Emissions Inventory Compilation and Forecast for the Cowichan Valley Regional District

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List of Acronyms

BC	British Columbia
BRN	Burning Reference Number
CEPEI	Canadian Energy Partnership for Environmental Innovation
dscm	Dry Standard Cubic Meter
DWT	Deadweight tonnage
EC	Environment Canada
ECx	Pollutant-specific Emission Control Factor
EDMS	Emissions and Dispersion Modelling System
EF	Emission Factor
EIIP	Emission Inventory Improvement Program
EPA	Environmental Protection Agency
FLNRO	Ministry of Forests, Lands and Natural Resources
FVRD	Fraser Valley Region District
GIS	Geographic Information System
GJ	Gigajoule
h	Hour
ha	Hectare
hp	Horsepower
km	Kilometre
LPG	Liquefied Petroleum Gases
LTO	Landing and takeoff
MoE	Ministry of Environment
mg	Milligram
MMBtu	One Million British Thermal Unit
MV	Metro Vancouver
NG	Natural Gas
NH_3	Ammonia
NOx	Nitrogen Oxides
NPRI	National Pollutant Release Inventory
OCPs	Official Community Plans
OFTS	Open Fire Tracking System
OGVs	Ocean Going Vessels
PEMs	Predictive and Parametric Emissions Monitoring
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter Less than 2.5 microns in Equivalent Diameter
PM_{10}	Particulate Matter Less than 10 microns in Equivalent Diameter

QA/QC	Quality Assurance and Quality Control
RPP	Refined Petroleum Products
SOx	Sulphur Oxides
t	Metric tonne
TPM	Total Particulate Matter
US EPA	United States Environmental Protection Agency
VKM	Vehicle Kilometres Travelled
VOCs	Volatile Organic Compounds
yr	Year

Executive Summary

Background

Levelton Consultants Ltd. (Levelton) was retained by BC Ministry of Environment (MoE) to compile an emissions inventory for the Cowichan Valley Regional District (CVRD) on Vancouver Island. The main purpose of the study is to provide direction to air quality/emissions managers in the CVRD regarding which pollutants and individual sectors/subsectors are most likely to require management actions. The regional inventory was compiled for 2011 as the base year. The base year emissions have been forecast at five-year intervals for 2016, 2021, 2026 and 2031.

Scope

The CVRD regional emissions inventory was compiled for the following pollutants of interest:

- Particulate Matter (PM), including the following size fractions:
  - Particulate matter less than 2.5 microns in equivalent diameter ($PM_{2.5}$);
  - Particulate matter less than 10 microns in equivalent diameter (PM_{10});
  - Total particulate matter (TPM);
- Carbon Monoxide (CO);
- Sulphur Oxides (SOx);
- Nitrogen Oxides (NOx);
- Ammonia (NH_3); and
- Volatile Organic Compounds (VOCs).

The source categories included point sources (large industrial facilities), area sources (light industrial, residential, commercial and institutional sources, agricultural activities, miscellaneous sources), mobile sources (on-road motor vehicles and non-road sources including aircraft, marine vessels, and others such as construction and lawn and garden equipment), and road dust. A summary of the emission inventory and emission trends for point, area, and mobile sources are provided below.

Baseline Emission Summary

The 2011 baseline CVRD emissions for point, area and mobile sources are summarized in Table ES-1. Mobile sources, excluding road dust, were the largest contributor of CO and NOx. The largest emitters for SO_2 were point sources. Majority of TPM, PM_{10}, $PM_{2.5}$, VOC and NH_3 emissions were from area sources.

Table ES-1 CVRD Baseline Emission Inventory by Source Sector

Emission Source	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Point Source	1,922.7	1,084.7	637.3	406.6	256.4	2,173.0	940.6	
Area Source	5,172.7	343.1	1,700.3	1,304.9	1,164.8	21.9	1,412.3	241.4
Mobile (excluding road dust)	10,082	2,553	88	86.8	82.8	5.7	811.6	22.6
Total	17,178	3,981	2,425	1,798	1,504	2,201	3,165	264.0

Point Sources

A total of 19 facilities were identified within the CVRD area. Among them, emissions for 14 facilities were taken from the air permits database and the emissions for the remaining 5 facilities were obtained from the National Pollutant Release Inventory (NPRI). An emission summary for point sources is presented in Table ES-2.

Table ES-2 Summary of 2011 CVRD Industrial Point Source Emission Inventory by Subsector (metric tonnes)

Industry Sector	Emissions (metric tonnes)						
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Pulp and Paper	1,673.3	1,028.2	396.0	312.8	220.4	2,166	632.8
Sawmills	43.31	50.30	171.16	60.6	19.96	0.67	20.33
Wood Products	206.06	5.85	37.21	21.06	13.58	1.29	14.6
Petroleum Product Storage							272.9
Cement	0.08	0.33	7.73	2.34	0.41	4.76	
Other	0.01	0.04	25.20	9.825	2.05		
Total	1,922.7	1,084.7	637.3	406.6	256.4	2,173	940.6

The majority of industry emissions were from the pulp and paper sector, which accounted for 87% of CO, 95% of NOx, 62% of TPM, 77% of PM_{10}, 86% of $PM_{2.5}$, 67% of VOC, and 99.7% of SOx emissions in this sector. The petroleum product storage sector was the second largest contributor at 29% in terms of total VOC emissions.

Area Sources

The breakdown of area source CAC emissions by sub-sector is summarized in Table ES-3. Open burning was the largest contributor of CO, NOx, TPM, PM_{10} and $PM_{2.5,}$ VOC emissions from gasoline marketing and solvent evaporation accounted for approximately half of the total VOC emissions from area sources.

Agricultural activities were the largest source for the regional NH_3 emissions and the main contributor of SO_2 emissions is from space heating.

Table ES-3 Summary of Area Source Emission Inventory by Subsector (metric tonnes)

Emission Source	Emissions (metric tonne)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Space Heating	2,120.1	122.3	364.5	344.5	344.5	15.4	484.6	6.5
Agricultural Sources			72.99	26.93	5.86		47.8	149.0
Open Burning	3,049.7	219.9	1,241.5	912.2	800.9	6.5	223.8	64.7
Gasoline Marketing							108.3	
General Solvent Use							547.1	
Miscellaneous Area Sources	3.03	0.88	21.39	21.39	13.55	0.00	0.67	21.15
Total Area Sources	**5,172.7**	**343.1**	**1,700.3**	**1,304.9**	**1,164.8**	**21.9**	**1,412.3**	**241.4**

Mobile Sources

Emissions from mobile sources are summarized in Table ES-4. Data analyses indicated that emissions from on-road mobile source were the largest contributor of all CACs with exception of NOx. The second largest emission contributor to CO, TPM, PM_{10}, $PM_{2.5}$ and VOC emissions was non-road equipment/vehicles. CAC emissions due to aircraft activity were insignificant.

Table ES-4 Summary of Emissions from Mobile Sources* (metric tonnes)

Emissions from Mobile Source	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
On-road Emissions	7,033	1,152	39.3	39.3	37.4	4.9	538.0	21.69
Non-road Emissions								
Marine	93.09	1158.72	21.22	20.37	19.52	0.53	36.36	0.61
Aircraft	8.79	0.24	0.007	0.007	0.007	0.037	0.29	0.00
Non-road Equipment	2947.68	242.72	27.17	27.17	25.89	0.29	236.93	0.31
Mobile (Total)	**10,082**	**2,553**	**88**	**87**	**83**	**6**	**812**	**22.6**

*: Road dust was excluded in the mobile sources

Emission Inventory Forecast

The base year emissions have been forecast, at five-year intervals for 2016, 2021, 2026 and 2031. Emission forecasts were based on regional statistics when these data are available and determined by assigning appropriate surrogate factors. A summary of the emission forecast for the CVRD is presented in Table ES-5. In general, emission trends for NOx, TPM, PM_{10}, $PM_{2.5}$, VOC, and NH_3 exhibited an increase compared to the baseline. Regional CO emissions were forecast to decrease to the lowest level in 2021 (16,734 tonnes) before an upward trend was observed. The decrease in CO emissions was mainly attributed to lower demand for gasoline. SO_2 were predicted to remain at relatively stable emission rates at around 2,200 tonnes annually.

Table ES-5 Emission Forecast for CVRD Emissions Inventory (metric tonnes)

CVRD Inventory Forecast	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	17,177.8	3,981.3	2,425.3	1,798.3	1,504.1	2,200.6	3,164.5	264.0
2016	16,876.4	4,406.6	2,472.1	1,843.3	1,547.5	2,200.7	3,202.4	264.3
2021	16,733.5	4,595.9	2,513.7	1,883.2	1,586.3	2,200.3	3,253.6	265.0
2026	16,873.4	4,696.8	2,548.3	1,916.4	1,618.6	2,200.5	3,320.4	266.5
2031	17,016.1	4,805.0	2,572.2	1,939.4	1,640.6	2,200.5	3,377.0	267.9

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1. Introduction

Levelton was retained by BC Ministry of Environment (MoE) to compile a criteria air contaminants (CACs) inventory for the Cowichan Valley Regional District (CVRD) in Vancouver Island. The regional emission inventory was compiled for the base year of 2011 to coincide with the most recent census data. The 2011 CVRD inventory encompasses emission estimates for industrial point sources, diverse area sources, as well as on-road and non-road mobile sources. The 2011 base year inventory has been forecast at five-year intervals for 2016, 2021, 2026 and 2031 to estimate future emissions due to activity changes, future regulation requirements and technology advances. The forecast provides supportive information in identifying which pollutants and/or industrial sectors/sub-sectors are most likely to require management actions.

The report presents the results of the 2011 CVRD airshed emission inventory and forecast for each emission source category and identifies the largest sector and sub-sector emission contributors in the CVRD emissions inventory.

2. Study Area

The airshed emission inventory comprises the following CVRD regions:

- Areas A (Mill Bay/Malahat);
- Area B (Shawnigan Lake);
- Area C (Cobble Hill);
- Area D (Cowichan Bay);
- Area E (Cowichan Station/Sahtlam/Glenora);
- Area F (Cowichan Lake South/Skutz Falls);
- Area G (Saltair/Gulf Island);
- Area H (North Oyster/Diamond);
- Area I (Youbou/Meade Creek); and
- The municipality of North Cowichan, the City of Duncan, Ladysmith, Crofton, Lake Cowichan, and First Nations Lands.

In 2011, the CVRD airshed had a population of approximately 83,000[1], which accounts for 1.9% of the total population in BC. The 2011 population figures are for comparative purposes. Figure 2-1 shows the location of the study area.

[1] BC MoE Community Energy and Emissions Inventory (CEEI), http://www2.gov.bc.ca/gov/topic.page?id=9CD252EC63C84868AC2325F70E21683C&title=Community%20Energy%20%26%20Emissions%20Inventory%20%28CEEI%29, accessed in Feb 2014

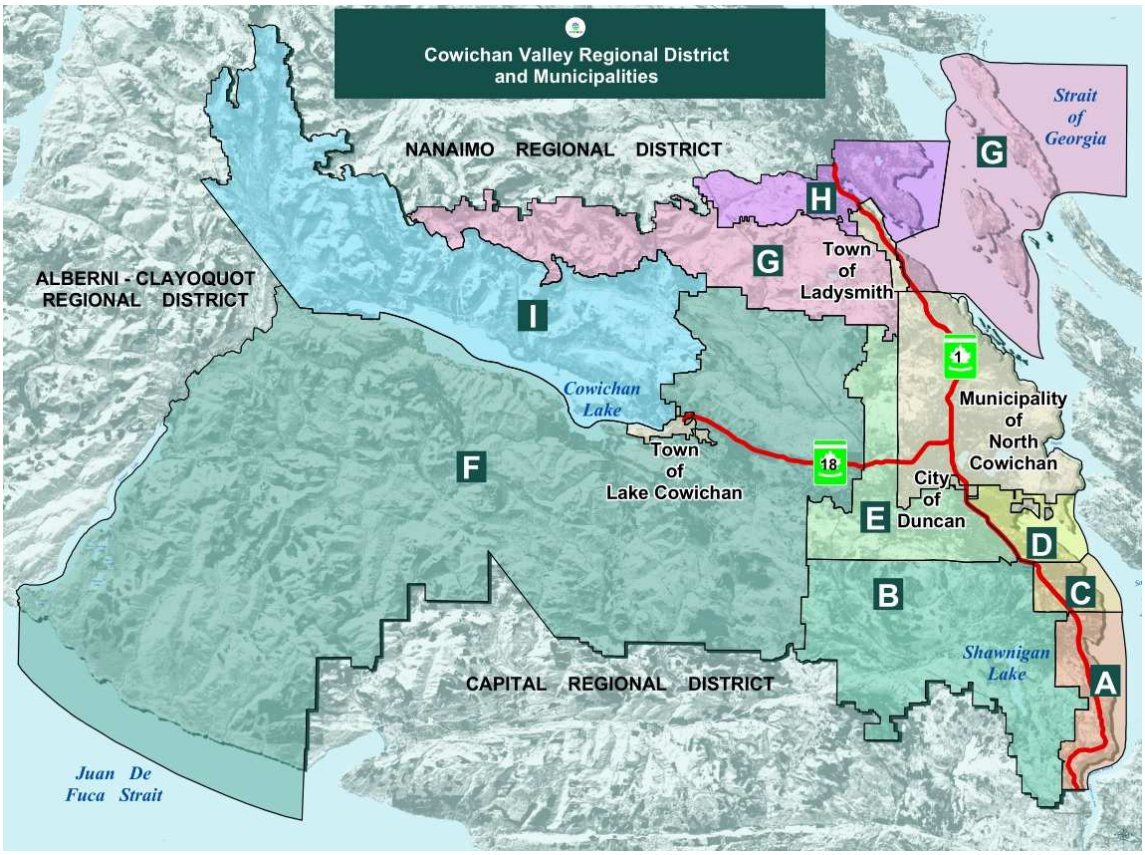


Figure 2-1 CVRD Emissions Inventory Study Area[2]

3. Substances Included

The pollutants which are of interest to the CVRD inventory are CACs, which consists of the following contaminants:

- Particulate Matter (PM), including the following size fractions:
  - Particulate matter less than 2.5 microns in equivalent diameter ($PM_{2.5}$);
  - Particulate matter less than 10 microns in equivalent diameter (PM_{10});
  - Total particulate matter (TPM);
- Carbon Monoxide (CO);
- Sulphur Oxides (SO_x);
- Nitrogen Oxides (NO_x);
- Ammonia (NH_3); and
- Volatile Organic Compounds (VOCs).

[2] Geocortex® Internet Mapping Framework, http://maps.geocortex.net/imf-5.2.0/sites/cvrdbasic/jsp/launch.jsp?popup_blocked=true, accessed in Feb 2014

4. Sources of Emissions

CVRD emission inventory consists of the following major categories of emissions: point, area, mobile, and road dust sources. The breakdown of each source category is illustrated below:

Point Sources
Point sources are large stationary, identifiable industrial facilities that are required to report their emissions to regulatory programs or are authorized to release emissions under the Environmental Management Act. Industrial sources were further grouped into the following sectors of relevance to the CVRD: pulp and paper, sawmill, wood products, petroleum product storage, cement, and others.
Area Sources
Area sources include smaller, broadly-distributed light industrial, commercial, institutional, residential, agricultural or naturally occurring emission sources. Area sources include: space heating, livestock, fertilizer and pesticide application, soil tilling, wind erosion, open burning, gasoline marketing, general solvent use, as well as miscellaneous sources, such as meat cooking, cigarette smoking, respiration and perspiration, and construction operation.
Mobile Sources
Mobile sources include both on-road as well as non-road vehicles and engines. Emissions from on-road sources include small passenger cars, large passenger cars, light trucks, vans, SUVs, commercial vehicles, tractor trailer trucks, motorhomes, motorcycles, mopeds, buses. The non-road emissions include non-road vehicles and equipment, marine vessels, and aircraft.
Road Dust
Road dust represents fugitive emissions from paved and unpaved roads due to the motion of vehicles along the surface. Road dust, which mainly consists of particulate matter, was expected to be a non-buoyant source and the impacted area is believed to be small. For this study, road dust is excluded in overall regional emission inventory analysis due to its data uncertainty and validity.

5. Air Emission Inventory Methodology

5.1 General Overview of Emission Quantification

Generally, several commonly accepted emission quantification methods, with varying degrees of accuracy, can be used to estimate air emissions from a given source. Depending on the source, one or a combination of these different methods may be needed for the emissions estimation. The data required and the level of effort needed for the gathering of data and performing the analysis are different for each estimation method. These recognized quantification methods, in order from highest to lowest accuracy, are listed below.

- Continuous Emission Monitors (CEMS);
- Predictive & Parametric Emissions Monitoring (PEMs);
- Stack Sampling;
- Mass Balance Estimates;
- Industrial Process Emission Models;

- Vendor Supplied Emission Factors;
- Industry Specific Emission Factors;
- Generic Emission Factors;
- Engineering Estimates.

The CVRD emissions quantification approach focused on the use of data of the highest accuracy available whenever possible. If no monitoring/sampling data are available, the emissions estimation method follows a generic formula shown by the equation below.

$$E_x = AF * EF_x * EC_x \qquad \text{Equation (a)}$$

where:

Ex = Emission of contaminant x

AF = Activity factor (e.g. fuel consumption, material processed, etc.)

EFx = Pollutant-specific emission factor

ECx = Pollutant-specific emission control factor

The activity data are from various sources, such as BC MoE, BC Statistics, the CVRD, Community Energy and Emissions Inventory (CEEI) [3], and Statistics Canada. The main emission factors (EF) were taken from the United States Environmental Protection Agency (US EPA) AP-42 (Fifth Edition)[4], the Metro Vancouver (MV) 2005 Methodology Report[5] as well as the MV 2010 Emissions Inventory and Forecast report[6] as appropriate. The following sections describe the methodologies for quantifying the pollutants of interest for the point, area and mobile sources in the CVRD study area.

5.2 Point Sources

Point sources are defined as large stationary, identifiable industrial facilities or utilities typically operating under an air discharge permit, rule or regulation. Emission information for point sources was compiled mainly from the following major files:

1. BC MoE Authorization Management System (AMS)[7];
2. 2011 National Pollutant Release Inventory (NPRI)[8]; and
3. Facility Stack Sampling Report.

[3] http://www.env.gov.bc.ca/cas/mitigation/ceei/reports.html (accessed in Feb 2014)

[4] US EPA AP42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, http://www.epa.gov/ttnchie1/ap42/ (accessed in Feb 2014).

