,952
Other Scope 3 (S3)	(all VI emissions)						0
TOTAL		**1,635,532**	**32,197**	**28,973**	**1,741,798**	**1,696,703**	**1,696,703**

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 28 presents the breakdown of the CRD's BASIC+ GHG emissions by Sector and Sub-Sector.

Table 28 Breakdown of the CRD's 2018 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	318,300	19,209	1,287	338,796
I.2	Commercial and institutional buildings and facilities	251,651	12,908	865	265,424
I.3	Manufacturing industries and construction	NE	NE	NE	NE
I.4.1/2/3	Energy industries	7,658	NO	NO	7,658
I.4.4	Energy generation supplied to the grid	8,147			
I.5	Agriculture, forestry, and fishing activities	55,787	IE	IE	55,787
I.6	Non-specified sources	IE	IE	IE	IE
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	1,510			1,510
I.8	Fugitive emissions from oil and natural gas systems	NO			0
Sub-Total	(community induced framework only)	**634,906**	**32,117**	**2,152**	**669,175**
II	**Transportation**				
II.1	On-road transportation	871,491	80	7,578	879,148
II.2	Railways	NO	NO	NO	NO
II.3	Waterborne navigation	51,455	IE	IE	51,455
II.4	Aviation	NO	IE	19,243	19,243
II.5	Off-road transportation	55,363	IE	IE	55,363
Sub-total	(community induced framework only)	**978,309**	**80**	**26,821**	**1,005,210**
III	**Waste**				
III.1.1/2	Solid waste generated in the Community	71,219		NO	71,219
III.2.1/2	Biological waste generated in the Community	5,307		NO	5,307
III.3.1/2	Incinerated and burned waste generated in the Community	NE		NE	NE
III.4.1/2	Wastewater generated in the Community	19,859		IE	19,859
III.1.3	Solid waste generated outside the Community	NO			
III.2.3	Biological waste generated outside the Community	NO			
III.3.3	Incinerated and burned waste generated outside community	NE			

Table 28 Breakdown of the CRD's 2018 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.4.3	Wastewater generated outside the Community	NO			
Sub-total	(community induced framework only)	**96,386**		**0**	**96,386**
IV	**Industrial Processes and Product Uses**				
IV.1	Emissions from industrial processes occurring in the Community boundary	NE			NE
IV.2	Emissions from product use occurring within the Community boundary	129,884			129,884
Sub-Total	(community induced framework only)	**129,884**			**129,884**
V	**Agriculture, Forestry, and Other Land Use**				
V.1	Emissions from livestock	4,299			4,299
V.2	Emissions from land	-209,262			-209,262
V.3	Emissions from aggregate sources and non-CO_2 emission sources on land	1,010			1,010
Sub-Total	(community induced framework only)	**-203,952**			**-203,952**
VI	**Other Scope 3**				
VI.1	Other Scope 3			NE	NE
Total	(community induced framework only)	**1,635,532**	**32,197**	**28,973**	**1,696,703**

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

5.3 TOTAL GHG EMISSIONS

Under the BASIC+ method, the CRD's GHG emissions totaled 1,692,593 tCO_2e. On a per capita basis, this works out to 4.2 tCO_2e per person.

Table 29 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	12,923,082	338,796	32	0.8
	Commercial & Institutional Buildings	9,434,748	265,424	23	0.7
	Manufacturing Industries & Construction	-	-	-	-
	Energy Industries	-	7,658	-	0.0
	Agriculture, Forestry & Fishing Activities	768,936	55,787	2	0.1
	Fugitive Emissions	-	1,510	-	0.0
Transportation	In-Boundary On-road Transportation	13,534,547	871,571	33	2.1
	Trans-Boundary On-road Transportation	117,673	7,578	0	0.0
	Waterborne Navigation	683,147	51,455	2	0.1
	Aviation	258,625	19,243	1	0.0
	Off-road Transportation	763,096	55,363	2	0.1
Waste	Solid Waste	-	71,219	-	0.2
	Biological Treatment of Waste	-	5,307	-	0.0
	Wastewater Treatment & Discharge	-	19,859	-	0.0
IPPU	Product Use	-	129,884	-	0.3
AFOLU	Land-Use Change	-	(209,262)	-	(0.5)
	Livestock	-	4,299	-	0.0
	Non-CO2 Land Emission Sources	-	1,010	-	0.0
Total		**38,483,853**	**1,696,703**	**95**	**4.2**

