

EXECUTIVE SUMMARY

SENES Consultants Limited (SENES) was commissioned by the City of Grand Forks to complete a comprehensive emissions inventory of all significant emission sources in and surrounding the City in 2006. The inventory work was managed on behalf of the City by the Boundary Air Quality Committee (BAQC), which is made up of representatives from the City, the public, industry and the B.C. Ministry of Environment (MoE). The emissions inventory corresponds to an 'airshed' that was defined as approximately 240 square kilometres, which fully contains the City and surrounding area known as Area D of the Kootenay Boundary Regional District.

Following the usual convention, the Grand Forks Emission Inventory (GFEI) is organized to three main source-groups:

- 1) *Point sources* refer to fixed-location large industrial sources that operate under a discharge permit from the Province. There are five point sources in the GFEI.
- 2) *Mobile sources* include all modes of motorized transportation, including motor vehicles, aircraft, rail, and non-road engines (lawnmowers, chainsaws, tractors etc).
- 3) *Area sources* include all remaining emission sources, which in many cases tend to be widely distributed throughout a community. An example of an area source is space heating due to combustion of natural gas.

Annual point source emissions were available from past emissions monitoring data or emission estimates managed by the MoE. The many individual mobile and area sources were characterized by a survey of residential activities, a highway traffic study, information requests sent to industry, the City and the Regional District, information from Statistics Canada and on-site observations made during a visit to the City during August 1-3, 2007. Activity data collection was very successful, thanks in large part to volunteers from the BAQC, industry representatives and many other individuals and groups named in the *Acknowledgements*.

The requirements for generating the GFEI included estimation of nitrogen oxides (NO_x), sulphur oxides (SO_x), suspended particulate matter (PM, as total suspended particulate matter – TSP, PM of diameter 10 microns or less – PM₁₀ and PM of diameter 2.5 microns or less – PM_{2.5}), carbon monoxide (CO), volatile organic compounds (VOC) and ammonia (NH₃). This group of pollutants is collectively referred to as 'Common Air Contaminants' (CACs). The requirements also included estimation of Greenhouse Gases (GHGs), including carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O).

In addition to the emissions directly released from emission sources (which can be referred to as 'primary' emissions), the GFEI contains estimates of organic and inorganic secondary particulate

matter. Secondary PM results from chemical reactions in the atmosphere involving primary gaseous emissions (NO_x, SO_x, NH₃, VOC). Although secondary PM estimates have been included in the GFEI, there is a much higher degree of uncertainty associated with their calculation methods when compared to the primary emissions estimates. The majority of secondary particulate matter accounted for in the GFEI results from biogenic emissions from coniferous forest species.

Fugitive TSP and PM₁₀ emissions (dust emissions resulting from wind erosion, actions of vehicle tires on roadway surfaces or material handling) were estimated as ‘suspendable’ and ‘transportable’ amounts. A significant proportion of suspendable TSP and PM₁₀ emissions (75% and 60%, respectively) were considered to be deposited very near the point(s) of release, and were therefore not included in the airshed summary totals. In effect, this approach distinguishes between the amount of dust that stays within 2 metres of the ground (and is deposited near the source of emission) and the amount that influences air quality over a significant area. All fugitive PM_{2.5} emissions were considered to be transportable.

Table ES-1 provides a general description of the source categories used in the GFEI. The 135 individual sources within the inventory are described within the main body of this report.

**Table ES-1
General Description of Emission Source Categories for the GFEI**

Source Type	Category	Description	Includes these individual sources
AREA	Area_Agriculture	Emissions due to Agricultural Activity	Animal husbandry, land clearing/tilling
	Area_Dust	Fugitive dust emissions	road dust, wind erosion, industrial yard dust
	Area_Energy	Emissions due to space heating	natural gas use, electricity, wood stoves
	Area_Other	All other significant area sources	vegetation, open burning, fuel marketing, landfill
	AREA TOTAL		
MOBILE	Mobile_Highway	Emissions due to highway traffic, tailpipe	cars, light, medium and heavy duty trucks
	Mobile_Local	Emissions due to local traffic, tailpipe	cars, light duty trucks
	NonRoad_Agriculture	Emissions from agricultural equipment	tractors, trucks, balers
	NonRoad_Commercial	Emissions from commercial equipment	chippers, leaf blowers, pressure washers, etc
	NonRoad_Construction	Emissions from construction equipment	backhoes, crushers, loaders, tampers etc
	NonRoad_Industry	Emissions from local industry equipment	loaders, generators, forklifts, water trucks etc
	NonRoad_Recreational	Emissions from recreational offroad engines	ATVs, dirt bikes, snow machines
	NonRoad_Residential	Emissions from residential small engines	chain saws, generators, small tractors etc.
MOBILE TOTAL			
POINT	CanPar	Stack emissions, process emissions	based on stack tests
	Pacific Abrasives	Fugitive dust emissions from handling	based on dustfall measurements
	Pope & Talbot	Stack emissions, process emissions	based on production rates and processes
	Roxul	Stack emissions, process emissions	based on stack tests
	Selkirk Paving	Process emissions	estimates based on asphalt production amounts
	POINT TOTAL		

Table ES-2 provides the common air contaminant and greenhouse gas emissions inventory for 2006. This inventory summary does not include secondary particulate matter or the diesel sub-fractions of particulate matter estimates (amount of PM that is associated with diesel combustion). The identification of diesel PM is a common feature of inventories for much larger municipal areas. For Grand Forks the diesel PM amounts are quite low.