[5] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

[6] Metro Vancouver, 2013. 2010 Lower Fraser Valley Air Emissions Inventory and Forecast and Backcast, Final Report and Summarized Results, http://public.metrovancouver.org/about/publications/Publications/2010LowerFraserValleyAirEmissionsInventoryandForecastandBackcast.pdf, (accessed in Feb 2014)

[7] BC MoE Water and Air Monitoring and Reporting Environmental Databases, http://www.env.gov.bc.ca/epd/wamr/ems_internet/#emsmon, (accessed in Feb 2014)

[8] Environment Canada, National Pollutant Release Inventory, http://www.ec.gc.ca/inrp-npri/, (accessed in Feb 2014)

BC MoE's AMS is a database that includes industrial facilities that are permitted to discharge air contaminants under the Environmental Management Act. Only large sources that are identifiable or have a significant impact on the surrounding environment are required to obtain an air permit. The air emission permits can be used to estimate emissions from a facility. In reality, the actual emissions could release more or less than the maximum allowable limits stipulated in the air permits depending on the actual operation condition in 2011. The NPRI is a publicly accessible annual inventory of pollutant releases, disposals and transfers. However, only facilities that meet certain emission thresholds are required to report under the NPRI program. Stack monitoring is a sampling program implemented at facilities to measure actual emissions during normal operation condition.

For this study, emissions from point sources were built upon the AMS database with supplemental emission information from NPRI and stack testing data. For this inventory, TPM emissions from cyclones in wood products sector, as provided in the AMS database, were assumed to be 50% of the maximum permitted limits. Emissions of PM_{10} and $PM_{2.5}$ emissions were estimated at 30% and 5% of TPM respectively as a first approximation based on a particulate emission study for wood product sector[9]. Small facilities that are not covered by large point sources were quantified under the area sources category.

Data sources of industrial emissions were documented in Levelton's inventory database for record keeping/tracking. Each facility's emissions were disaggregated to CVRD electoral area/municipality level using latitude and longitude information in the database. Industrial facilities were further categorized into the following sectors of relevance to CVRD:

- Pulp and Paper;
- Sawmill;
- Wood Products;
- Petroleum Product Storage;
- Cement; and
- Others.

5.3 Area Sources

Area sources include smaller, broadly-distributed light industrial, commercial, institutional, residential, agricultural or naturally occurring emission sources. Area sources are typically too small to require individual air permits, but may be addressed under more broad-based regulations. They are normally inventoried as an aggregate category.

Two approaches were used to compile area sources. The first approach is a bottom-up method when regional level activity data are available. The bottom-up approach applies published emission factors to corresponding activity data such as fuel use, animal counts, fertilizer consumption, and others (Equation (a) in Section 5.1). If regional activity data are not available, a top-down approach, which involves the scaling down of emissions from provincial datasets to regional level, was used. For each area source sector, a brief description of the emission factors used, activities data applied, and surrogate parameters chosen, if any, for scaling emissions to regional level is provided below. For temporal resolution, emissions for each area source were estimated on an annual basis based on its activity profile.

[9] AMEC Americas Limited, Final Report – Wood Product Sector Particulate Emission Study, prepared for Forest Products Association of Canada, Environment Canada, National Council for Air and Stream Improvement

5.3.1 Space Heating

Space heating emissions include commercial, institutional, and residential sources. Emissions from space heating arise from the combustion of light and heavy grades of fuel oil and/or natural gas, as well as wood stoves, and wood furnaces and/or boilers. Emission factors for fuel combustion are from US EPA AP42, Chapter 1: External Combustion Sources[10]. Ammonia emissions factors were taken from US EPA EIIP (2004)[11]. SO_x emissions were quantified based on a sulphur content of 17 mg/dscm of natural gas consumed and 0.037% in fuel oil[12] consumed. NO_x emission factors for commercial/industrial natural gas boilers were based on an arithmetic mean of uncontrolled emission factors for various boiler configurations within the 100 MMBtu/h (105.5 GJ/h) size category.

For particulate matter (PM) emissions from natural gas combustion, it has been noted in a recent report prepared for Canadian Energy Partnership for Environmental Innovation (CEPEI) that PM emission factors from the US EPA AP42, which were derived using traditional sampling methods, are significantly higher than those obtained by using the dilution tunnel tests and the AP42 emission factors have also been reported to show some bias[13]. Despite the CEPEI study findings, the more conservative AP 42 emission factors for natural gas combustion were applied in the CVRD inventory since the CEPEI factors are incomplete and only account for the filterable fraction and not the total PM.

The CVRD regional level energy consumption data were obtained from the CEEI website[14] for the CVRD areas. The latest updated CEEI report available was for 2010 and it was directly adopted to approximate 2011 base year emissions. CAC emissions from wood combustion were from a recent wood stove inventory[15] with the exception of NH_3. NH_3 emissions were quantified using emission factors from US EPA EIIP (2004). Table 5-1 summarizes the activity data and emission factors used for space heating emissions quantification.

Table 5-1 Energy Consumption and Emission Factors for Space Heating

Fuel Type	Fuel Consumption (GJ)	Emission Factor (kg/GJ)							
		CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Residential NG	310,128	0.017	0.040	0.0008	0.0008	0.0008	0.00094	0.0023	0.000237
Residential Oil	524,081	0.015	0.055	0.0012	0.0012	0.0012	0.016	0.0022	0.0031
Commercial / Industrial NG	605,868	0.036	0.057	0.0008	0.0008	0.0008	0.0009	0.0023	0.000058
Residential Propane	90,362	0.035	0.061	0.00094	0.00094	0.00094	0.00047	0.0038	-
Wood*	628,066	3.31	0.0653	0.5780	0.5461	0.5461	0.0096	0.7658	0.0077

*: Emission factors for wood were back calculated using emission data from wood stove survey and CVRD wood consumption data

[10] US EPA AP42, Fifth Edition, Volume I, Chapter 1: External Combustion Sources, http://www.epa.gov/ttnchie1/ap42/ch01/ (accessed in Feb 2014)

[11] US EPA Emission Inventory Improvement Program (EIIP), Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report, 2004

[12] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

[13] Ortech Environmental, Methodologies Manual for the 2012 Calculator Airborne Contaminant Emissions from Natural Gas Combustion, 2013

[14] http://www.env.gov.bc.ca/cas/mitigation/ceei/reports.html (accessed in Feb 2014)

[15] Envirochem Services Inc., Wood Stove Inventory and Behaviour Analysis, 2012

5.3.2 Agricultural Sources

Agricultural emissions from livestock, fertilizer and pesticide use, soil tilling and wind erosion sources have been included in the scope of this inventory study. Recently, the CVRD and the Ministry of Agriculture have completed an agricultural land analysis[16] at the lot level which can be linked and used for more refined analysis if necessary at a community or lot level. The agricultural land area survey was conducted using geographic information system (GIS) data in 2012 for Agricultural Water Demand Modeling purpose. For this project, the activity data, such as the number of animals and area of farm land in crops, have been collected at the census division (CD) level (Cowichan Valley, CD 590119000) from the 2011 Agricultural Census (Statistics Canada, 2011)[17] for data source consistency purpose. CD level referred to in the Statistics Canada is the same as the CVRD region geographically.

5.3.2.1 Livestock

Livestock generate particulate matter and VOCs from animal husbandry operations. The primary mechanism for releases of particulate matter is the entrainment of feeds, dry manure, soil, and other material caused by movement of animals in both indoor and outdoor confinement while the emissions of VOCs are from the excreta of livestock. Livestock NH_3 emissions arise from the microbial decomposition of manure. The nitrogen in animal manure can be converted to ammonia by a combination of mineralization, hydrolysis, and volatilization processes.

CAC emission factors used in this study are taken from the Metro Vancouver 2005 Methodology Report[18] with the exception of VOCs. The VOC emission factor in this study was adjusted to be 78.7% lower than the published 2005 data as Metro Vancouver believes this new VOC emission factor is more accurate than the EF contained in the 2005 publication (Sidi, 2014)[19]. The activity data for this source are the numbers of animals by types and they have been obtained from the 2011 Census of Agriculture, Farm Data and Farm Operator Data, catalogue no. 95-640-X (Statistics Canada, 2011). Table 5-2 shows the animal types, quantities and emission factors in units of kilograms of pollutant per animal type.

[16] CVRD and Agricultural and Agri-Food Canada, 2012, Agriculture Waster Demand Model, Report for the Cowichan Valley Regional District.

[17] Statistics Canada, http://www.statcan.gc.ca/ca-ra2011/index-eng.htm (accessed in Feb 2014)

[18] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

[19] Shelina Sidi, Metro Vancouver, 2014, personal communication

Table 5-2 Livestock Types, Quantities and Emission Factors

Livestock		Animal Counts	Emission factors (kg/head/year)				
		Head	TPM	PM_{10}	$PM_{2.5}$	VOC	NH_3
Cattle	Steers	219	6.38	2.13	0.32	2.98	10.32
	Dairy cows	3,582				7.18	21.03
	Bulls	93				5.01	12.92
	Beef Cows	946				4.79	10.5
	Dairy Heifers	1,769				3.89	10.08
	Beef Heifers	218				3.99	10.08
	Heifers for slaughter	456				3.35	10.08
	Calves	2,286				2.13	7.91
Pigs	Boars	5	3.74	1.87	0.37	0.07	5.68
	Sows	36	2.76	1.38	0.28	0.09	11.04
	Pigs	256	0.76	0.38	0.08	0.04	
Sheep	Ewes and rams	1,345				0.42	2
	Market Lambs	1,481				0.20	2
Poultry[1]	Broilers	39,644	36.76	3.68	0.36	0.21	0.21
	Layers	170,237	19.98	3.996	0.396	0.64	0.37
Horses[2]	Paddocks	357	2.15	0.72	0.11	0.88	8.67
	Rings	357	1.61	0.54	0.08	0.88	8.67
Miscellaneous Animals	Goats	712				0.61	6.4
	Llamas & Alpacas	431				0.61	1.08

[1] Emission factors for poultry are in kg/1000head/year

[2] Amount of paddocks and rings are evenly distributed based on total horses at the regional level

5.3.2.2 Fertilizer and Pesticides Application

Fertilizers provide essential plant nutrients in the soil to improve crop production and pesticides are used to kill or control undesired insects, fungi and weeds (insecticides, fungicides, and herbicides). The PM emission factors for fertilizers and pesticides were obtained from the Metro Vancouver 2005 Methodology report[20]. The size in hectares of the land area to which pesticides (herbicides, fungicides, and insecticides) were applied was taken from 2011 Statistics Canada at regional level. The fertilizer sales data were provided by the CVRD staff based on information from five retailers of fertilizer. Emissions due

[20] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

to fertilizer application only included sales from three retailers and the sales from other two retailers were not included in the EI compilation due to data unavailability. An ammonia emission factor of 130 kg NH_3/tonne of fertilizer was applied to this study based on US EPA AP42, Chapter 9.2.1[21]. Table 5-3 lists the emission factors and activity data for the application of fertilizers and pesticides in the CVRD study area.

Table 5-3 Fertilizer and Pesticides Application Activity Data and Emission Factors

Application Type	Activity		Emission Factor				
	Quantity	Unit	TPM	PM_{10}	$PM_{2.5}$	NH_3	Unit
Fertilizer	1.88	tonne	2.23	1.09	0.31	130	kg/tonne fertilizer
Pesticide	1118	ha	1.67	0.82	0.23	0	kg/ha pesticide

5.3.2.3 Soil Tilling

The soil tilling source category includes the airborne soil particulate produced during the preparation of agricultural lands for planting and after harvest activities. Operations included in this methodology are discing, shaping, chiselling, levelling, and other mechanical disturbance of the soil by the implement used and the tractor pulling it. Emissions for soil tilling operations were quantified based on the following equation:

$$E_x = AF * EF_x * N/1000 \qquad \text{Equation (b)}$$

where:

Ex = Emission of contaminant x (tonne)

EFx = Particulate emission factor (kg/ha)

AF = Activity data (total tilling area in hectares)

N = numbers of tilling events per year per crops

The number of tilling events is dependent on crop type and tilling practice (conventional or conservation). For this study, it is assumed that the number of tilling events in the CVRD are the same as those in Metro Vancouver and the Fraser Valley Region District (FVRD) except for forage/hay and pasture. The tilling events for forage/hay and pasture are assumed to be half of those in Metro Vancouver due to twice longer average period between renovations in CVRD[22]. PM emission factors and number of tilling events per crop per season were directly taken from the 2005 Metro Vancouver Methodology Report. The crop area at the Cowichan Valley was obtained from the 2011 Census of Agriculture, Farm Data and Farm Operator Data, catalogue no. 95-640-X. The crop area and number of tilling events per crop per season is presented in Table 5-4.

[21] US EPA AP 42, Fifth Edition, Chapter 9.2.1: Fertilizer Application, http://www.epa.gov/ttn/chief/ap42/ch09/draft/d09s0201.pdf (assessed in Feb 2014)

[22] Wayne Haddow, BC Ministry of Agriculture, personal communication

Table 5-4 Crop Area and Number of Tilling Events per Season

Crop	Area	Number of Tilling Events per Season		
	ha	Spring	Summer	Fall
Corn	412	3	0.5	0.75
Forage/Hay	3836	0.5		0.25
Pasture	798	0.25		
Alfalfa	267	1		0.5
Blueberries	17	0.47		0
Turf	19	0	1	1
Other Vegetables	19	6	1.5	2

PM emission factors for soil tilling are shown in Table 5-5 and these factors are valid for soil silt contents in the range of 1.7% to 88% and a tilling speed between 8 to 10 km/h[23]. For this inventory, the PM emission factors were estimated based on a silt content of 30% in soil and moisture reduction factor of 0.02 for spring, 0.5 for summer and 0.2 for fall[24].

Table 5-5 PM Emission Factors for Tilling Operation per Season

Pollutant	Emission Factors Per Season (kg/ha)		
	Spring	Summer	Fall
TPM	4.1	20.7	4.1
PM_{10}	0.9	4.3	0.9
$PM_{2.5}$	0.2	0.9	0.2

5.3.2.4 Wind Erosion

The wind erosion process involves the detaching, transporting, sorting, abrading, avalanching, and depositing of soil particles. Turbulent winds blowing over erodible soils can cause wind erosion. Particulate matter emissions due to wind erosion of agricultural soils depend on five broad factors: a soil erodibility factor I, a surface roughness factor K (dimensionless), a climate factor C (dimensionless), an unsheltered field width factor L′ (dimensionless) and a vegetative cover factor V′ (dimensionless). The particulate matter emission factors can be calculated by the following formula where A is the measured particulate portion (A = 0.025 for TPM, 0.0125 for PM_{10} and 0.00025 for $PM_{2.5}$).

$$EF = A * I * K * C * L' * V' \qquad \text{Equation (c)}$$

[23] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

[24] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

Metro Vancouver has developed wind erosion emission factors for 12 regions in the Lower Fraser Valley using 25-year climate normals for each crop type. For this study, the averaged PM emission factors for the entire Canadian Lower Fraser Valley (CLFV), as presented in the Metro Vancouver 2005 Methodology Study, were applied to the CVRD region as the first approximation. Land area by each type of crop was obtained from the 2011 Census of Agriculture at regional level for data consistency purpose with other agricultural activity. The land area and emission factors for each type of crop are presented in Table 5-6.

Table 5-6 Land Area and PM Emission Factors for Wind Erosion

Crop	CVRD Area (ha)	Emission Factor (t/ha)		
		TPM	PM_{10}	$PM_{2.5}$
Oats	32	0.0000	0.0000	0.0000
Barley	49	0.0000	0.0000	0.0000
Grain Corn	20	0.1079	0.0540	0.0120
Silage Corn	392	0.0717	0.0359	0.0080
Alfalfa and Alfalfa Mixtures	267	0.0000	0.0000	0.0000
Other Tame Hay	3836	0.0000	0.0000	0.0000
Potatoes	10	0.0406	0.0203	0.0045
Other Field Crops	4	0.0000	0.0000	0.0000
Vegetables	88	0.0678	0.0339	0.0075

5.3.3 Open Burning

5.3.3.1 Prescribed Burning

Prescribed burning is the combustion of material in larger cleared areas as a result of agricultural land clearing, or for the purpose of industrial/commercial building construction activities, etc. Prescribed burning emission estimates were based on activity data provided by the BC MoE staff[25] from the Ministry of Forests, Lands and Natural Resources (FLNRO). The FLNRO issues tracking burning information through the Open Fire Tracking System (OFTS) for category 3 (larger piled debris) and category 4 (resource management) burning. Category 2 (smaller piled debris) and backyard burning was not required to obtain a Burning Reference Number (BRN) from the FLNRO system and these emissions are included in backyard burning category.

Emission estimates for the prescribed burning followed the methodology documented in the BC MoE's CAC Emission Inventory Report[26]. The OFTS database were first filtered to remove burning activities that were occurred outside the CVRD in 2011. Then the prescribed burning was grouped into the following three categorizes based on pile numbers for each BRN:

- Class A: Clean, > 19.5 piles
- Class B: Dirty, > 9.5 and <19.5 piles

[25] BC MoE, Warren McCormick, 2014, Personal Communication
[26] BC MoE, Warren McCormick, CAC Emission Inventory for the Province outside of the Lower Fraser Valley for 2010, 2013.

- Class C: Very dirty, < 9.5 piles

For this study, an average volume of 190.5 m^3 per pile and wood density of 444 kg/m^3 were applied follow the same assumption used in the BC MoE CAC Emission Inventory Report. A consumption factor of 0.90 and packing ratio of 0.25 for the Class A BRNs, 0.15 for the Class B BRNs, and 0.1 for the Class C BRNs were also applied as suggested in the BC MoE CAC Emission Inventory Report. Emission factors and activity data for prescribed burning are presented in Table 5-7.

Table 5-7 Activity Data and Emission Factors for Prescribed Burning

Burning Category	Quantity (tonne)	Emission Factor (kg/tonne)							
		CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Class A (Clean)	101,825	26.3	2	11	7.8	6.8	0.04	1.8	0.63
Class B (Dirty)	308.1	65.2	2	13.5	10	8.5	0.04	3.4	0.63
Class C (Very Dirty)	608.6	111.1	2	18	14	11.9	0.04	9	0.63

5.3.3.2 Backyard Burning

Backyard burning refers to the burning of organic materials or household trash at residential properties. Under this category, emissions are sub-grouped into burning of residential yard waste and household waste. The residential yard waste burning is the open burning of materials such as grass clippings, leaves, as well as other yard debris such as trimmings from trees and shrubs. The open burning of household waste is the burning of nonhazardous refuse or trash produced by residents.

Backyard burning is restricted in some CVRD municipalities/towns due to local open burning bylaws[27]. Therefore, activity data for backyard burning were adjusted to exclude emissions from three such municipalities, namely Duncan, Lake Cowichan and Ladysmith to reflect the requirements of local bylaws.