Total GHG emissions for 2018 are 1,696,703 tCO_2e and have decreased 1.1% from the 2007 base year. Scope 1 and 2 Emissions are 96.4% and 1.9% of the total GHG inventory. Scope 1 emissions are the GHG emissions that result from the combustion of fuel in sources within the CRD's boundaries, primarily from Stationary Energy and Transportation. Scope 1 GHG emissions also include IPPU and AFOLU GHG emissions. Scope 2 emissions result from the use of electricity supplied to the CRD 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 CRD that are occurring outside of the CRD's boundaries. For 2018, Scope 3 GHG emissions make up 1.7% of the GHG inventory. This breakdown by emission scope is depicted in Figure 4.

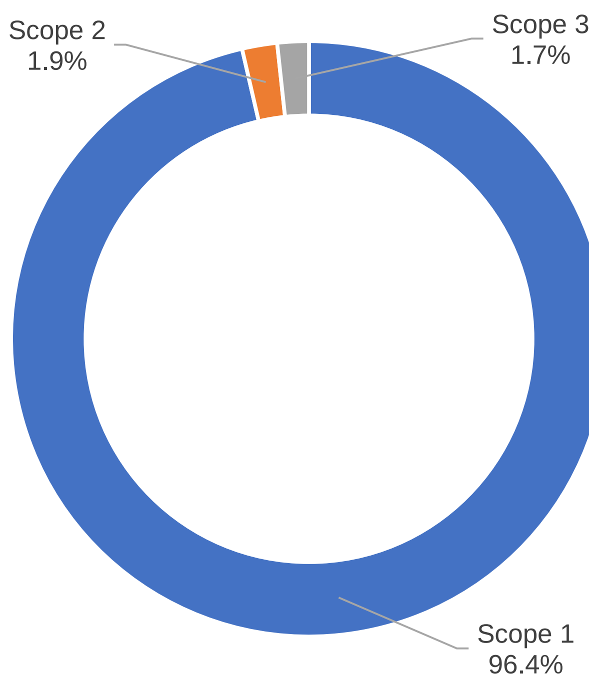

Figure 4 CRD BASIC+ GHG Emissions by Emissions Scope

A breakdown of GHG emissions by reporting scope for the 2007 base and reporting year are presented in Table 30 below.

Table 30 Change in GHG Emissions from Base Year

Emissions Scope	2007 GHG Emissions (tCO_2e)	2018 GHG Emissions (tCO_2e)	Change
Scope 1	1,589,511	1,635,533	2.9%
Scope 2	81,358	32,197	-60.4%
Scope 3	44,945	28,972	-35.5%
Total	**1,715,814**	**1,696,703**	**-1.1%**

5.4 SECTORAL GHG EMISSIONS ANALYSIS

5.4.1 Stationary Energy

Stationary energy sources are one of the largest contributors to the CRD's GHG emissions. In 2018, it contributed 35.1% of the community's GHG emissions. In general, stationary energy emissions include the 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 31 summarizes the energy and GHG emissions for the 2018 reporting year.

Table 31 2018 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	20,496	110,632	142,004	24,569	25,843	15,252	**338,796**	**12,923,082**
Commercial & Institutional Buildings	13,773	209,087	9,778			32,786	**265,424**	**9,434,748**
Energy Industries						7,658	**7,658**	
Agriculture, Forestry & Fishing activities						55,787	**55,787**	**768,936**
Fugitive Emissions						1,510	**1,510**	
Total GHG Emissions (tCO_2e)	**34,269**	**319,719**	**151,782**	**24,569**	**25,843**	**112,993**	**669,175**	
Total Energy (GJ)	**11,562,215**	**6,411,356**	**2,219,813**	**401,770**	**1,100,555**	**1,431,057**		**23,126,766**

It can be seen in Figure 5 that heating oil and natural gas use contribute to 70.5% of the CRD's total Stationary Energy GHG emissions.