Table ES-3 provides the diesel and secondary particulate matter emissions inventory for 2006. This inventory includes secondary organic aerosol (SOA) and inorganic (nitrates and sulphates) compounds, as well as fine particulate matter caused by diesel combustion (PM_{10_D} and PM_{2.5_D}). Secondary PM should be considered to be entirely within the smallest PM size fraction (PM_{2.5}). As a general rule, estimates for the secondary particulates are accurate within an order of magnitude. Also worth noting, secondary particulate matter formation occurs throughout the airshed and at various heights above the ground. For these reasons, it is considered to be inappropriate to add primary and secondary particulate matter emissions as total PM emissions for the airshed.

**Table ES-2
CAC and GHG Emissions Inventory for Grand Forks***

Source Type	Category	CACs (tonnes)								GHGs (tonnes)		
		CO	NO _x	SO _x	VOC	NH ₃	TSP	PM10	PM25	CO ₂	CH ₄	N ₂ O
AREA	Area_Agriculture	39.79	1.37	0.00	16.51	8.22	17.94	13.52	8.50	0.00	53.11	0.99
	Area_Dust	0.00	0.00	0.00	0.00	0.00	615.10	309.24	74.94	0.00	0.00	0.00
	Area_Energy	179.47	12.66	0.61	39.51	0.70	28.03	26.46	26.46	34,092.93	28.39	1.01
	Area_Other	32.91	31.39	0.24	1,973.70	0.19	5.38	5.04	4.94	1,214.10	446.34	7.78
	AREA TOTAL	252.2	45.4	0.9	2,029.7	9.1	666.5	354.3	114.8	35,307.0	527.8	9.8
MOBILE	Mobile_Highway	1,031.96	98.71	0.88	90.10	3.24	2.48	2.48	1.74	20,586.35	4.47	5.42
	Mobile_Local	614.64	49.95	0.38	52.74	2.07	1.28	1.28	0.89	10,591.60	2.75	2.83
	NonRoad_Agriculture	68.55	12.98	1.04	4.84	0.05	0.84	0.84	0.81	1,261.49	0.41	0.40
	NonRoad_Commercial	156.95	13.43	0.40	19.77	0.01	1.29	1.29	1.21	1,041.43	0.57	0.24
	NonRoad_Construction	25.85	4.49	0.46	1.66	0.01	0.38	0.38	0.37	445.75	0.11	0.15
	NonRoad_Industry	43.44	18.43	1.75	3.13	0.03	0.98	0.98	0.95	1,786.97	0.29	0.56
	NonRoad_Recreational	67.92	0.27	0.01	31.63	0.01	0.87	0.87	0.80	380.73	0.44	0.01
	NonRoad_Residential	412.67	2.51	0.02	41.90	0.01	1.18	1.18	1.09	770.12	0.88	0.02
	MOBILE TOTAL	2,422.0	200.8	4.9	245.8	5.4	9.3	9.3	7.8	36,864.5	9.9	9.6
POINT	CanPar	116.40	81.66	1.14	269.13	0.50	420.00	87.00	66.00	0.00	0.00	0.00
	Pacific Abrasives	0.00	0.00	0.00	0.00	0.00	17.00	3.60	3.60	0.00	0.00	0.00
	Pope & Talbot	14.50	72.70	0.43	50.00	0.00	62.00	54.00	34.00	0.00	0.00	0.00
	Roxul	1.31	2.18	0.03	26.04	3.31	84.20	78.20	74.20	0.00	0.00	0.00
	Selkirk Paving	1.00	0.20	0.03	0.25	0.00	0.25	0.18	0.17	0.00	0.00	0.00
	POINT TOTAL	133.2	156.7	1.6	345.4	3.8	583.5	223.0	178.0	0.0	0.0	0.0
Grand Total		2,807.4	402.9	7.4	2,620.9	18.4	1,259.2	586.6	300.7	72,171.5	537.7	19.4

*Includes transportable fugitive dust emissions only. GHG emissions for point sources (industry) are captured within Area_Energy sources.