Estimates of residential backyard burning emissions follow the methodology presented in the US Emission Inventory Improvement Program (EIIP) Volume 9[28]. Activity data for the amount of waste generated by households in the CVRD region were obtained from Environmental Reporting BC – Municipal Solid Waste Disposal (MSW) in B.C[29] at 386 kg/capita/year. Due to the lack of data, the CVRD residential waste composition was assumed to have the same characteristics as the US MSW stream[30] in which 19.8% are yard trimmings and wood. Based on this assumed waste composition, the annual yard waste generation rate was estimated at 76.4 kg/capita/year (0.21 kg/cap/day).

Of the total yard waste generated, it was assumed that waste composition consists of 25% leaves, 25% brush and 50% grass clippings by weight. US EPA assumed that 28% of the residential yard waste generated is burned and they occurs primary in rural areas. The same assumptions were applied to the CVRD region as first approximation to quantify yard waste generation in the study area. CAC emission

[27] BC MoE, 2011 Inventory of Air Quality Bylaws in British Columbia: Vehicle Idling, Open Burning, and Wood Burning Appliances, January 2012

[28] US Emission Inventory Improvement Program, technical report series volume 9 particulate emissions, http://www.epa.gov/ttn/chief/eiip/techreport/volume09/index.html, accessed in May 2014

[29] BC MoE, Waste – Municipal Solid Waste Disposal in B.C. http://www.env.gov.bc.ca/soe/archive/print_ver/waste/2013_Municipal_Solid_Waste_print_ver.pdf, accessed in May 2014

[30] US EPA Municipal Solid Waste Charts, http://www.epa.gov/waste/facts-text.htm#chart2, accessed in May 2014

factors were taken from US EPA AP42 Chapter 2, section 5 for unspecified leaves, unspecified brush, and grasses. The activity data and emission factors for the residential yard waste burning are summarized in Table 5-8.

Table 5-8 Activity Data and Emission Factors for Residential Yard Waste Burning

Backyard Burning – Yard Waste	Quantity	Emission Factor (kg/tonne)				
	tonne	CO	TPM	PM_{10}	$PM_{2.5}$	VOC
Leaves	356	56	19	19	19	14
Brush	356	70	8	8	8	9
Grass Clippings	711	50	8	8	8	7.5

The residential household waste was estimated by subtracting non-combustibles, such as glass (4.6%), and metals (8.9%), as well as yard waste (19.8%) from the total to reflect the amount of household waste generated. Of this total, US EPA assumed that 28% is burned[31]. Hence, the quantity of household waste burnt is estimated at 72 kg/capita/year. CAC emission factors were taken from the US EPA (1997)[32] and US EPA EIIP Chapter 16. The activity data and emission factors for the residential household waste burning are summarized in Table 5-9.

Table 5-9 Activity Data and Emission Factors for Residential Household Waste Burning

Backyard Burning – Household Waste	Quantity	Emission Factor* (kg/tonne)						
	tonne	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Household Waste	4,791	42.5	3	19	19	17.4	0.5	4.28

*Emission factors for PMs were based on non-recycler

5.3.3.3 Forest Fires

There are also uncontrolled combustion processes, such as forest fires, that occur in a geographical area. The 2011 wildfire emissions in BC were documented in a report entitled "Wildfire CAC Emission Inventory for 2011"[33]. The report presents the methodology used for quantifying emissions and a breakdown of CAC emissions at 6 sub-regions. In 2011, there were no fires of note that were larger than 10 ha or those of public interest within the CVRD[34]. For inventory purposes, emissions due to wildfires within the CVRD were considered to be negligible.

5.3.4 Gasoline Marketing

Emission sources under this category include distribution and retail sales of petroleum products at service stations. Gasoline is the key product of interest with respect to emissions. Evaporative VOC emissions from the transportation and marketing of gasoline have been estimated based on the emission factors provided in the US EPA AP-42 manual. Table 5-10 lists the emission factors in units of mg of pollutant per liter throughput of gasoline.

[31] US Emission Inventory Improvement Program, technical report series volume 9 particulate emissions, http://www.epa.gov/ttn/chief/eiip/techreport/volume09/index.html, accessed in May 2014
[32] US EPA, Evaluation of Emissions from the Open Burning of Household Waste in Barrels
[33] Warren McCormick, BC MoE, 2012, Wildfire CAC Emission Inventory for 2010
[34] Warren McCormick, BC MoE, 2014, Personal Communication

Table 5-10 Emission Factors for Gasoline Marketing

Emission Source	VOC mg/Liter throughput
Gasoline Tank Trucks in Transit - Vapor-filled Tank Trucks	6.5
Filling Underground Tank - Submerged Filling	880
Underground Tank Breathing and Emptying	120
Vehicle Refueling Operations - Controlled	132
Spillage	80
Total	1218.5

The activity factor for this source type is gasoline sales and this was available from the Statistics Canada CANSIM Table 405-0002. In 2011, the gross sales of gasoline in BC were 4,741,085,000 litres. As no gasoline sales data were available at the regional level, the Statistics Canada's province-wide gasoline sales data were prorated to the CVRD region level using population data as the proration surrogate based on the assumption that the average gasoline consumption per capital in BC is the same.

5.3.5 General Solvent Use

Solvent evaporation emissions cover a wide range of source types. In this study, dry cleaning and general solvent use sources are included. The dry cleaning process involves the handling of solvents in the washing, drying and solvent recovery operations while the general solvent use sources cover processes from industrial, commercial and domestic uses of solvent. The primary emissions from these processes are fugitive VOCs. The VOC emissions from solvent evaporation are dependent on the type and quantity of solvents used in the dry cleaning and general consumer and commercial solvent use activities. Emissions were calculated by applying per capita emission factors to the population in a geographic area. For this study, VOC emissions data were obtained from Environment Canada and the Provincial VOC emissions data were then apportioned to the regional level according to the population in the CVRD area.

5.3.6 Miscellaneous Area Sources

5.3.6.1 Meat Cooking

Emission factors for meat cooking were taken from the Metro Vancouver 2005 Methodology report and are presented in the following table. The average meat consumption (beef, port, mutton, lamb, veal, chicken and fish) was taken from the Statistics Canada report and total meat consumption was 42.26 kg per capita (sum of 23.43 for red meat, 13.4 for poultry and 5.43 for fish[35]). For all the meat consumed, 46% was assumed to be fried and 4% was charbroiled. The remaining 50% of meat was assumed to be prepared with negligible emissions[36].

[35] Statistics Canada, 2010, Food Statistics, 2009, Catalogue no. 21-020-X

[36] Metro Vancouver, 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology, http://public.metrovancouver.org/about/publications/Publications/2005-LFV-Air_Emissions_Inventory-Forecast-Backcast.pdf, (accessed in Feb 2014).

Table 5-11 Activity Data and Emission Factors for Meat Cooking

Cooking Method	Meat Cooked	Emission Factor (kg/tonne of meat)			
	tonne	TPM	PM_{10}	$PM_{2.5}$	VOC
Charbroiled	140	27	27	27	2.72
Fried	1,611	2.4	2.4	2.4	0.18

5.3.6.2 Cigarette Smoking

Emission factors for cigarette smoking were taken from Metro Vancouver's 2005 Methodology report. The population of smokers in BC was obtained from Statistics Canada[37] and prorated to regional level using population data. Based on this assumption, it was estimated that there are approximately 11,639 smokers in the CVRD. Daily tobacco consumption of 14.4 cigarettes per capita was assumed for this study based on a Canadian tobacco use monitoring survey[38] conducted by Health Canada. It was assumed that 90% of cigarette was consumed for cigarette smokers. Cigarette estimation was multiplied by 0.90 to reflect the adjusted inventory. Cigarette inventory and emission factors for tobacco smoke are shown in Table 5-12.

Table 5-12 Activity Data and Emission Factors for Cigarette Smoking

Tobacco Consumption (count)	Emission Factor (kg/1000 tobacco)				
	CO	NO_x	TPM	PM_{10}	$PM_{2.5}$
55,056,619	0.055	0.016	0.0715	0.0715	0.0715

5.3.6.3 Respiration and Perspiration

Emissions from human respiration and perspiration were estimated using the EF from MV's 2005 methodology report. The total population of smokers and non-smokers in the CVRD was prorated using the provincial population data from Statistics Canada by assuming that the distribution of smokers and non-smokers in BC is the same as in the CVRD. The following table summarizes activity data and ammonia emission factors for human respiration and perspiration.

Table 5-13 Activity and Emission Factors for Human Respiration and Perspiration

Activity		CVRD Population	NH_3 Emission Factor
			kg/capita/yr
Human Respiration	Smokers	11,639	0.0041
	Non-smokers	71,232	0.0054
Human Perspiration		82,871	0.25

[37] Statistics Canada, Smokers, by sex, provinces and territories, http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/health74a-eng.htm, accessed in Feb 2014.

[38] Health Canada, Canadian Tobacco Use Monitoring Survey (CTUMS), http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/_ctums-esutc_2011/ann_summary-sommaire-eng.php, accessed in Feb 2014.

5.3.6.4 Construction Operations

Fugitive dust emissions from construction activity are estimated following the emission factors provided in the Metro Vancouver 2005 Methodology report and the activity data for new buildings in the CVRD were obtained from BC Building Permits[39]. The $PM_{2.5}$ emission factor was assumed to be 20% of PM_{10} based on the 2005 MV Methodology Report. The construction activity data and emission factors used in this study are presented in Table 5-14. Fugitive dust emissions were quantified by multiplying the number of buildings, conversion factor, construction duration, and adjusted EF factors of TPM, PM_{10} and $PM_{2.5}$ for each type of building.

Table 5-14 Base Quantities and Emission Factors for Construction Operations

Item	Number	Unit	Conversion Factor (ha/unit[2])	Duration (months)	Adjusted EF (tonnes TPM and PM_{10}/ha-month)	Adjusted EF (tonnes $PM_{2.5}$/ha-month)
Single-detached[1]	295	dwellings	0.067	4.2	0.014	0.0028
Duplex/Row	12	dwellings	0.067	4.2	0.014	0.0028
Apartment	45	dwellings	0.02	12	0.049	0.0098
Commercial	6.273	$ million	0.55	11	0.085	0.017
Industrial	3.487	$ million	0.55	11	0.085	0.017
Institutional	12.055	$ million	0.27	11	0.085	0.017

[1]: Assumed that all single-detached houses are without basement.

[2]: Unit for conversion factor is either ha/dwellings or ha/$ million

5.4 Mobile Sources

Mobile sources include both on-road and non-road (including aircraft, rail, marine and other) vehicles and engines. Similar to area sources, mobile source emissions are generally determined as the product of a fuel quantity and an emission factor for a given pollutant. The on-road mobile sources included emissions of light and heavy duty motor vehicles (diesel and gasoline), buses (diesel and gasoline) and motorcycles (gasoline).

5.4.1 On-road Emissions

On-road sources include all vehicles that are licensed for use on public roadways. The method used to estimate on-road vehicular emissions was based on an emission factor approach as stated. The activity data required in the quantification of vehicle emissions are the annual kilometres travelled by each type of vehicle within the CVRD region, which were obtained from the 2010 CEEI report. The emission factors, typically given in grams per kilometre, were derived from Metro Vancouver's on-road mobile database (D. Jennejohn)[40] using total emissions divided by total kilometres travelled for each type of vehicle and fuel. Total vehicle kilometers travelled (VKT) by hybrid cars and by other types of fuels are included in the gasoline and diesel vehicles category respectively as first approximations due to the relatively small number of these types of vehicles and the lack of EF information. Emission factors for buses were based

[39] BCStats, 2014, British Columbia Building Permits for Development Regions and Regional Districts by Type 2005-2013, (2013 preliminary).

[40] Derek Jennejohn, Metro Vancouver. Personal Communication

on weighted average EF of intercity bus, transit bus and school bus. The activity data and emission factors for each type of vehicle class and fuel type are summarized in Table 5-15 and Table 5-16.

Table 5-15 Activity Data and Emission Factors for On-road Gasoline Vehicles

Vehicle Type	Total VKT	Gasoline EFs g/km							
		CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Small Passenger Cars	274,365,200	5.34	0.51	0.01	0.01	0.01	0.004	0.49	0.02
Large Passenger Cars	123,419,200	7.75	0.85	0.02	0.02	0.02	0.005	0.58	0.02
Light Trucks, Vans, SUVs	457,665,000	7.38	0.81	0.01	0.01	0.01	0.005	0.44	0.02
Commercial Vehicles	34,903,000	7.38	0.81	0.01	0.01	0.01	0.005	0.44	0.02
Tractor Trailer Trucks	283,800	33.33	3.03	0.05	0.05	0.05	0.010	1.55	0.02
Motorhomes	8,358,200	42.83	4.16	0.08	0.08	0.08	0.010	2.44	0.02
Motorcycles, Mopeds	29,304,500	11.78	0.47	0.03	0.03	0.03	0.004	1.43	0.02
Bus	1,006,000	47.23	3.35	0.01	0.01	0.01	0.0000	1.94	0.00

Table 5-16 Activity Data and Emission Factors for On-road Diesel Vehicles

Vehicle Type	Total VKT	Diesel EFs g/km							
		CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Small Passenger Cars	18,852,500	0.44	0.87	0.10	0.10	0.10	0.00	0.14	0.00
Large Passenger Cars	2,904,800	1.77	2.77	0.18	0.18	0.17	0.00	0.44	0.02
Light Trucks, Vans, SUVs	15,277,900	1.56	2.57	0.15	0.15	0.15	0.00	0.38	0.02
Commercial Vehicles	66,656,600	1.56	2.57	0.15	0.15	0.15	0.00	0.38	0.02
Tractor Trailer Trucks	27,361,300	2.11	6.36	0.30	0.30	0.29	0.01	0.46	0.02
Motorhomes	4,760,400	2.11	6.17	0.34	0.34	0.33	0.00	0.59	0.01
Bus	2,281,600	2.41	7.56	0.39	0.39	0.38	0.01	0.40	0.01

5.4.2 Non-road Emissions

Non-road mobile sources include aircraft, rail, marine and non-road vehicles and engines, such as construction and agricultural vehicles and equipment. Similar to on-road sources, non-road source emissions are generally determined as the product of a fuel quantity and an emission factor. The estimation methods are discussed below.

5.4.2.1 Non-road Vehicles and Equipment

The non-road vehicles and equipment category includes a variety of engine and equipment used in different sectors, such as:

- Lawn and garden equipment;
- Agricultural equipment;

- Construction and mining equipment;
- Industrial equipment;
- Logging equipment; and
- Light commercial equipment.

Due to this diversity and the deficiency in current equipment specific data, preparation of a region-wide inventory presented considerable challenges. Since agricultural activity is the main contributor to emissions from this source, non-road emissions were prorated using the size of farm land in the region as a surrogate parameter to scale down emissions from the province level. Agricultural land area at the regional and the provincial level were obtained from Statistics Canada data.

5.4.2.2 Marine

Marine CAC emissions were estimated using the emission factors from the recent Environment Canada (EC) Canadian 2010 National Marine Emissions Inventory[41]. Marine activity data were provided by CVRD staff. Engine information is only available for ferries, vessels, and recreational boats but not for cargos. The missing engine information for each cargo was estimated using the ratio of 1 horsepower per dead weight tonnage (hp/DWT) derived from vessel census data[42].

The marine vessels were further regrouped into the following ship category based on engine types:

- Engine category C1 -– Harbor vessels;
- Engine category C2 -– Auxiliary Engines in ocean going vessels (OGVs);
- Engine category C3 -– Main Engines in OGVs.

Emission factors in the recent EC study were only available for C2 and C3 engines. To account for emissions from C1 vessels, emission factors for the C2 category were used as the first approximation. Due to the large number and different types of recreation boats operating in the CVRD, the average engine power for each category of recreation boats was used in this study. Emission factors along with marine activity data are presented in Table 5-17. SO_2 emissions were estimated at a fuel sulphur content of 15 ppmw (mg/kg) in anticipation that "Regulations Amending the Sulphur in Diesel Fuel Regulations" [43] will take effect after May 31, 2014. For this study, emissions from marine vessels excluded 5 marinas and a number of recreational boats that are not underway or berthed at a marina due to input data unavailability.

[41] SNC-Lavalin, 2012, Canadian 2010 National Marine Emissions Inventory
[42] The World Bank, 2014, Facilitating Trade through Competitive Low-Carbon Transport,
[43] Canada Gazette, Regulations Amending the Sulphur in Diesel Fuel Regulations, http://www.gazette.gc.ca/rp-pr/p1/2011/2011-12-03/html/reg1-eng.html, accessed in March 2014

Table 5-17 Activity Data and Emission Factors for Marine Vessel

Class of Vessel	Vessel Count	Engine Size (kw)	Runtime in CVRD (hr/yr)	Emission Factor (g/kw)							
				CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Mill Bay - Brentwood Bay Ferry	1	522	1,556	1.1	13.2	0.25	0.24	0.23	0.0063	0.5	0.022
Crofton - Vesuvius Ferry	1	1,200	2,421	1.1	13.2	0.25	0.24	0.23	0.0063	0.5	0.022
Chemainus - Penelakut - MV Kuper	1	708	6,570	1.1	13.2	0.25	0.24	0.23	0.0063	0.5	0.022
Small recreational (<40 feet) - sail boats	190	11	29	1.1	13.9	0.25	0.24	0.23	0.0063	0.4	0.001
Small recreational (<40 feet) - power boats	215	119	29	1.1	13.9	0.25	0.24	0.23	0.0063	0.4	0.001
Medium recreational (40 to 60 feet) - sail boats	36	48	29	1.1	13.9	0.25	0.24	0.23	0.0063	0.4	0.001
Medium recreational (40 to 60 feet) - power boats	62	485	29	1.1	13.9	0.25	0.24	0.23	0.0063	0.4	0.001
Small commercial (<40 feet) - water taxi	2	149	30	1.1	13.9	0.25	0.24	0.23	0.0063	0.4	0.001
Recreational (10 to 100 feet) - transient boats	9500	377	16	13.9	1.1	0.006	0.25	0.24	0.23	0.4	0.001
Small and medium recreational &commercial (15 feet to 67 feet	50	188	58	13.9	1.1	0.006	0.25	0.24	0.23	0.4	0.001
Commercial Vessels	55	5,856-153,831	1.7 - 10	13.2	1.1	0.006	0.25	0.24	0.23	0.5	0.022

5.4.2.3 Airport

Emissions from aircraft were quantified using the US Federal Aviation Administration (FAA) model Emissions and Dispersion Modeling System (EDMS) 5.1.4.1. EDMS incorporates US EPA approved emission inventory methodologies to ensure that the analyses performed conform to US EPA guidelines. The databases internal to EDMS contain a comprehensive list of aircraft names and codes, aircraft engines, ground support, auxiliary power units, vehicular, and stationary source emission factor data. A fuel sulphur content of 0.0339 percent by weight was used for this study based on typical sulphur content in western Canadian jet fuel[44].