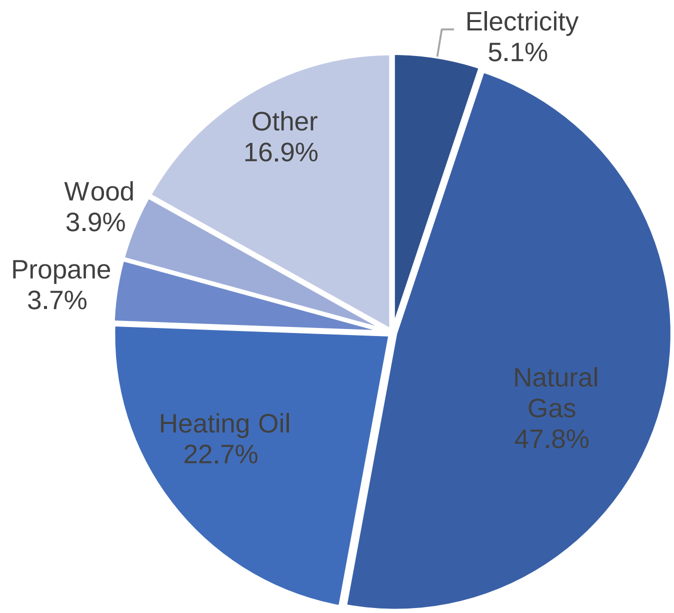

Figure 5 Stationary Energy GHG Emissions Contribution to the GHG Inventory

Figure 6 shows that more than 90.3% of the stationary GHG emissions arise from the operation of buildings.

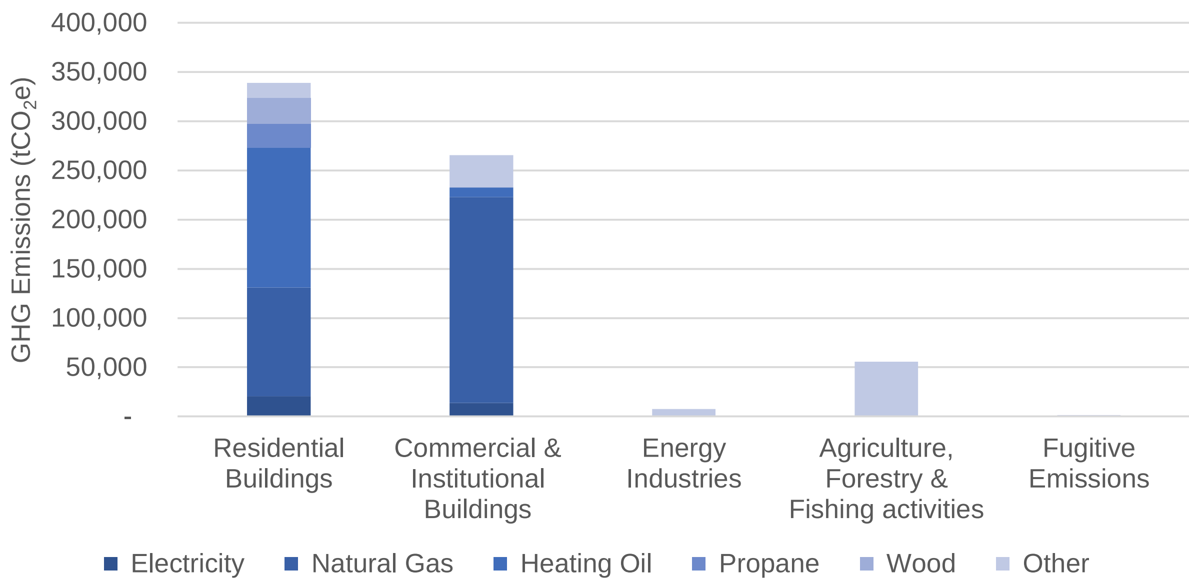

Figure 6 Total Stationary Energy Use By Sub-Sector

Stationary energy GHG emissions have decreased by 6.3% since the base year (Table 32).

Table 32 Stationary Energy—Energy and GHG Emissions Trends

Sector	Change in GJ: 2007 & 2018	Change in tCO_2e: 2007 & 2018
Residential Buildings	-9.0%	-16.0%
Commercial & Institutional Buildings	6.2%	7.3%
Energy Industries		1,731.0%
Agriculture, Forestry & Fishing activities	-4.2%	-10.1%
Fugitives		52.0%
Total	**-3.2%**	**-6.3%**

5.4.2 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 2018 reporting year, transportation GHG emissions accounted for 52.7% of the CRD GHG inventory with the bulk of transportation GHG emissions resulting from the on-road transportation sub-sector (87.4%). 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 33 summarizes the on-road energy and GHG emissions for the 2018 reporting year.