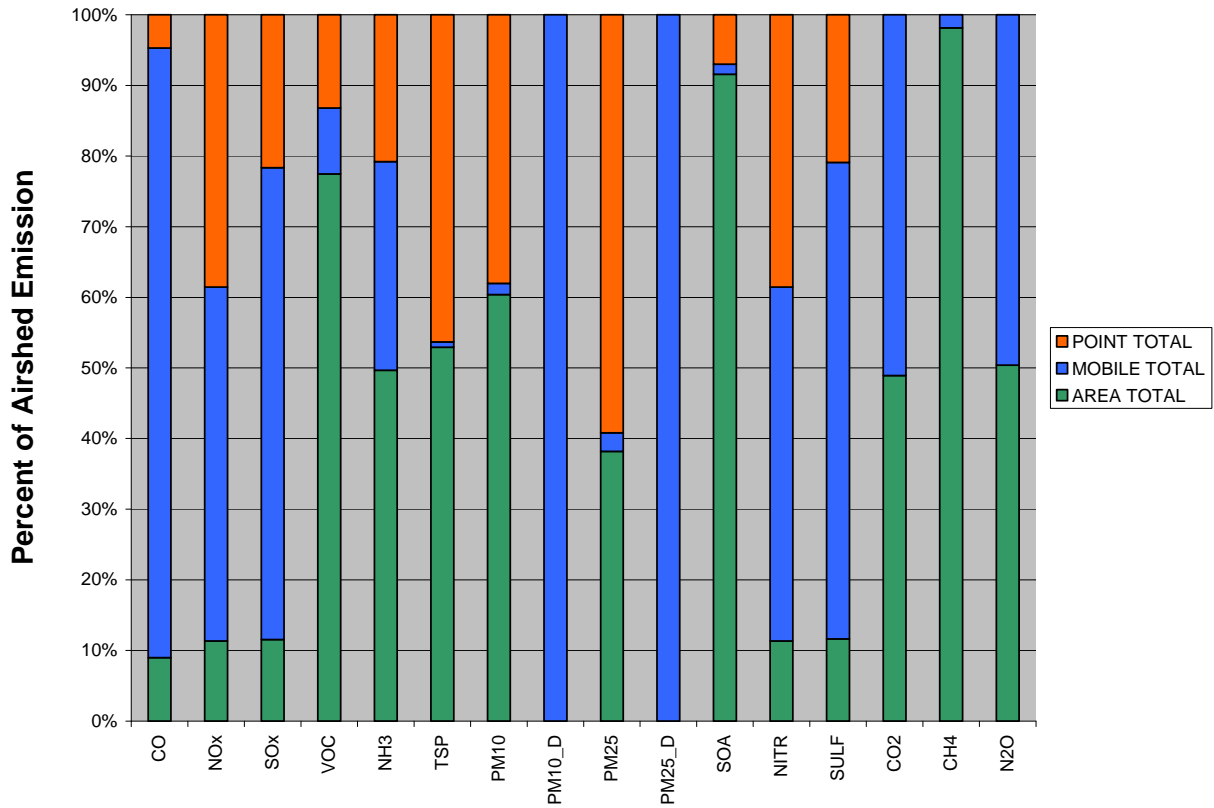
**Table ES-3
Diesel and Secondary Particulate Matter Emissions Inventory for Grand Forks***

Source Type	Category	CACs (tonnes)		Secondary PM (tonnes)		
		PM10_D	PM25_D	SOA	NITR	SULF
AREA	Area_Agriculture	0.00	0.00	0.01	0.06	0.00
	Area_Dust	0.00	0.00	0.00	0.00	0.00
	Area_Energy	0.00	0.00	0.00	0.58	0.01
	Area_Other	0.00	0.00	192.86	1.44	0.00
	AREA TOTAL	0.0	0.0	192.9	2.1	0.0
MOBILE	Mobile_Highway	1.26	1.17	1.06	4.52	0.02
	Mobile_Local	0.65	0.60	0.63	2.29	0.01
	NonRoad_Agriculture	0.81	0.78	0.02	0.59	0.02
	NonRoad_Commercial	0.17	0.16	0.25	0.61	0.01
	NonRoad_Construction	0.35	0.34	0.01	0.21	0.01
	NonRoad_Industry	0.91	0.88	0.03	0.84	0.04
	NonRoad_Recreational	0.00	0.00	0.42	0.01	0.00
	NonRoad_Residential	0.00	0.00	0.57	0.11	0.00
	MOBILE TOTAL	4.1	3.9	3.0	9.2	0.1
POINT	CanPar	0.00	0.00	1.70	3.74	0.02
	Pacific Abrasives	0.00	0.00	0.00	0.00	0.00
	Pope & Talbot	0.00	0.00	13.07	3.33	0.01
	Roxul	0.00	0.00	0.16	0.10	0.00
	Selkirk Paving	0.00	0.00	0.00	0.01	0.00
	POINT TOTAL	0.0	0.0	14.9	7.2	0.0
Grand Total		4.1	3.9	210.8	18.5	0.1

Notes: PM10_D is the fraction of PM₁₀ caused by diesel combustion PM25_D is the fraction of PM_{2.5} caused by diesel combustion
 SOA is the total amount of secondary organic aerosol formed within the airshed
 NITR is total nitrate aerosols formed within the airshed SULF is total sulphate aerosols formed within the airshed

Figure ES-1 provides a bar chart of the GFEI, showing the relative contribution of each of the three general source types (point, area and mobile), for each air contaminant inventoried.