[44] Environment Canada, 2009. Volumes of Liquids Fuels Produced/Imported and Fuel Sulphur Content (West Region Summary for 2009). https://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=AEDFD28D-1&offset=4

The activity data are the number of landing and takeoff (LTO) cycles, which include the following five cycles:

- Startup;
- Taxi out;
- Take off;
- Climb out; and
- Approach.

Activity data are provided by the CVRD staff and the aggregate aircraft activity in the CVRD region are summarized in the following table.

Table 5-18 Activity Data for Aircraft in the CVRD

Aircraft type	Engine type	# of Arrivals	# of Departures	Aircraft Taxi Times
Single Otter	Turbine	350	350	3 minutes
Beaver	Piston	1,050	1,050	3 minutes
Cessna 185	Piston	408	408	3 minutes

5.5 Road Dust

Road dust is typically generated by the pulverization and abrasion of the surface material when a force, such as that generated by the wheels of a moving vehicle, is applied to the surface. This emission source is usually divided between paved and unpaved road dust.

Factors that determine the amount of fugitive dust arose from surfaces include vehicle travel speed, vehicle weight, moisture and silt content on the surface, weather conditions and others. In 2011, road dust emissions, which mainly consist of particulate matter, contribute to almost 81 percent of the total particulate matter emissions in the Province. Of that total amount of road dust, about 61 percent is generated from paved roads. Fugitive road dust is expected to be a non-buoyant source and emitted close to the ground, thus the impacted area is believed to be small[45]. Due to large uncertainty and validity of the fugitive road dust emissions, estimation of road dust in the CVRD was presented as a separate source category and excluded in the total regional emission inventory analysis.

Road dust emissions in the CVRD were quantified by determining the percent of total vehicle kilometres traveled in the region versus the total VKT in the province using the information from the CEEI report. In 2011, total VKT in the CVRD accounts for approximately 1.75% of the distances that vehicles traveled in the whole province. Based on the 2010 CEEI data, the average fugitive emissions from road dust were approximately 9.42 g of TPM per kilometres travelled. The emissions for PM_{10} and $PM_{2.5}$ were averaged at 2.35 and 0.44 g per kilometres travelled, respectively.

[45] BC MoE, Warren McCormick, 2013, CAC Emission Inventory for the Province outside of the Lower Fraser Valley for 2010.

6. Emission Forecast

In this study, base year (2011) air emissions have been forecast at five-year intervals for 2016, 2021, 2026 and 2031. The forecasts were based on the best available information, and are referred to as the moderate case in this project since they represent the most realistic socio-economic values.

Forecasts were developed by applying a growth factor to each emission sources category and any control technology applied in the future. Emission forecasts from a particular source or source type for a year Y were quantified using the following equation.

$$E_Y = E_{baseline} * G * EC$$

where:

E_Y = Emissions for Forecast Year

$E_{baseline}$ = Baseline Emissions (2011)

G = Growth Factor

EC = Pollutant-specific Emission Control Factor

The agricultural forecast was built upon the Cowichan Region Area Agricultural Plan[46]. The plan discovered that total area farmed in the CVRD has declined 38% in 15 years from 1991 to 2006 and farm size (by area) has decreased by 50% in the 20 years from 1986 to 2006. However, the irrigated area increased by about 10% from 2000 to 2005 despite the decline in area farmed. The livestock industry has a noticeable decline due to increasing feed, fuel and fertilizer costs as well as significant increases in slaughter costs. These factors, combined with a reduction in processing capacity (and regulatory pressure), appear to move the livestock industry toward the mainland. On the other hand, the loss of livestock production has been partially offset by an increase in intensive horticultural operations.

The identified issues have been addressed in the agricultural plan by developing a framework and guideline for local government policy related to agriculture. The Official Community Plans (OCPs) contain unequivocal policies regarding local government support for maintaining existing agricultural lands and enhancing the farm economy. Besides, a number of positive trends, such as “buy local” have increased demand for local products, thus improving sales at direct farm markets. The increased revenue could provide expansion opportunities for small and medium sized farms. For this study, the emission forecast for agricultural activity was assumed to be the same as the baseline due to government policy to reserve the land and high demand for local products despite the historical decline in farm land and livestock production. The non-road emissions from vehicles and equipment were assumed to remain the same as the baseline as well based on the assumption that the majority of non-road equipment is related to the agricultural activity.

In 2010, CVRD has passed bylaw No. 2020 - landclearing management regulation bylaw. The bylaw regulates machine-piled land clearing debris and quantities of land clearing debris. According to the bylaw 2020, operations wishing to conduct open burning are required to register in CVRD. Therefore, the emission forecast for prescribed burning was assumed to be the same as the baseline as a first approximation.

[46] CVRD Economic Development Commission, 2010, Cowichan Agricultural Area Plan

The emission forecasts for other area and mobile sources were determined by assigning appropriate surrogate factors as determined from the following studies:

- Population and households Projects in CVRD: 2011 to 2031 (BC Stats, 2013[47])
- Canada's Energy Future Energy Supply and Demand Projects to 2035 (National Energy Board, 2013) – The reference case for British Columbia[48]
    - End-use Energy Demand - Residential Sector
        - Biomass
        - Natural gas
        - Refined Petroleum Products (RPP) and Liquefied Petroleum Gases (LPG)
    - End-use Energy Demand - Commercial Sector
        - Natural gas
    - End-use Energy Demand - Transportation Sector
        - Aviation fuel
        - Diesel
        - Electric
        - Biofuels
        - Heavy fuel oil
        - LPG
        - Motor Gasoline

The surrogate growth factors applied for each emission source forecast are presented in Table 6-1. The detailed growth factor by absolute value and by growth percent is presented in Table 6-2 and Table 6-3, respectively.

[47] BC Statistics, http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx, accessed in March 2014

[48] National Energy Board, End-use Energy Demand, http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2013/ppndcs/pxndsdmnd-eng.html

Table 6-1 Surrogate Growth Factors Applied for the CVRD Emission Forecast

Area Source	**Surrogate Growth Factors**
Space Heating	Energy demand for residential sector (natural gas, biomass, RPP and LPG) and commercial sector (natural gas)
Agricultural	No change, same as baseline
Prescribed Burning	No change, same as baseline
Backyard Burning	Population projection
Gasoline Marketing	Energy demand for motor gasoline
General Solvent Use	Population projection
Meat Cooking	Population projection
Cigarette Smoking	Population projection
Respiration and Perspiration	Population projection
Construction Operations	Household projection
Mobile Sources	**Surrogate Growth Factors**
On-road Emissions	Energy demand for transportation sector (diesel, biofuel, and LPG)
Non-road Emissions	
Non-road Vehicles and Equipment	No change, same as baseline
Marine	Energy demand for transportation sector (heavy oil)
Airport	Energy demand for transportation sector (aviation fuel)
Road Dust	**Surrogate Growth Factors**
Fugitive Road Dust	Total Energy demand for transportation excluding aviation fuel

Table 6-2 CVRD Growth Factors from 2011-2031

Year	CVRD Population	CVRD Households	Energy Demand in BC (Peta-joules)											
			Residential			Commercial	Transportation							
			Biomass	Natural Gas	RPP and LPG	Natural Gas	Total	Aviation	Diesel	Electric	Biofuels	Heavy Fuel Oil	LPG	Gasoline
2011	82,871	35,710	10.2	83.8	1.8	69.4	341.9	67.5	86.9	0.7	0.7	23.1	3	159.5
2016	86,281	39,338	11	88	1.7	69.2	368	73.2	96.1	0.8	17.3	30.1	3	146.1
2021	91,009	41,698	11.8	91.3	1.5	71.2	384	79.1	101.7	0.9	24.7	33.3	2.8	137.4
2026	95,562	43,743	12.5	93.6	1.4	74.9	399.7	85.3	106.8	1	24.9	34.8	2.6	136.4
2031	99,848	45,623	12.9	95.2	1.3	78.8	418.1	91.9	112.1	1.2	25.2	36.3	2.5	136.8

Table 6-3 CVRD Growth Factors Change from 2011-2031 (percentage)

Year	CVRD Population	CVRD Households	Energy Demand in BC											
			Residential			Commercial	Transportation							
			Biomass	Natural Gas	RPP and LPG	Natural Gas	Total	Aviation	Diesel	Electric	Biofuels	Heavy Fuel Oil	LPG	Gasoline
2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	4.1%	10.2%	7.8%	5.0%	-5.6%	-0.3%	7.6%	8.4%	10.6%	14.3%	2371.4%	30.3%	0.0%	-8.4%
2021	5.5%	6.0%	7.3%	3.7%	-11.8%	2.9%	4.3%	8.1%	5.8%	12.5%	42.8%	10.6%	-6.7%	-6.0%
2026	5.0%	4.9%	5.9%	2.5%	-6.7%	5.2%	4.1%	7.8%	5.0%	11.1%	0.8%	4.5%	-7.1%	-0.7%
2031	4.5%	4.3%	3.2%	1.7%	-7.1%	5.2%	4.6%	7.7%	5.0%	20.0%	1.2%	4.3%	-3.8%	0.3%

7. Baseline Air Emission Inventory Results

This section highlights the results of the 2011 emissions inventories for the CVRD airshed.

7.1 Baseline Emission Summary

The 2011 baseline CVRD emissions inventory for point, area and mobile sources by mass and by percent is summarized in Table 7-1 and Table 7-2, respectively.

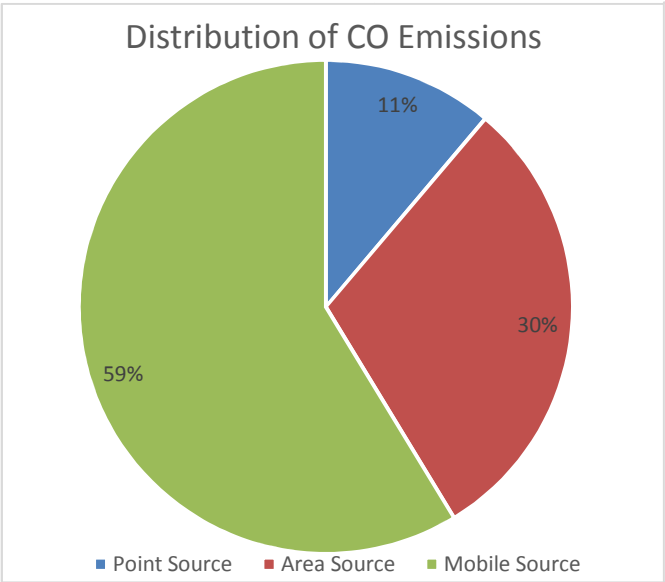
Table 7-1 CVRD Baseline Emission Inventory by Source Sector

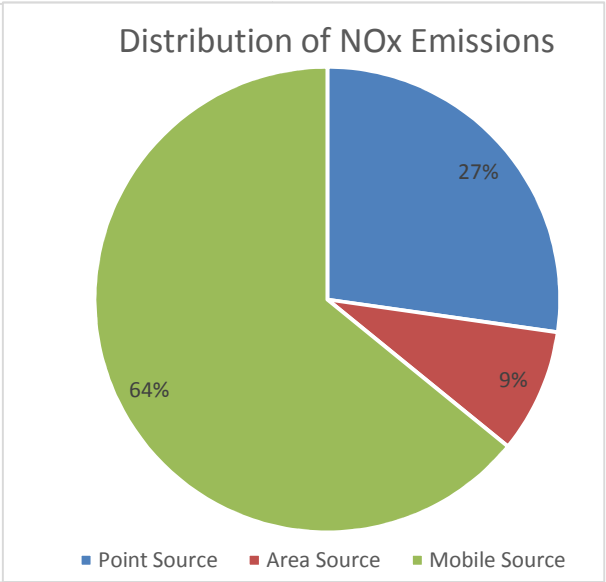
Emission Source	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Point Source	1,922.7	1,084.7	637.3	406.6	256.4	2,173.0	940.6	
Area Source	5,172.7	343.1	1,700.3	1,304.9	1,164.8	21.9	1,412.3	241.4
Mobile	10,082	2,553	88	86.8	82.8	5.7	811.6	22.6
Total	**17,178**	**3,981**	**2,425**	**1,798**	**1,504**	**2,201**	**3,165**	**264.0**

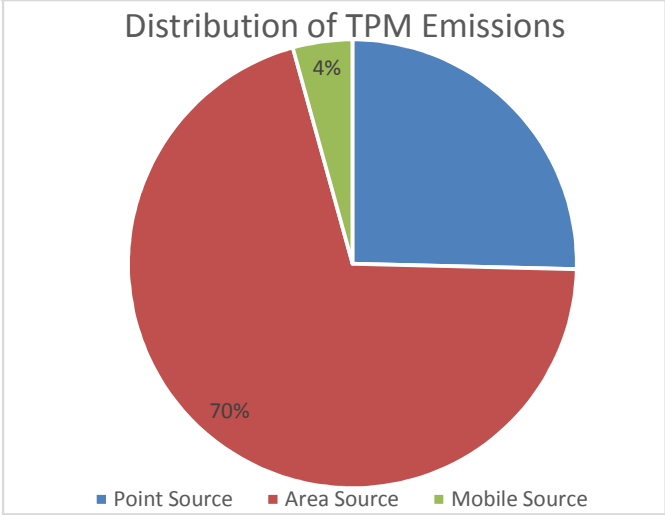
Table 7-2 CVRD Baseline Emission Distribution by Source Sector (Percent)

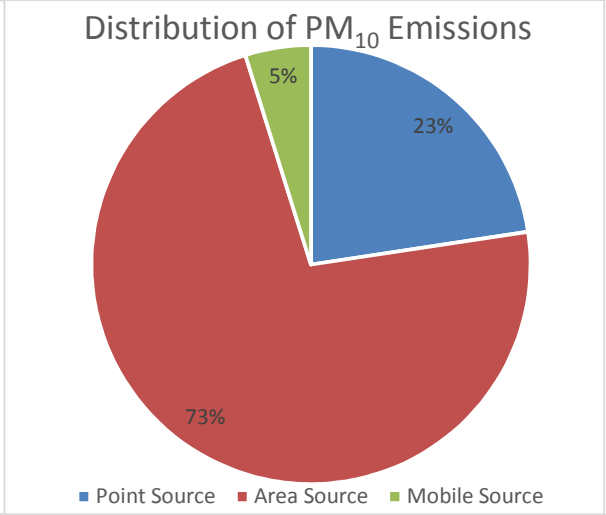
Emission Source	Emissions (Percent)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Point Source	11%	27%	26%	23%	17%	98.7%	30%	
Area Source	30%	9%	70%	73%	77%	1.0%	45%	91%
Mobile	59%	64%	4%	5%	6%	0.3%	26%	9%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

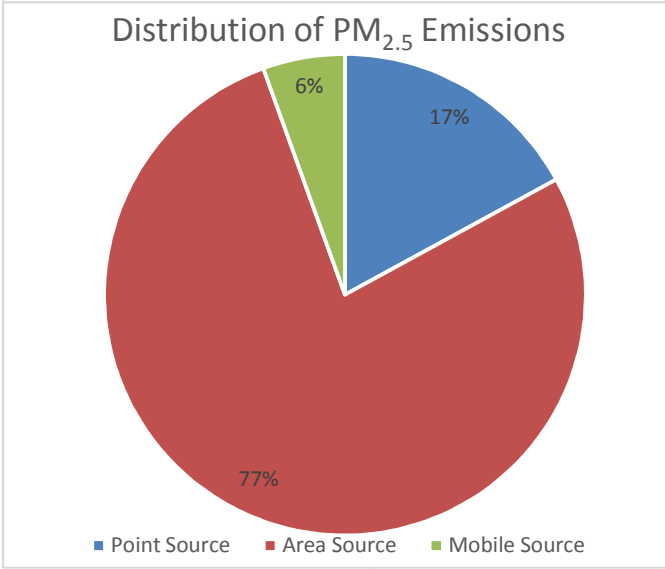
The distribution of each CAC emission from the three emission sectors is presented in the following figures:

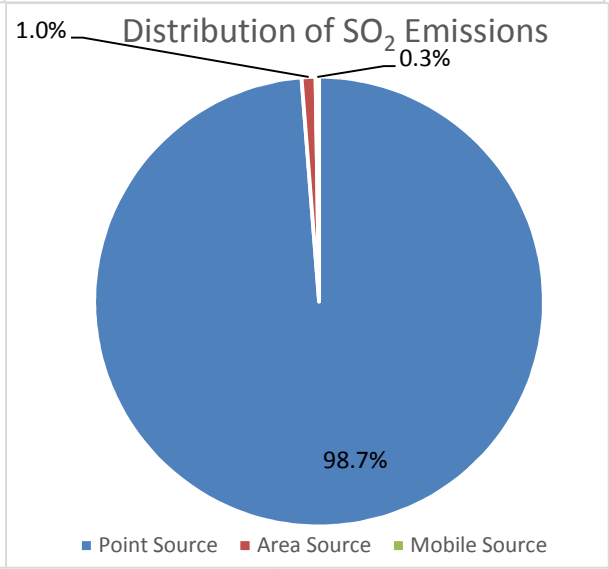

Distribution of CO Emissions
11%
30%
59%
Point Source
Area Source
Mobile Source


Distribution of NOx Emissions
27%
9%
64%
Point Source
Area Source
Mobile Source


Distribution of TPM Emissions
4%
70%
Point Source
Area Source
Mobile Source


Distribution of PM10 Emissions
5%
23%
73%
Point Source
Area Source
Mobile Source


Distribution of PM2.5 Emissions
6%
17%
77%
Point Source
Area Source
Mobile Source


Distribution of SO2 Emissions
1.0%
0.3%
98.7%
Point Source
Area Source
Mobile Source

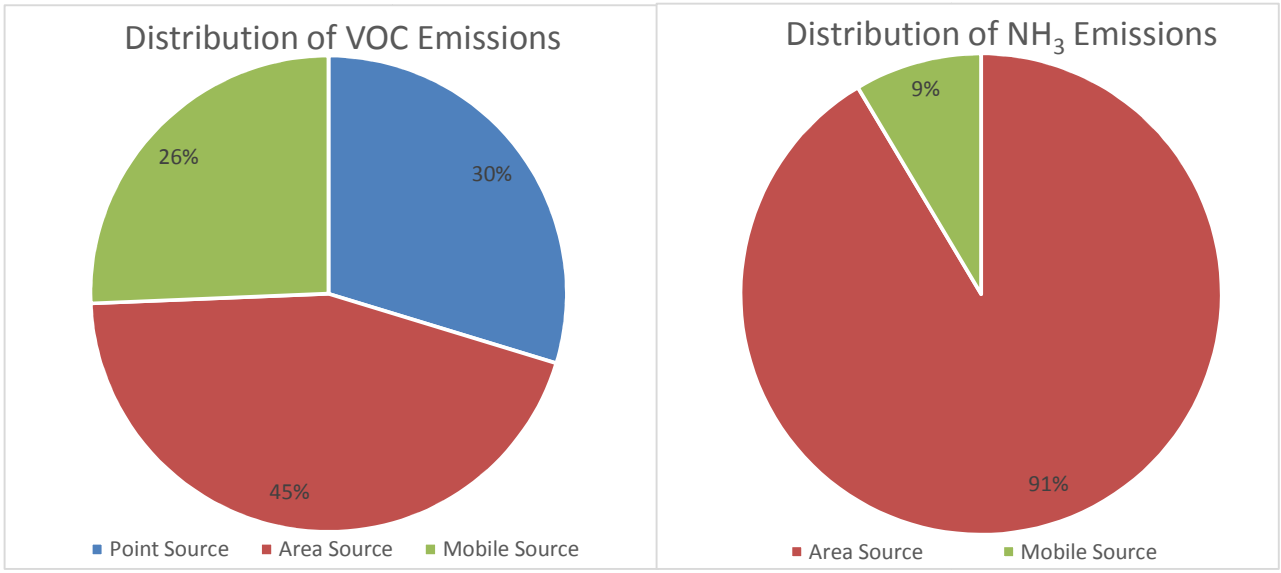


Figure 7-1 CVRD Emission Distribution by Sub-sector

7.2 Point Sources

A total of 19 facilities were identified within the CVRD area. Among them, emissions for 14 facilities were taken from the air permits database and the emissions from the remaining 5 facilities were obtained from NPRI. One facility (Catalyst Paper Corporation) has stack measurements for TPM and SOx and these measurements were included in the CVRD emission inventory. A detailed breakdown of CACs emissions for each facility is presented in Table 7-3. Facility information, such as location of CVRD region, NPRI/Air Permits ID, industry category, North American Industry Classification System (NAICs), are included in the following table as well.