Table 33 2018 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	1,678	6,622,251	kWh	24	80
Gasoline	253,599	333,808,198	Liters (L)	11,569,792	740,974
Diesel	13,843	53,644,281	Liters (L)	2,074,961	137,645
Propane	76	291,534	Liters (L)	7,443	449
Total	**269,196**	**N/A**	**N/A**	**13,652,220**	**879,148**

Overall, GHG emissions from on-road transportation have decreased by 4.2% compared to the 2007 base year. The majority of these GHG emissions (86.5%) are from passenger vehicles, light trucks, and SUVs (Figure 7).

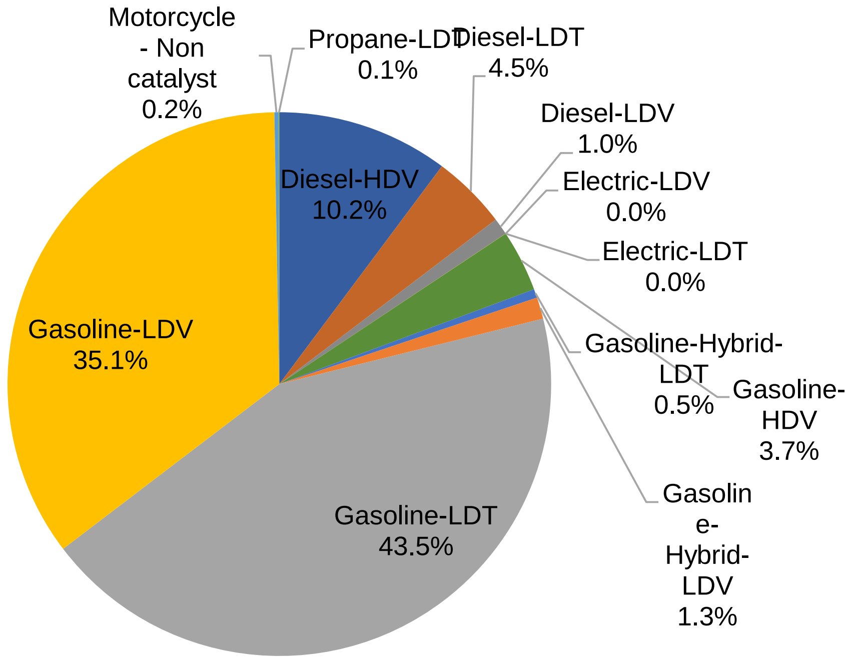

Figure 7 Breakdown of On-Road GHG Emissions by Vehicle Type

Table 34 summarizes the aviation, waterborne, and off-road transportation energy and emissions by fuel type. These GHG emissions contribute to 12.5% of the total transportation GHG emissions and 6.6% to the total inventory (Figure 8).

Table 34 2018 Aviation, Waterborne, and Off-Road Transportation Energy and Emissions by Fuel Type

Fuel Type	Total	Units	Energy (GJ)	GHG Emissions (tCO_2e)
Marine Gasoline	7,303	Liters (L)	253	16
Marine Diesel	17,654,954	Liters (L)	682,894	51,439
Aviation Jet Fuel	7,453,169	Liters (L)	258,625	19,243
Other Off-Road Transportation Diesel	19,728,427	Liters (L)	763,096	55,363
Total	**N/A**	**N/A**	**1,704,868**	**126,061**

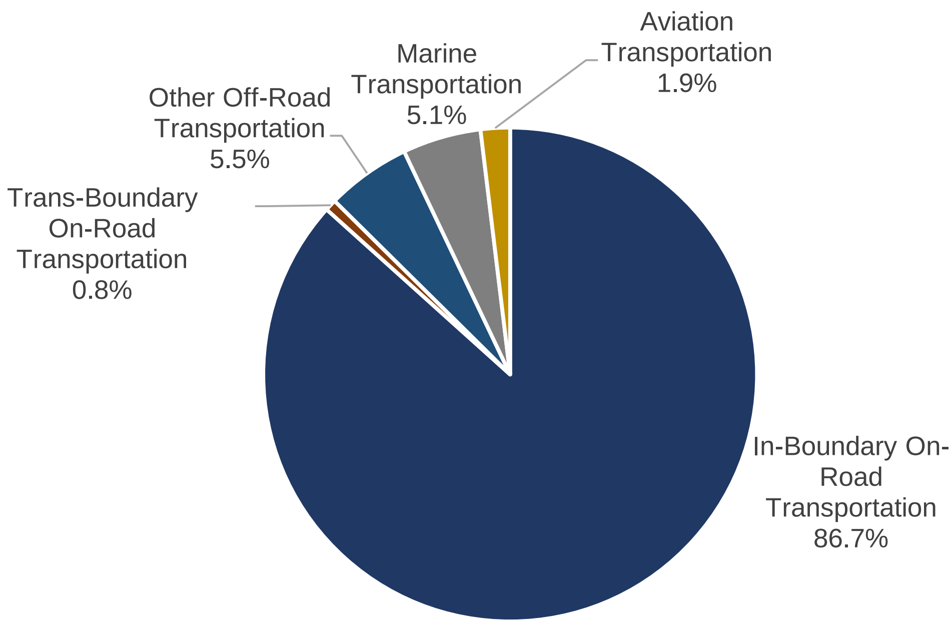

Figure 8 Summary of Transportation GHG Emissions by Sub-Sector

5.4.3 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 2018 reporting year, waste emissions contributed 5.1% to the GHG inventory. A breakdown of the Waste Sub-Sector GHG emissions is presented in Table 35.

Table 35 Summary of Waste Sub-Sector GHG Emissions

Sector	2018 GHG Emissions (tCO_2e)	GHG Emissions Per Capita (tCO_2e / Capita)	Change from Base Year (2007)
Wastewater Treatment And Discharge	19,859	0.05	4.5%
Biological Treatment of Solid Waste	5,307	0.01	7,236%
Solid Waste	71,219	0.18	-36.0%
Total	**96,386**	**0.24**	**-26.0%**

For the 2018 reporting year, in scope GHG emissions from waste have decreased by 26.0% compared to the 2007 base 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 73.9% of total waste GHG emissions (Figure 9). To reduce the amount of waste landfilled, and thus GHG emissions, the CRD and its members are making a significant effort to reduce waste going to landfills through organics diversion and recycling.

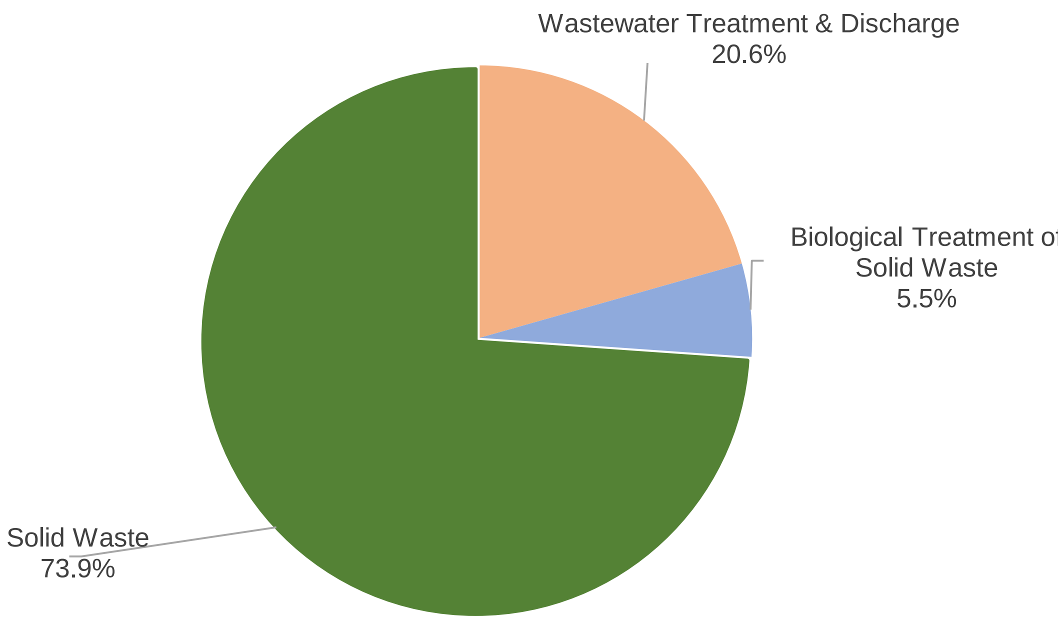

Figure 9 2018 GHG Emissions from Waste (tCO_2e)

5.4.4 Industrial Processes and Product Use (IPPU)

Reporting on IPPU GHG emissions are 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 CRD'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 CRD on the basis that other GHG emissions sources identified in the NIR are not likely to be occurring in the CRD. The sources of these GHG emissions are typically fridges, heat pumps, and air conditioners. To estimate Product Use GHG emissions for the CRD, a per capita estimate was developed using the Provincial emissions data from the 2020 NIR, and BC's NIR reporting year population from Statistics Canada. This value was applied to the 2018 reporting year population to estimate the total Product Use emissions for the CRD.