Table 7-3 2011 CVRD Industrial Point Source Emission Inventory by Region (metric tonnes)

CVRD Area	Permit ID	NPRI ID	NPRI Facility Name (2011)	Industry Sector	NAICS	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Area A	5601		LEHIGH NORTHWEST CEMENT LIMITED	Cement	493190			7.68	2.30	0.38	2.37	
Area C	6244	0000007809	Chevron Canada Limited, Hatch Point Terminal	Petroleum Product Storage	412110							161.9
Area D	4396		Western Forest Products Inc., Cowichan Bay Division	Sawmill	321111			37.35	11.20	1.87		
Area E		0000007752	Schnitzer Steel Pacific Inc., Steel Pacific Recycling Duncan	Other	331490			3.30	3.30	1.04		
Municipality of North Cowichan (Includes Chemainus)	7633	0000006652	Shell Canada Products, Bare Point Terminal	Petroleum Product Storage	412110							111.0
	7149		Western Forest Products Inc., Chemainus Sawmill	Sawmill	321111	3.15	15.82	21.4	6.7	1.4	0.25	0.84
	10837		Western Forest Products Inc., Value Added Division	Sawmill	321111	33.52	1.21	11.99	10.79	9.11	0.21	2.36
	13257	0000007928	Western Forest Products Inc., South Island Renman	Sawmill	321111	4.27	21.43	9.64	3.09	0.75	0.13	0.5
	7937		PAULCAN ENTERPRISES LTD.	Sawmill	321111	0.49	2.44	26.9	9.764	3.644	0.02	0.13
	9082		CHEMAINUS FOREST PRODUCTS LTD.	Sawmill	321111			6.52	1.956	0.326		
	14416		JEMICO ENTERPRISES LTD.	Sawmill	321111			1.37	0.41	0.07		
	3086		OSBORNE CONTRACTING LIMITED	Cement	327390	0.08	0.33	0.044	0.034	0.0307	2.39	0.08

Table 7-1 - Continued: 2011 CVRD Industrial Point Source Emission Inventory (metric tonnes)

CVRD Area	Permit ID	NPRI ID	NPRI Facility Name (2011)	Industry Sector	NAICS	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Town of Crofton (within Municipality of North Cowichan)	1902	1266	Catalyst Paper Corporation, Crofton Division	Pulp and Paper	322112	1673.3	1028.2	396	312.75	220.44	2166.3	632.76
Town of Ladysmith	7605	20036	Western Forest Products Inc., Saltair Division	Sawmill	321111			37.35	11.21	1.87		
	3877		WFP WESTERN LUMBER LTD.	Sawmill	321111	1.88	9.4	18.66	5.51	0.92	0.06	16.5
City of Duncan	8534		C AND C LATH MILL LTD.	Wood Products	337123			18.0	5.4	0.9		
	17202		CANADIAN BAVARIAN MILLWORK & LUMBER LTD.	Wood Products	321992	206.06	5.85	19.22	15.666	12.676	1.29	14.6
	3822	7737	Top Shelf Feeds	Other	311119	0.01	0.04	8.56	2.568	0.428		
		7903	Duncan Paving	Other	324121			13.341	3.957	0.5855		
Total						**1922.7**	**1084.7**	**637.3**	**406.6**	**256.4**	**2173.0**	**940.6**

A summary of point sources for each sub-industrial sector by mass and by percent is shown in Table 7-4 and Table 7-5, respectively.

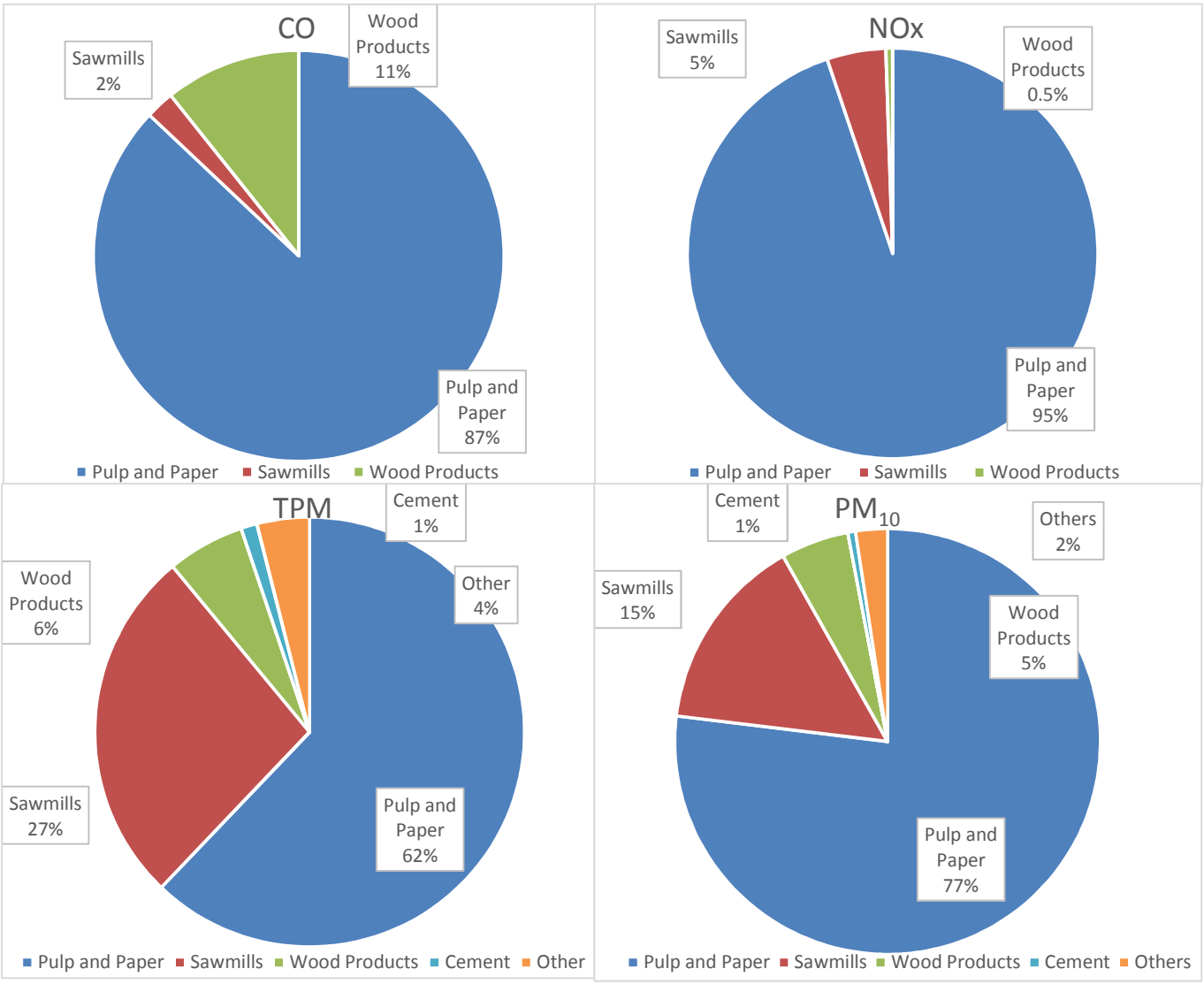
Table 7-4 Summary of 2011 CVRD Industrial Point Source Emission Inventory by Subsector (metric tonnes)

Industry Sector	Emissions (metric tonnes)						
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Pulp and Paper	1,673.25	1,028.2	396	312.8	220.44	2,166.3	632.8
Sawmills	43.31	50.30	171.16	60.6	19.96	0.67	20.33
Wood Products	206.06	5.85	37.21	21.06	13.58	1.29	14.6
Petroleum Product Storage							272.9
Cement	0.08	0.33	7.72585	2.34	0.41	4.76	
Others	0.01	0.04	25.2	9.8	2.05		
Total	**1,922.7**	**1,084.7**	**637.3**	**406.6**	**256.4**	**2,173.0**	**940.6**

Table 7-5 Distribution of 2011 CVRD Industrial Point Source Emission Inventory by Subsector (Percent)

Industry Sector	Emission Distribution (Percent)						
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC
Pulp and Paper	87%	95%	62%	77%	86%	100%	67%
Sawmills	2%	5%	27%	15%	8%	0.0%	2%
Wood Products	11%	0.5%	6%	5%	5%	0.1%	2%
Petroleum Product Storage	0%	0%	0%	0%	0%	0.0%	29%
Cement	0%	0%	1%	1%	0%	0.2%	0%
Others	0%	0%	4%	2%	1%	0.0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The distribution patterns of emissions by subsector are presented in the following figures.


CO
Wood Products 11%
Sawmills 2%
Pulp and Paper 87%
Pulp and Paper
Sawmills
Wood Products
NOx
Sawmills 5%
Wood Products 0.5%
Pulp and Paper 95%
Pulp and Paper
Sawmills
Wood Products
TPM
Cement 1%
Other 4%
Wood Products 6%
Sawmills 27%
Pulp and Paper 62%
Pulp and Paper
Sawmills
Wood Products
Cement
Other
PM10
Cement 1%
Others 2%
Sawmills 15%
Wood Products 5%
Pulp and Paper 77%
Pulp and Paper
Sawmills
Wood Products
Cement
Others

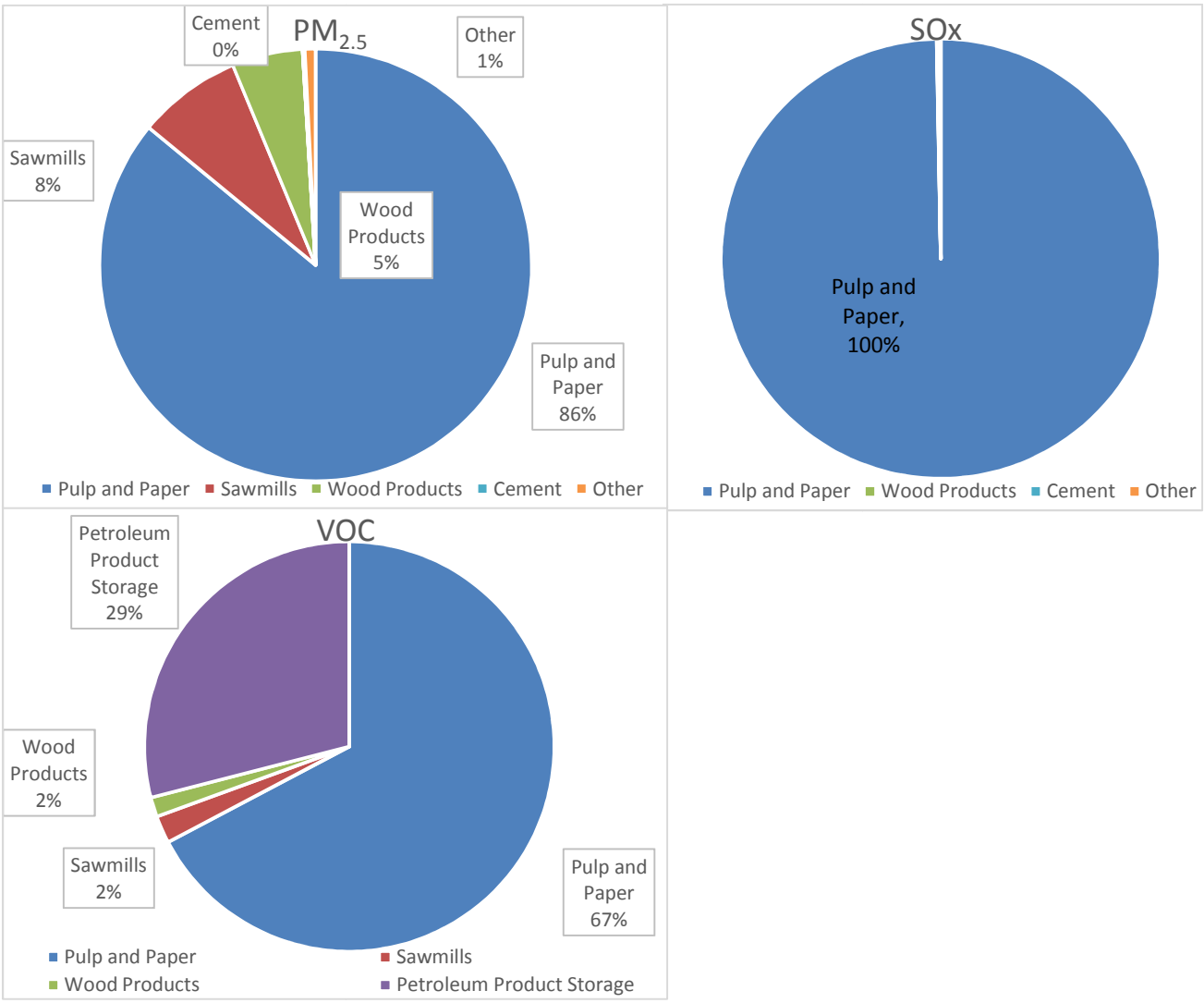


Figure 7-2 Point Source Emission Distribution by Sub-sector

7.3 Area Sources

Results of the 2011 CVRD emission inventory for area sources emissions by source sector are summarized in Table 7-6. The distribution percentage for each area source sector is presented in Table 7-7.

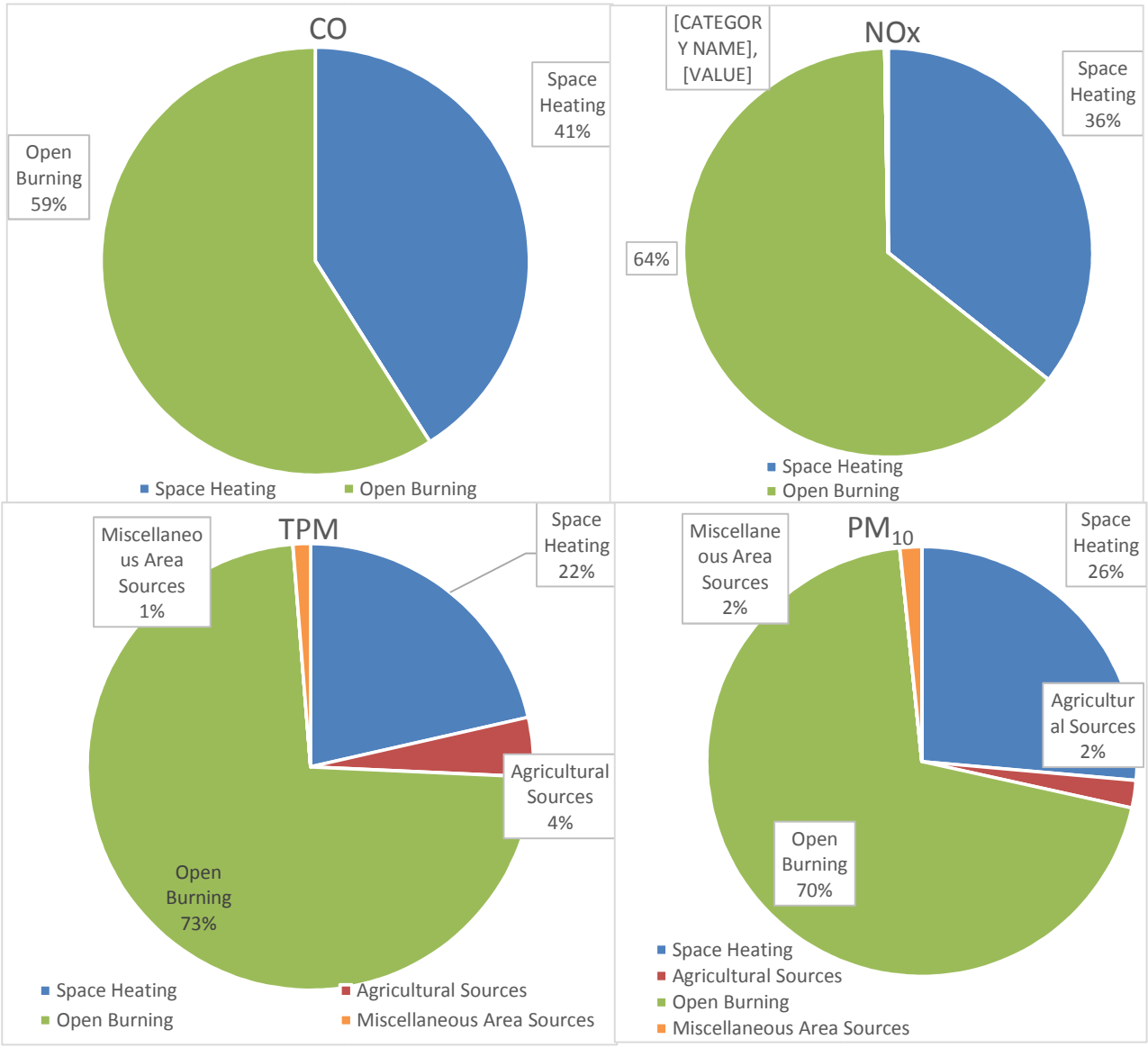
Table 7-6 Summary of Area Source Emission Inventory by Sector (metric tonnes)

Emission Source	Emissions (metric tonne)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Space Heating	2,120.1	122.3	364.5	344.5	344.5	15.4	484.6	6.5
Agricultural Sources			72.99	26.9	5.86		47.82	149.0
Open Burning	3,049.7	219.9	1,241.5	912.2	800.9	6.5	223.8	64.7
Gasoline Marketing							108.3	
General Solvent Use							547.1	
Miscellaneous Area Sources	3.03	0.88	21.39	21.39	13.55	0.00	0.67	21.15
Total Area Sources	**5,172.7**	**343.1**	**1,700.3**	**1,304.9**	**1,164.8**	**21.9**	**1,412.3**	**241.4**

Table 7-7 Distribution of Area Source Emission Inventory by Sector (Percent)

Emission Source	Emissions (metric tonne)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Space Heating	41%	36%	21%	26%	30%	70%	34%	3%
Agricultural Sources	0%	0%	4%	2%	1%	0%	3%	62%
Open Burning	59%	64%	73%	70%	69%	30%	16%	27%
Gasoline Marketing	0.0%	0.0%	0%	0%	0%	0%	8%	0%
General Solvent Use	0.0%	0.0%	0%	0%	0%	0%	39%	0%
Miscellaneous Area Sources	0.1%	0.3%	1%	2%	1%	0%	0%	9%
Total Area Sources	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The distribution of emissions to each area source sub-sector are presented in the figures below.