Between the 2007 and 2018 reporting years, IPPU GHG emissions have increased 67.9%. The reason for the increase is attributed to Environment Canada having better data available to make the estimate, than the actual GHG emissions increasing such an amount.

Table 36 Product Use GHG Emissions for the 2007 and 2018 Reporting Years

Sub-Sector	2007 GHG Emissions (tCO_2e)	2018 GHG Emissions (tCO_2e)	Change
Product Use Emissions	77,348	129,884	67.9%

5.4.5 Agriculture, Forestry, and Other Land Use

The AFOLU Sector includes GHG emissions from livestock, land use, and all other agricultural activities occurring within the CRD's boundaries. Using remotely sensed imagery, land cover data was used to estimate land use changes between the reporting years. In 2018, the CRD's greenspace is estimated to have sequestered and stored 209,262 tCO_2e (Table 37), a decrease of 19.2% compared to the 2007 base year.

Table 37 Summary of Land-Use Change in 2018

Land-Use Type	Total Hectares (ha)	Sequestered (-) / Released (+) GHG Emissions in tCO_2e
Forest Land	167,091.9	1,335.8
Cropland	4,567.8	(42,773.1)
Grassland	18,906.5	(128,443.5)
Wetlands	6,865.3	(41,261.0)
Settlements	20,654.6	1,879.7
Other Land	12,931.7	-
Total	**231,017.8**	**(209,262.2)**

5.4.5.1 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 CRD is reporting 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

Table 38 summarizes these other land-use GHG emissions for the 2018 reporting year. Compared to the 2007 base year, these GHG emissions have increased 7.7%.

Table 38 Total AFOLU GHG Emissions for 2018

AFOLU Sub-Sector	GHG Emissions (tCO_2e)
Livestock	4,299
Aggregate Sources And Non-CO_2 Emissions Sources On Land	1,010
Total	**5,310**

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 CRD, 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 CRD reviews to confirm assumptions, data and reasonableness of the estimates.

7.0 RECOMMENDATIONS

To remain accurate and reflective of the current community conditions, the CRD should revise and improve its GHG emissions inventory either annually or in line with capital planning cycles (i.e., every 3-4 years), to which there are the following aspects should be focused on:

- 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 base 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 2018 GHG emissions inventory, there are several assumptions were made in the analysis that will have some influence on accuracy of the CRD'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 39 which summarizes the main assumptions, possible impacts on the data, and recommended improvement. It is recommended that the CRD prioritize improvements for that are likely to have a material (>5%) influence on the GHG inventory estimate.

Table 39 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	The energy utility providers provide energy in lump sum amounts for: residential, commercial, and industrial. As such, other sectors, like agricultural buildings, could not be split out. A related accuracy issue is the assignment of mixed use buildings without separate metering.	No impact on the GHG inventory. The change would only happen between emission sub-sectors.	Work with the utility provider to get a more detailed breakdown of energy use by sub-sector.

Table 39 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	Propane, fuel oil and wood GHG emissions were estimated based on 2007, 2010, and 2012 CEEI GHG emissions. for the District of Saanich and the City of Victoria, heating oil emissions were estimated based on the number of known tanks and the estimated square footage based on BC Assessment data, and the estimated average annual energy usage.	Immaterial impact on the GHG inventory (<5%)	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. Work with the Province on developing a methodology to estimate wood fuel use.
Stationary Energy	FortisBC provided a total estimate of fugitive emissions for the CRD region for the 208 reporting year only; however, this did not include upstream fugitive emissions as suggested as best practice by the GPC Protocol.	Immaterial impact on the GHG inventory (<5%)	Work with FortisBC to refine this estimate.
Transportation	ICBC has not been collecting off-road vehicle data so this source could not be estimated.	Immaterial impact on the GHG inventory (<5%)	Work with ICBC to begin collecting this data regionally.
Transportation	ICBC provided the Province of BC with raw vehicle registration data which was then processed and provided to the CRD. It is understood that some vehicle category registrations were withheld or not included in the inventory which results in the under estimation of GHG emissions.	Immaterial impact on the GHG inventory (<5%)	Work with Province to derive an estimate of how vehicles may be excluded so that the GHG emissions may be estimated.
Transportation	Taxable fuel volumes only represent about 67% of taxable fuel sales (a value that fluctuates yearly). Without more detailed information, a fuel allocation amount could not be allocated to the CRD. As such, the	Possibly material (>10%) impact to the GHG inventory. Using the estimated VKT data, it is likely that the CRD is over-estimating the GHG emissions from	If the CRD can get complete fuel sales data for the Region, a more robust estimate of fuel use and GHG emissions, using vehicle registration data, can be determined. If the CRD can incorporate estimated