CO
Space Heating 41%
Open Burning 59%
Space Heating
Open Burning
[CATEGORY NAME], [VALUE]
NOx
Space Heating 36%
64%
Space Heating
Open Burning
TPM
Miscellaneous Area Sources 1%
Space Heating 22%
Agricultural Sources 4%
Open Burning 73%
Space Heating
Agricultural Sources
Open Burning
Miscellaneous Area Sources
PM10
Miscellaneous Area Sources 2%
Space Heating 26%
Agricultural Sources 2%
Open Burning 70%
Space Heating
Agricultural Sources
Open Burning
Miscellaneous Area Sources

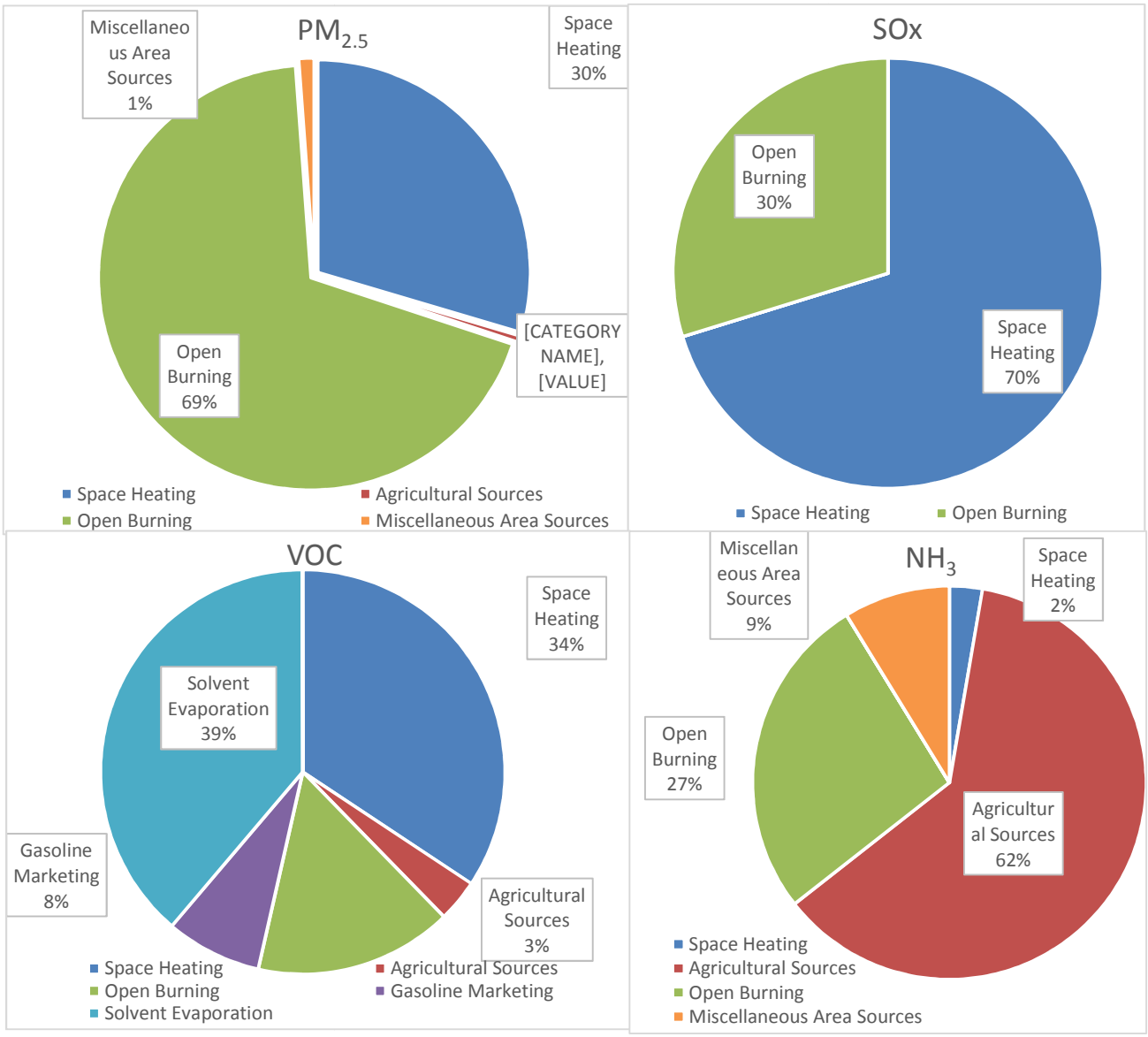


Figure 7-3 Area Source Emission Distribution by Sub-sector

The breakdown of emissions by each area source is presented in Table 7-8 to Table 7-15.
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Table 7-8 Emission Summary for Space Heating (metric tonnes)

Space Heating	**Emissions (Metric tonnes)**							
Residential	**CO**	**NOx**	**TPM**	**PM_{10}**	**$PM_{2.5}$**	**SOx**	**VOC**	**NH_3**
Natural Gas	5.20	12.3	0.249	0.249	0.249	0.290	0.72	0.07
Heating Oil	8.05	29.0	0.64	0.64	0.64	8.46	1.15	1.61
Propane	3.18	5.5	0.085	0.085	0.085	0.042	0.34	
Wood Stove	2,082	41.0	363	343	343	6	481	4.8
Commercial/Small-Medium Industrial	**CO**	**NOx**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**NH_3**
Natural Gas	34.5	21.6	0.49	0.49	0.49	0.57	1.4	0.0035
Total	**2120**	**122.3**	**364.5**	**344.5**	**344.5**	**15.4**	**484.6**	**6.5**

Table 7-9 Emission Summary for Livestock Enteric Fermentation, Dust Generation and Manure Management (metric tonnes)

Livestock		Emissions (metric tonnes)				
		TPM	PM_{10}	$PM_{2.5}$	VOC	NH_3
Cattle	Steers	1.40	0.47	0.07	0.65	2.26
	Dairy cows				25.71	75.33
	Bulls				0.47	1.20
	Beef Cows				4.53	9.93
	Dairy Heifers				6.88	17.83
	Beef Heifers				0.87	2.20
	Heifers for slaughter				1.53	4.60
	Calves				4.87	18.08
Pigs	Boars	0.019	0.009	0.0019	0.0004	0.03
	Sows	0.10	0.05	0.01	0.00	0.40
	Pigs	0.19	0.10	0.02	0.01	
Sheep	Ewes and rams				0.56	2.69
	Market Lambs				0.29	2.96
Poultry	Broilers	1.46	0.15	0.01	0.01	0.01
	Layers	3.40	0.68	0.07	0.11	0.06
Turkey	Turkey	0.00	0.00	0.00	0.00	0.00
Horses	Paddocks	0.77	0.26	0.04	0.31	3.10
Miscellaneous Animals	Rings	0.57	0.19	0.03	0.31	3.10
	Goats				0.43	4.56
	Minks				0.00	0.00
	Llamas & Alpacas				0.26	0.47
Total Emissions		**7.91**	**1.90**	**0.25**	**47.82**	**148.79**

Table 7-10 Emission Summary for Fertilizer and Pesticide Application (metric tonnes)

Activity	Emissions (tonne)			
	TPM	PM_{10}	$PM_{2.5}$	NH_3
Fertilizer	0.004	0.002	0.0006	0.24
Pesticide	1.87	0.92	0.26	
Total Emissions	**1.87**	**0.92**	**0.26**	**0.24**

Table 7-11 Summary of Emissions from Soil Tilling (metric tonnes)

Crop	Emissions (metric tonnes)		
	PM	PM_{10}	$PM_{2.5}$
Corn	10.60	2.28	0.49
Forage/Hay	11.8	2.59	0.58
Pasture	0.82	0.18	0.04
Alfalfa	1.64	0.36	0.08
Blueberries	0.03	0.01	0.00
Turf	0.47	0.10	0.02
Other Vegetables (any crop not identified in the above category, excluding greenhouse vegetables)	1.21	0.26	0.06
Total	**26.57**	**5.77**	**1.27**

Table 7-12 Summary of Emissions from Wind Erosion (metric tonnes)

Crop	Emissions (metric tonnes)		
	TPM	PM_{10}	$PM_{2.5}$
Grain Corn	2.16	1.08	0.24
Silage Corn	28.11	14.07	3.14
Potatoes	0.41	0.20	0.05
Vegetables	5.97	2.98	0.66
Total Emissions	**36.64**	**18.34**	**4.08**

Table 7-13 Summary of Emissions from Open Burning (metric tonnes)

Burning Category	Emissions (Metric tonne)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Prescribed Burning								
Clean (Class A)	2,678	203.65	1,120.	794.2	692.4	4.07	183.3	64.15
Dirty (Class B)	20.09	0.62	4.16	3.08	2.62	0.01	1.05	0.19
Very Dirty (Class C)	67.61	1.22	10.95	8.52	7.24	0.02	5.48	0.38
Backyard Burning – Yard Waste								
Leaves	19.91		6.76	6.76	6.76		4.98	
Brush	24.89		2.84	2.84	2.84		3.20	
Grasses	35.55		5.69	5.69	5.69		5.33	
Backyard Burning – Household Waste								
Household waste	203.6	14.4	91.0	91.0	83.4	2.4	20.5	
Total	**3,049.7**	**219.9**	**1,241.5**	**912.2**	**800.9**	**6.5**	**223.8**	**64.7**

Table 7-14 Summary of Emissions from Gasoline Marketing, Solvent Use, Meat Cooking, Cigarette Smoking, as well as Human Respiration and Perspiration (metric tonnes)

Sector		Emissions (metric tonnes)							
		CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Gasoline Marketing								108.3	
General Solvent Use								547.1	
Meat Cooking	Charbroiled			3.78	3.78	3.78		0.38	
	Fried			3.87	3.87	3.87		0.29	
Cigarette Smoking		3.03	0.88	3.94	3.94	3.94			
Human Respiration									0.43
Human Perspiration									20.72

Table 7-15 Summary of Emissions from Construction Operations (metric tonnes)

Construction Activity	Emissions (metric tonnes)		
	TPM	PM_{10}	$PM_{2.5}$
Single-detached House	1.16	1.16	0.23
Duplex/Row	0.05	0.05	0.01
Apartment	0.53	0.53	0.11
Commercial	3.23	3.23	0.65
Industrial	1.79	1.79	0.36
Institutional	3.04	3.04	0.61
Total	**9.80**	**9.80**	**1.96**

7.4 Mobile Sources

Emissions from mobile sources are summarized in Table 7-16.

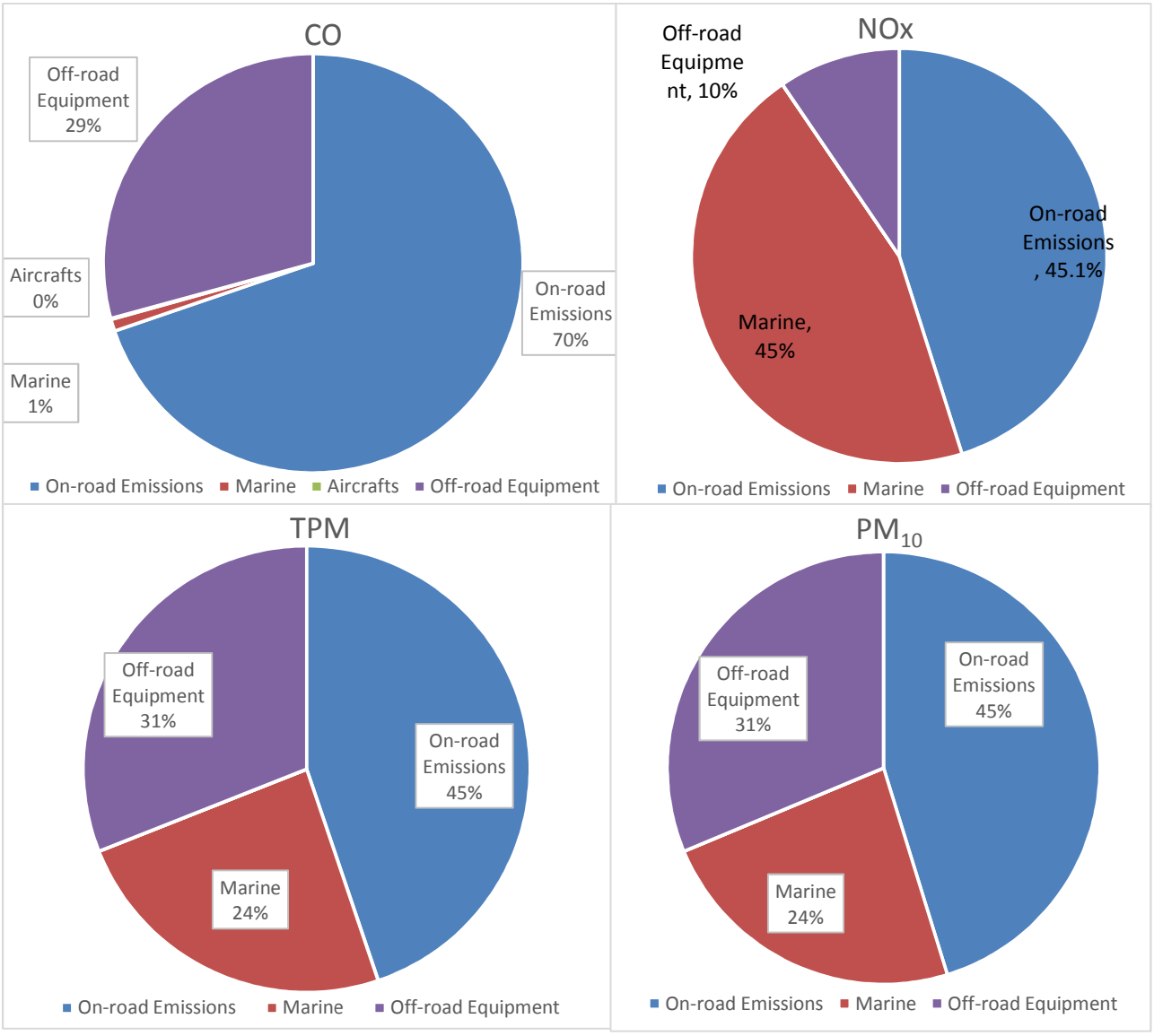
Table 7-16 Summary of Emissions from Mobile Sources (metric tonnes)

Emissions from Mobile Sources	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
On-road Emissions	7,033	1,152	39.3	39.3	37.4	4.9	538.0	21.69
Non-road Emissions								
Marine	93.09	1,158.7	21.22	20.37	19.52	0.53	36.36	0.61
Aircraft	8.79	0.24	0.01	0.01	0.01	0.04	0.29	
Non-road Equipment	2,947.7	242.7	27.17	27.17	25.9	0.29	236.9	0.31
Mobile (Total)	**10,082**	**2,553**	**88**	**87**	**83**	**6**	**812**	**22.6**

The breakdown of emission source by percent is presented in Table 7-17 and Figure 7-4.

Table 7-17 Breakdown of Emissions from Mobile Sources (Percent)

Emissions from Mobile Sources	Emissions (Percent)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
On-road Emissions	69.8%	45.1%	44.8%	45.2%	45.2%	85.0%	66.3%	95.9%
Non-road Emissions								
Marine	1%	45%	24.2%	23.5%	23.6%	9.3%	4.5%	2.7%
Aircraft	0.1%	0.01%	0.01%	0.01%	0.01%	0.6%	0.0%	0.0%
Non-road Equipment	29%	10%	31%	31%	31%	5%	29%	1%
Mobile (Total)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



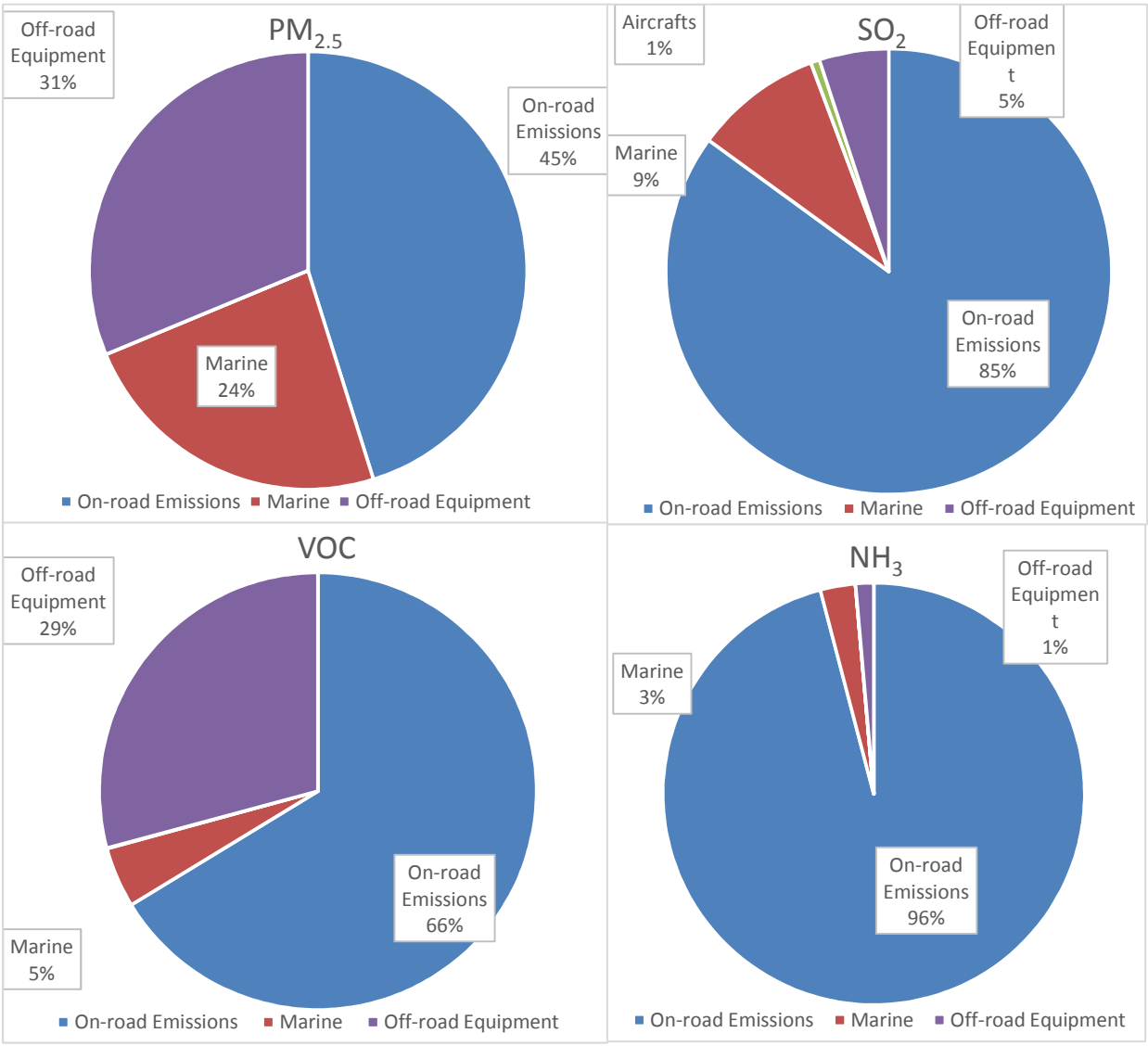


Figure 7-4 Mobile Source Emission Distribution by Sub-sector

7.4.1 On-road Emissions

Emissions from on-road mobile sources by vehicle and fuel type are summarized in Table 7-18.

Table 7-18 Summary of Emissions from On-road Vehicles (metric tonnes)

Gasoline Vehicles	Emissions (tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Small Passenger Cars	1,466	139	3.9	3.9	3.6	1.0	133	6.2
Large Passenger Cars	957	105	2.1	2.1	1.9	0.6	71	2.7
Light Trucks, Vans, SUVs	3,377	371	5.8	5.8	5.4	2.3	202	9.2
Commercial Vehicles	258	28	0.4	0.4	0.4	0.2	15	0.7
Tractor Trailer Trucks	9	0.9	0.0	0.0	0.0	0.0	0	0.0
Motorhomes	358	35	0.7	0.7	0.7	0.1	20	0.2
Motorcycles, Mopeds	345	14	0.9	0.9	0.9	0.1	42	0.7
Bus	48	3	0.01	0.01	0.01	0.00	2	0.00
Diesel Vehicle	**Emissions (tonnes)**							
	CO	**NOx**	**TPM**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**NH_3**
Small Passenger Cars	8.36	16.31	1.95	1.95	1.90	0.04	2.57	0.08
Large Passenger Cars	5.14	8.05	0.52	0.52	0.50	0.01	1.28	0.05
Light Trucks, Vans, SUVs	23.80	39.24	2.29	2.29	2.22	0.05	5.86	0.25
Commercial Vehicles	103.82	171.21	9.97	9.97	9.67	0.22	25.55	1.11
Tractor Trailer Trucks	57.62	174.15	8.14	8.14	7.89	0.21	12.69	0.41
Motorhomes	10.04	29.37	1.62	1.62	1.57	0.00	2.80	0.06
Bus	5.49	17.25	0.88	0.88	0.86	0.01	0.90	0.03
Total for On-road Vehicles	**7,033**	**1,152**	**39.3**	**39.3**	**37.4**	**4.9**	**538**	**21.69**

7.4.2 Non-road Emissions

7.4.2.1 Non-road Equipment

Results of non-road equipment emissions are summarized in Table 7-19.

Table 7-19 Summary of Emissions from Non-road Vehicles/Equipment (metric tonnes)

Sectors	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
CVRD Non-road Use of Diesel	104.2	210.5	17.3	17.3	16.8	0.2	19	0.2
CVRD Non-road Use of Gasoline/LPG/CNG	2,843.5	32.2	9.8	9.8	9.1	0.1	217.9	0.1
Total from Non-road Equipment	**2,947.7**	**242.7**	**27.2**	**27.2**	**25.9**	**0.3**	**236.9**	**0.3**

7.4.2.2 Marine

Results of marine emissions are presented in Table 7-20, which shows a detailed listing of CACs by vessel type. The biggest contributor to marine emissions is recreational boats, due to the large number of boats in the CVRD.

Table 7-20 Marine Vessel Emissions Inventory

Class of Vessel	Emission Factor (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
Mill Bay - Brentwood Bay Ferry -	0.89	10.72	0.20	0.20	0.19	0.01	0.41	0.02
Crofton - Vesuvius Ferry	3.19	38.34	0.73	0.70	0.67	0.02	1.45	0.06
Chemainus - Penelakut - MV Kuper	5.12	61.44	1.17	1.12	1.07	0.03	2.33	0.10
Small recreational (<40 feet) - sail boats	0.07	0.85	0.02	0.01	0.01	0.00	0.02	0.000
Small recreational (<40 feet) - power boats	0.81	10.27	0.19	0.18	0.17	0.00	0.30	0.001
Medium recreational (40 to 60 feet) - sail boats	0.06	0.70	0.01	0.01	0.01	0.00	0.02	0.000
Medium recreational (40 to 60 feet) - power boats	0.95	12.03	0.22	0.21	0.20	0.01	0.35	0.001
Small commercial (<40 feet) - water taxi	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.000
Recreational (10 to 100 feet) - transient boats	62.96	795.64	14.35	13.78	13.20	0.36	22.90	0.057
Small and medium recreational and commercial (15 feet to 67 feet	0.60	7.54	0.14	0.13	0.13	0.00	0.22	0.001
Various cargos	18.4	221.1	4.2	4.0	3.9	0.11	8.4	0.4
Total	**93.09**	**1,158.72**	**21.22**	**20.37**	**19.52**	**0.53**	**36.36**	**0.61**

7.4.2.3 Aircraft

Aircraft emissions represent a relatively small portion of the total air emissions in CVRD. The aggregated emissions for each type of aircraft in the CVRD are summarized Table 7-21.

Table 7-21 CVRD Aircraft Emission Inventory by Aircraft Type

Aircraft Type	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SOx	VOC	NH_3
Single Otter	0.423	0.062	0	0	0	0.009	0.061	0
Beaver	1.222	0.169	0.003	0.003	0.003	0.024	0.18	0
Cessna 185	7.146	0.007	0.004	0.004	0.004	0.004	0.055	0
Total	**8.79**	**0.238**	**0.007**	**0.007**	**0.007**	**0.037**	**0.292**	**0**

7.5 Road Dust

The emissions of fugitive dust from paved and unpaved surfaces are summarized in Table 7-22.

Table 7-22 CVRD Road Dust Emissions

CVRD Fugitive Dust Emissions	Emissions (tonnes)		
	TPM	PM_{10}	$PM_{2.5}$
Dust from Paved Roads	9,431	1,808	434
Dust from Unpaved Roads	6,049	2,059	296
Total	**15,481**	**3,867**	**729**

8. Emission Forecast

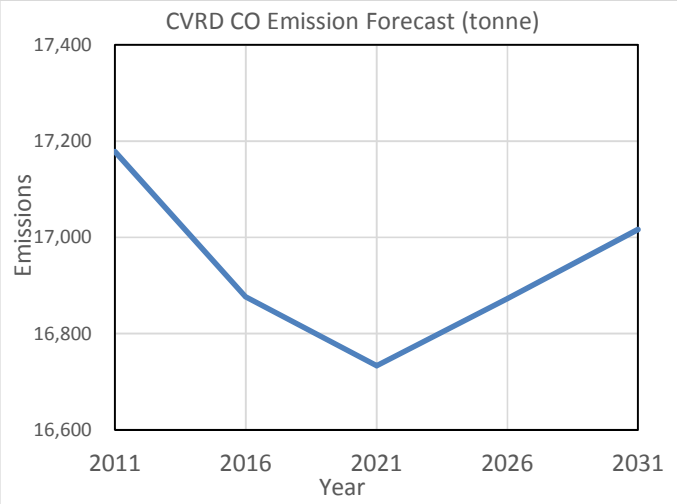
8.1 Forecast Summary

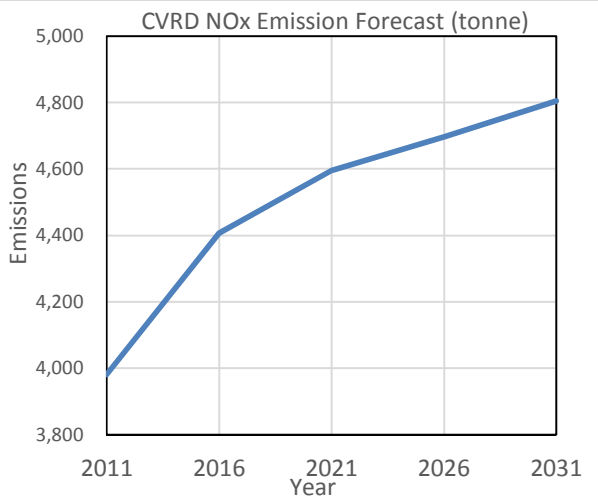
A summary of emission forecasts for the CVRD is presented in Table 8-1.

Table 8-1 Emission Forecast for CVRD Emissions Inventory (metric tonnes)

CVRD Inventory Forecast	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	17,177.8	3,981.3	2,425.3	1,798.3	1,504.1	2,200.6	3,164.5	264.0
2016	16,876.4	4,406.6	2,472.1	1,843.3	1,547.5	2,200.7	3,202.4	264.3
2021	16,733.5	4,595.9	2,513.7	1,883.2	1,586.3	2,200.3	3,253.6	265.0
2026	16,873.4	4,696.8	2,548.3	1,916.4	1,618.6	2,200.5	3,320.4	266.5
2031	17,016.1	4,805.0	2,572.2	1,939.4	1,640.6	2,200.5	3,377.0	267.9

The emission trends for each CAC contaminant are shown in the following figures.





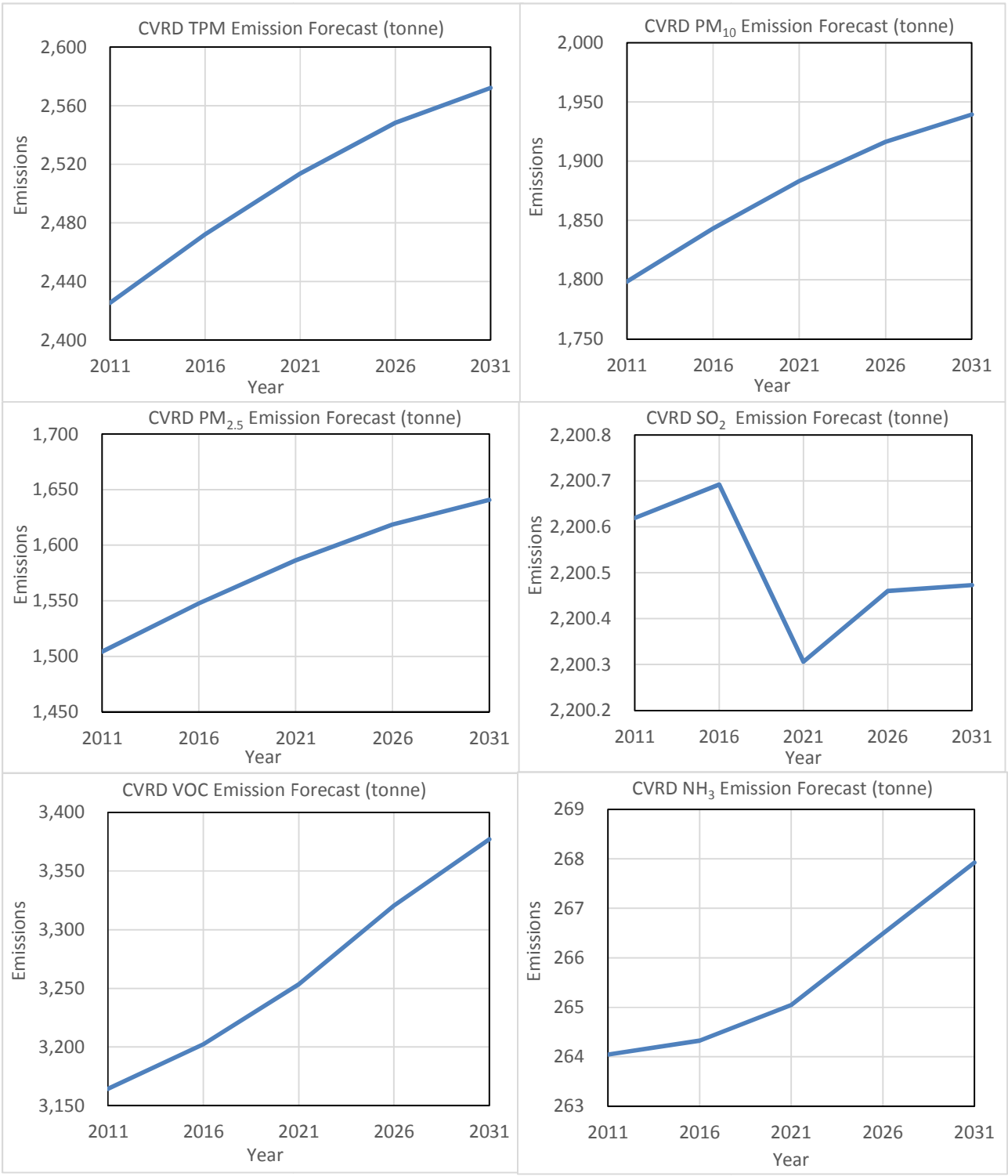


Figure 8-1 CVRD CACs Emissions Trends

8.2 Point Sources

Emission forecast for point source emissions was assumed to be the same as the base year. The base year emissions were established mainly based on air permits data. It was anticipated that the majority of the facilities will be in compliance with air permits limits. Besides, to our best knowledge, there are no new planned facilities in the CVRD based on Community/Municipal/Regional Development strategies. Therefore, forecast of point sources are assumed to be the same as the baseline year.

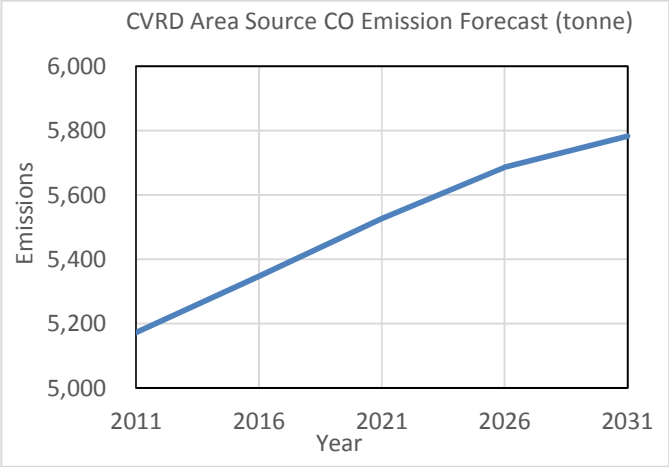
8.3 Area Sources

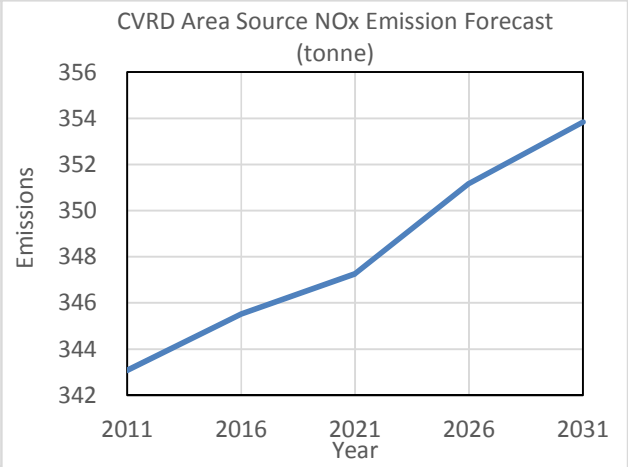
The emission forecast for area sources is shown in Table 8-2.

Table 8-2 Summary of Area Source Emission Forecast (metric tonnes)

Area Source	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	5,172.7	343.1	1,700.3	1,304.9	1,164.8	21.9	1,412.3	241.4
2016	5,347.4	345.5	1,734.6	1,337.6	1,196.4	22.0	1,464.9	242.6
2021	5,526.7	347.3	1,770.4	1,371.9	1,229.7	21.7	1,529.8	244.0
2026	5,686.0	351.2	1,802.4	1,402.4	1,259.4	21.8	1,594.1	245.4
2031	5,783.2	353.8	1,823.2	1,422.5	1,278.6	21.7	1,643.3	246.6

The emission trends for area source by each CAC species are presented in the following figures.