Table 39 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	CRD had to rely on vehicle registration data from ICBC and estimated vehicle kilometers travelled (VKT). The CRD's 2016 Origin and Destination Study estimates total VKT data was considered but was deemed to likely result in significant underestimate of GHG emissions as the study estimates that light duty vehicles in the CRD travel less than 5,000 km per year. This is less than 1/3 of the national average. On this basis, the VKTs from a 2009 National vehicle travel study for Canada were applied.	transportation. This is the most conservative approach available to the CRD at this point.	travel data, in VKT through its next Origin Destination Survey, this data could be used to replace the 2009 study and be more specific to CRD and its members.
Transportation	The Victoria International Airport does not report on GHG emissions from tenants or aircraft. Keeping in line with the GPC Protocol, only the aircraft GHG emissions were estimated using NAV Canada airplane movement statistics, estimated taxi times, and estimated fuel use. The fuel use only accounts for departing and arriving planes up to 3,000ft to avoid double counting with other cities.	Immaterial impact on the GHG inventory (<5%)	The Victoria International Airport will not be collecting or reporting on GHG emissions from tenants or aircraft. This is the best available data at this point.
Transportation	The GHG emissions from recreational watercraft and US/Can ferries were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors.	Immaterial impact on the GHG inventory (<5%)	Work with the Victoria Harbor Master as they begin to deploy a database tracking the types and number of boats entering the Victoria harbor.
Transportation	The GHG emissions from marine aviation are estimated based on Victoria Harbor NAV Canada air traffic movements for 2016. Statistics Canada	Immaterial impact on the GHG inventory (<5%)	No recommended improvement currently.

Table 39 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	stopped collecting Victoria Harbor aircraft movement data in 2016. To estimate 2018 marine aviation GHG emissions, the 2016 data was applied and adjusted using the change in aircraft traffic between the 2016 and 2018 reporting years at the Victoria International Airport. It is assumed that the activity at both airports would be corelated, but not causational.		
Waste	There is tracking to the origin of solid waste but is based on reported origin which may or may not be accurate. For example, some haulers will identify that they are hauling waste from Victoria when in fact the waste is originating from Saanich.	There is no impact to the GHG Inventory for the CRD but will have impacts to the CRD member inventories.	Work with waste haulers to devise a better system to track waste origination.
IPPU	Product use emissions were estimated on a per capita basis using the 2020 NIR estimates. The product use emissions were estimated by the NIR using an IPCC Tier 1 approach and thus will have high uncertainty.	Immaterial impact on the GHG inventory (<5%)	No recommendations currently.
AFOLU	GHG estimates for land use change are based on a period of years (2011-2017) and thus were averaged for each period. As there was no current data, land use change for the reporting year was estimated using the average value between the data years.	Immaterial impact on the GHG inventory (<5%)	Work with the planning department to track land-use change annually so that a more refined estimate can be made.
AFOLU	The land-use data available for the CRD was incomplete between and within reporting years (e.g., some land-use data was collected in early	Immaterial impact on the GHG inventory (<5%)	Complete a region wide land-use analysis every 3-5 years to track land use change.

Table 39 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	spring and others collected in summer). As such, other data sets, like building footprint data, had to be used to estimate changes in land use.		
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 CRD. 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 CRD 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 University to derive refined sequestration emission factors.

8.0 REFERENCES

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CAPITAL REGIONAL DISTRICT 2018 GPC BASIC+ COMMUNITY GREENHOUSE GAS (GHG) EMISSIONS INVENTORY REPORT

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