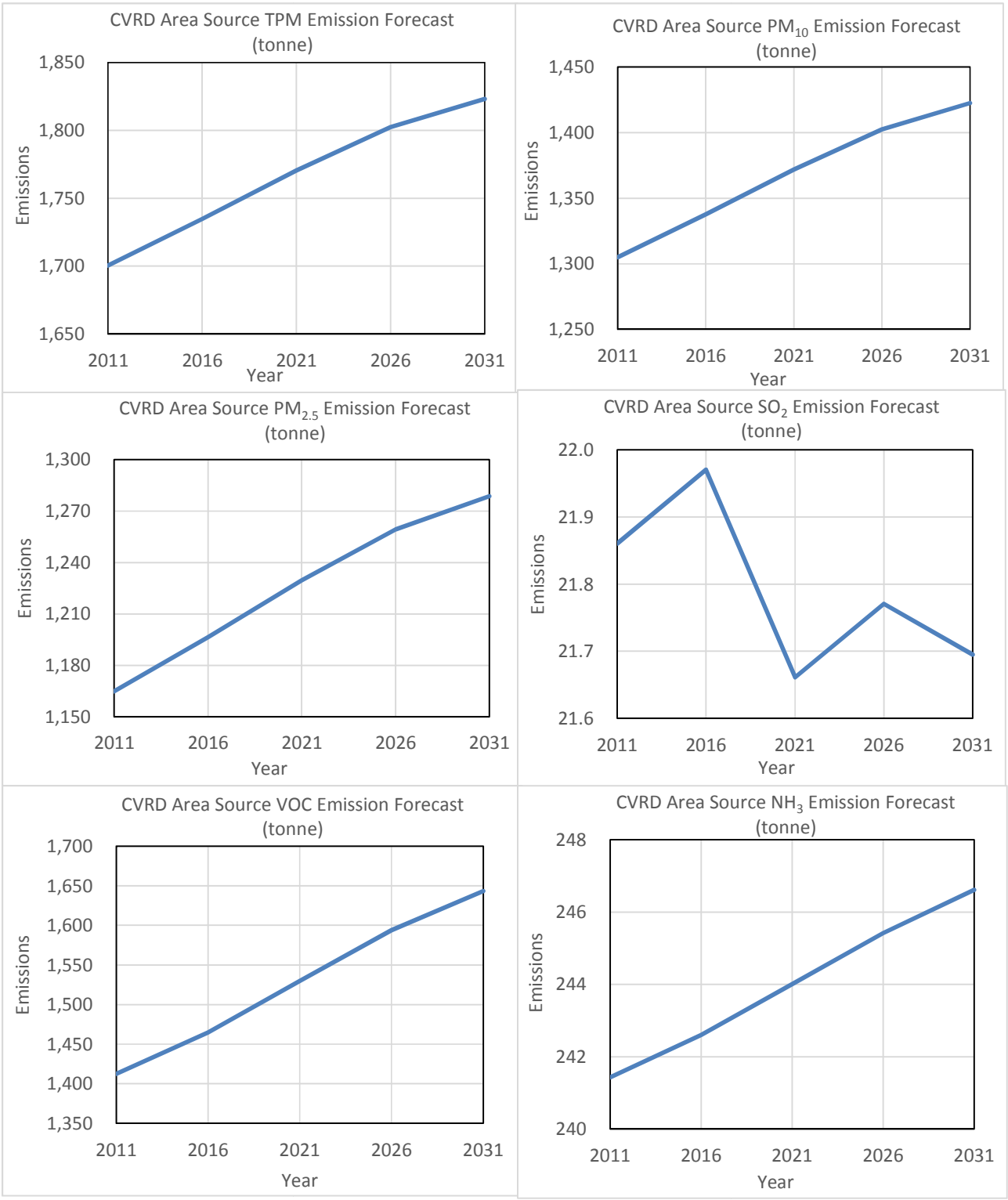


Figure 8-2 CVRD Area Source Emission Forecast

The emission forecasts for area source by source category are summarized from Table 8-3 to Table 8-9.

Table 8-3 Emission Forecast for Space Heating (metric tonnes)

Space Heating	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	2,120	122	364	344	344	15.4	485	6.5
2016	2,283	124	393	371	371	15.4	522	6.8
2021	2,446	125	421	398	398	14.9	560	7.0
2026	2,589	128	446	422	422	14.9	593	7.3
2031	2,672	130	460	435	435	14.7	612	7.4

Table 8-4 Emission Forecast for Gasoline Marketing (metric tonnes)

Gasoline Marketing	Emissions (metric tonnes)
	VOC
2011	108.3
2016	99.2
2021	93.3
2026	92.6
2031	92.9

Table 8-5 Emission Forecast for General Solvent Use (metric tonnes)

General Solvent Use	Emissions (metric tonnes)
	VOC
2011	547.09
2016	569.61
2021	600.82
2026	630.88
2031	659.17

Table 8-6 Emission Forecast for Meat Cooking (metric tonnes)

Meat Cooking	Emissions (metric tonnes)			
	TPM	PM_{10}	$PM_{2.5}$	VOC
2011	7.65	7.65	7.65	0.67
2016	7.96	7.96	7.96	0.70
2021	8.40	8.40	8.40	0.74
2026	8.82	8.82	8.82	0.77
2031	9.22	9.22	9.22	0.81

Table 8-7 Emission Forecast for Cigarette Smoking (metric tonnes)

Cigarette Smoking	Emissions (Metric tonnes)				
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$
2011	3.03	0.88	3.94	3.94	3.94
2016	3.15	0.92	4.10	4.10	4.10
2021	3.33	0.97	4.32	4.32	4.32
2026	3.49	1.02	4.54	4.54	4.54
2031	3.65	1.06	4.74	4.74	4.74

Table 8-8 Emission Forecast for Human Respiration and Perspiration (metric tonnes)

Human Respiration and Perspiration	Emissions (metric tonnes)
	NH_3
2011	21.15
2016	22.02
2021	23.23
2026	24.39
2031	25.48

Table 8-9 Emission Forecast for Construction (metric tonnes)

Construction	Emissions (Metric tonnes)		
	TPM	PM_{10}	$PM_{2.5}$
2011	9.80	9.80	1.96
2016	10.80	10.80	2.16
2021	11.44	11.44	2.29
2026	12.01	12.01	2.40
2031	12.52	12.52	2.50

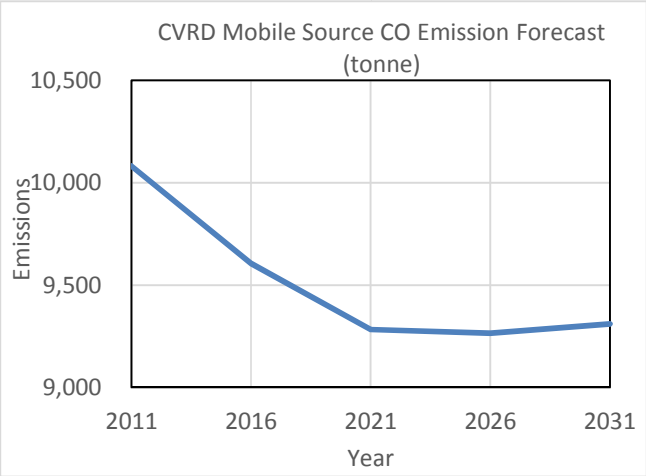
8.4 Mobile Sources

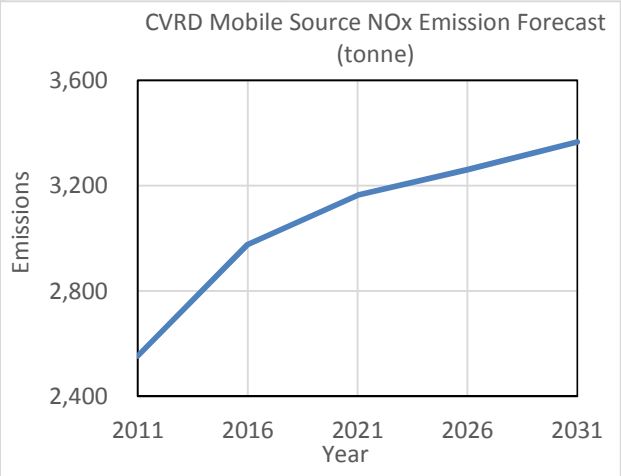
The forecasts of mobile source emissions are summarized in Table 8-10.

Table 8-10 Emission Forecast for Mobile Sources (metric tonnes)

Mobile Sources	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	10,082	2,553	87.7	86.8	83	5.74	812	22.6
2016	9,606	2,976	100.2	99.1	94.7	5.71	797	21.7
2021	9,284	3,164	106.0	104.7	100.2	5.63	783	21.0
2026	9,265	3,261	108.7	107.4	102.8	5.67	786	21.1
2031	9,310	3,366	111.7	110.3	105.6	5.76	793	21.3

The emission trends for mobile sources by each CAC species are presented in the following figures.





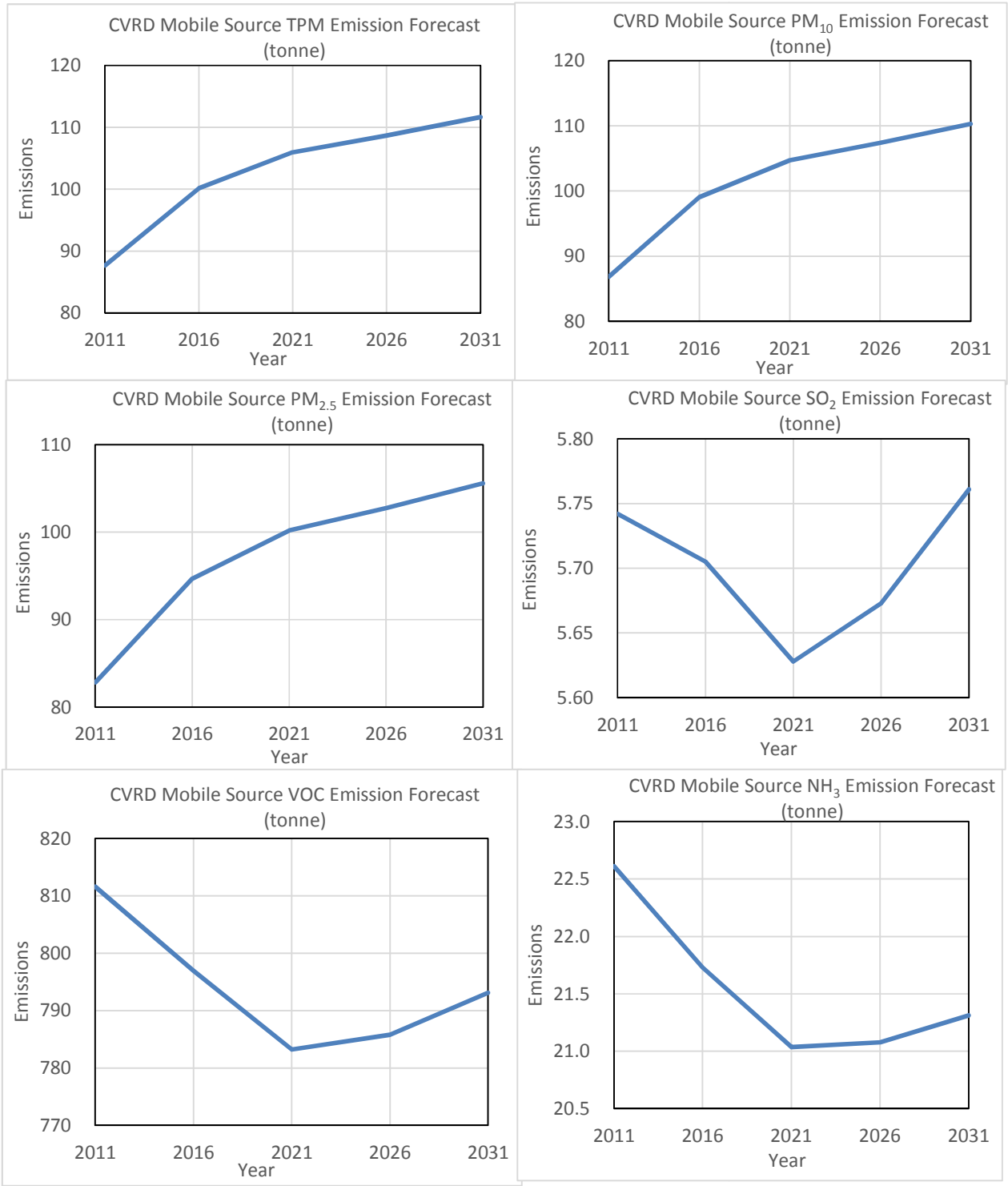


Figure 8-3 CVRD Mobile Source Emission Forecast

The breakdown of CAC emissions from mobile sources is presented from Table 8-11 to Table 8-14.
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Table 8-11 Emission Forecast for On-road Vehicles (metric tonnes)

On-road Vehicles	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	7,033	1,152	39.28	39.28	37	5	538	22
2016	6,528	1,224	45.4	45.4	43.4	4.7	512.3	20.6
2021	6,192	1,251	48.2	48.2	46.2	4.5	493.5	19.8
2026	6,166	1,272	49.5	49.5	47.5	4.5	493.7	19.8
2031	6,204	1,303	51.1	51.1	49.0	4.6	498.7	20.0

Table 8-12 Emission Forecast for Off-road Vehicles/Equipment (metric tonnes)

On-road Vehicles	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	2947.7	242.7	27.17	27.17	25.89	0.29	236.9	0.31
2016	2947.7	242.7	27.17	27.17	25.89	0.29	236.9	0.31
2021	2947.7	242.7	27.17	27.17	25.89	0.29	236.9	0.31
2026	2947.7	242.7	27.17	27.17	25.89	0.29	236.9	0.31
2031	2947.7	242.7	27.17	27.17	25.89	0.29	236.9	0.31

Table 8-13 Emission Forecast for Marine Emissions (metric tonnes)

Marine Emissions	Emissions (Metric tonnes)							
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC	NH_3
2011	93.1	1158.7	21.2	20.4	19.5	0.53	36.36	0.61
2016	121.3	1509.9	27.6	26.5	25.4	0.69	47.38	0.80
2021	134.2	1670.4	30.6	29.4	28.1	0.77	52.42	0.88
2026	140.2	1745.6	32.0	30.7	29.4	0.80	54.78	0.92
2031	146.3	1820.9	33.3	32.0	30.7	0.84	57.14	0.96

Table 8-14 Emission Forecast for Aircraft Emissions (metric tonnes)

Aircraft Emissions	Emissions (Metric tonnes)						
	CO	NOx	TPM	PM_{10}	$PM_{2.5}$	SO_2	VOC
2011	8.8	0.2	0.007	0.007	0.007	0.04	0.29
2016	9.5	0.3	0.008	0.008	0.008	0.04	0.32
2021	10.3	0.3	0.008	0.008	0.008	0.04	0.34
2026	11.1	0.3	0.009	0.009	0.009	0.05	0.37
2031	12.0	0.3	0.010	0.010	0.010	0.05	0.40

8.5 Road Dust

Forecast for road dust emissions is summarized in Table 8-15.

Table 8-15 Emission Forecast for Road Dust Emissions (metric tonnes)

Road Dust	Emissions (metric tonnes)		
Year	TPM	PM_{10}	$PM_{2.5}$
2011	15,481	3,867	729
2016	16,631	4,155	784
2021	17,201	4,297	811
2026	17,737	4,431	836
2031	18,403	4,597	867

9. Conclusions and Recommendation for Future Improvement

The CVRD emission inventory focused on using the bottom-up approach whenever activity data are available. Mobile sources, were the largest contributor of CO and NOx. The largest emitters for SO_2 were point sources. Majority of TPM, PM_{10}, $PM_{2.5}$, VOC and NH_3 emissions were from area sources.

For point sources, emissions from a total of 19 industrial facilities were inventoried. The majority of industry emissions were from the pulp and paper sector, which accounted for 87% of CO, 95% of NOx, 62% of TPM, 77% of PM_{10}, 86% of $PM_{2.5}$, 67% of VOC, and 99.7% of SOx emissions in this sector. The petroleum product storage sector was the second largest contributor at 29% in terms of total VOC emissions from industrial sources. Due to time and budgetary restraints, emissions from industrial sources were not broken down at facility level. For future improvement for the purpose of emissions modelling, the breakdown of emission sources at facility level along with information on modeling parameters, such as stack diameter and height, stack exit velocity and temperature should be included in the regional emission inventory.

Emissions from area sources were quantified using the most up-to-date activity information available. Among all area sources, open burning was the largest contributor of CO, NOx, TPM, PM_{10} and $PM_{2.5}$. VOC emissions from gasoline marketing and solvent evaporation account for approximately half of the total VOC emissions from area sources. Agricultural activities were the largest source for the regional NH_3 emissions and the main contributor of SO_2 emissions is from space heating.

Mobile emissions were quantified using the activity data provided by the CVRD staff and information contained in the CEEI report. Data analyses indicated that emissions from on-road mobile sources were the largest contributor for all CAC emissions, except for NOx. NOx emissions from marine activity were slightly higher than that from on-road vehicles. Total NOx emissions from these two activities account for more than total 90% of mobile sources. Non-road equipment emissions of CO, TPM, PM_{10}, $PM_{2.5}$ and VOC account of approximately 30% of total mobile emissions. CAC emissions due to aircraft were relatively small.

For this study, emissions from area and mobile sources were not allocated at census level or CVRD electoral region. The spatial allocation of area and mobile sources are recommend for future regional emission inventory database compilation. The preferred format for the CVRD inventory will be a geographic information system (GIS) based database to incorporate detailed information, such as facility location, local population, animal counting, and gridded area/mobile emissions in to the database system.

The base year emissions have been forecast at five-year intervals for 2016, 2021, 2026 and 2031. In general, emissions for NOx, TPM, PM_{10}, $PM_{2.5}$, VOC, and NH_3 exhibited rising trends when compared to the baseline. Regional CO emissions were forecast to be at the lowest level in 2021 (16,734 tonnes) then emissions continue to increase afterwards. The decrease of CO emissions were mainly attributed to lower demand for gasoline. In 2011, CO emissions from gasoline alone account for approximately 40% of total regional baseline emissions. Since the majority of regional CO emissions were from gasoline consumption, the emissions decline of this source resulted in the overall decrease in regional emissions till 2021 despite increases in CO emissions from other sectors during this same period. After 2021, the increase of CO emissions from other sources has overtaken the CO emission decrease from gasoline consumption, resulting in a net regional increase in CO when compared to 2021. SO_2 were predicted to remain at relatively stable emission rates around 2,200 tonne annually since industrial sources were the largest contributor of SO_2 emissions.

Appendix A:
Data Quality Assurance and Quality Control (QA/QC)

Data QA/QC were carried out throughout the project. The key elements of the QA/QC was summarized in the following table.

Table A-1 Key Elements of the QA/QC Management System

QA/QC Management System	
Component	**Content**
Responsibility	▪ Individual responsibilities for data collection, analysis, compilation, review, report writing are clearly defined, documented and understood. ▪ Organizational level of responsibility is clearly identified and established. ▪ Necessary technical and administrative support are defined and available on a timely basis.
Data Analysis & Compilation	▪ Procedures for data collection, analysis and compilation are well documented and followed. ▪ Emission quantification methodologies follow the best available accuracy approach and are documented. ▪ Emission inventory compilation was compared with datasets from other studies for cross checking. ▪ Assumptions and references for emission estimates using surrogate parameters are documented. ▪ Any changes or discrepancies discovered during data review and analysis are reported and corrected.
Senior Review	▪ Emission estimates and methodologies are reviewed and approved by senior staff. ▪ Errors during review process are updated and modifications are implemented as appropriate.

QA/QC Management System	
Component	**Content**
Record Tracking & Keeping	▪ Original raw data are retained in an electronic or hardcopy formats for retention. ▪ Data sources, assumptions, estimation methodologies, and references are achieved. ▪ Data analysis with explanations and comments are provided. ▪ Reasons and actions for data modification and improvement are documented. ▪ Data uncertainty, limits and future improvement are filed. ▪ Document all decisions and information including that not submitted to BCMoE, Examples are: o Identification of unreported source emissions and substances; o Calculations, including copies of work conducted manually and all electronic spreadsheets; o Records of all relevant communication with team members and data contacts (including minutes of biweekly meetings).
Schedule	▪ Deadlines for data collection, calculations, review, data entry, and approval of results and report preparation are identified. ▪ Identified milestones to help meet the "critical path" events.