**Figure ES-1
GFEI by Emission Source Group***



* PM10_D, = diesel fraction of PM₁₀, PM25_D = diesel fraction of PM_{2.5}, SOA = secondary organic aerosols, NITR = nitrates, SULF = sulphates

Figures ES-2 to ES-5 provide further breakdown of the relative source contributions for annual NO_x, TSP, PM_{2.5} and CO₂. Secondary PM is not included in the PM_{2.5} and TSP diagrams.

Figure ES-2: NO_x Emissions by Source Type (total = 403 tonnes)

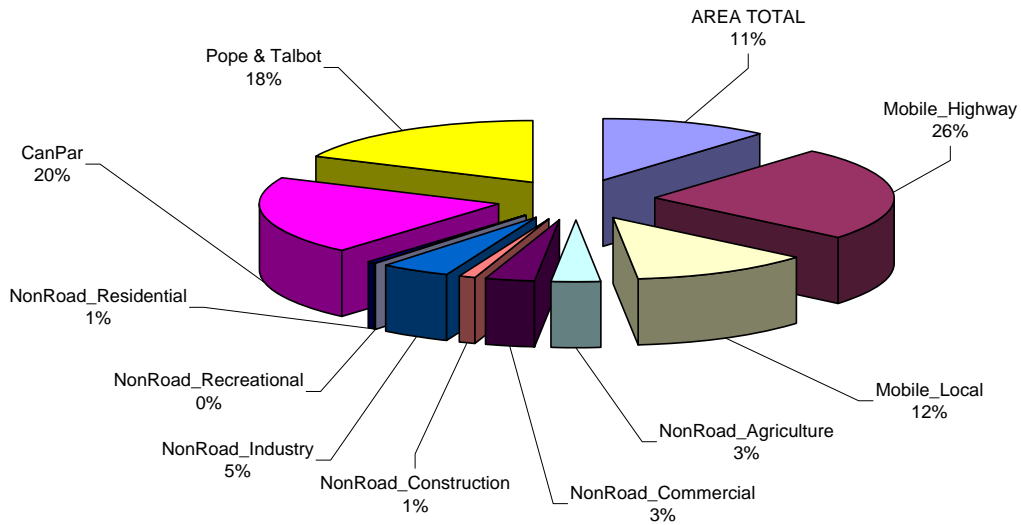
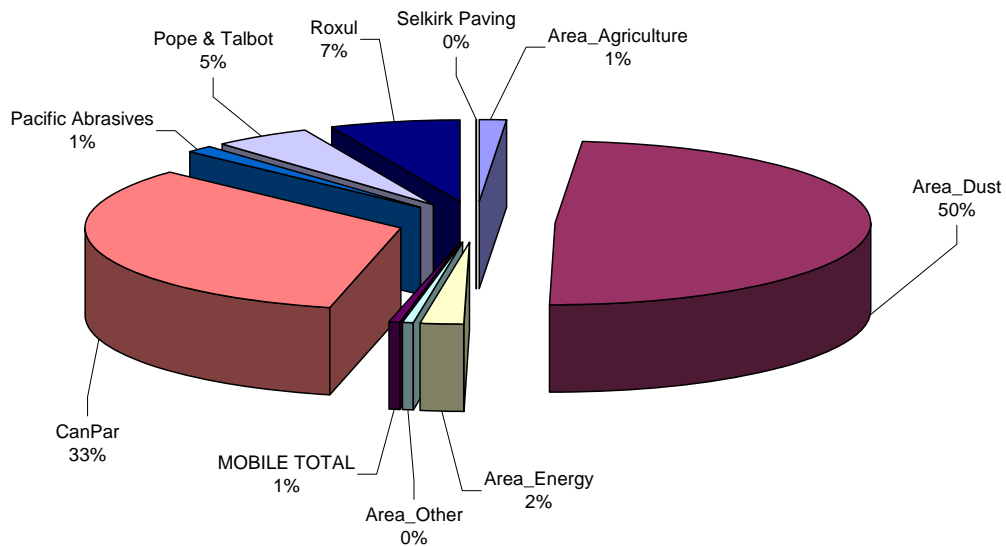
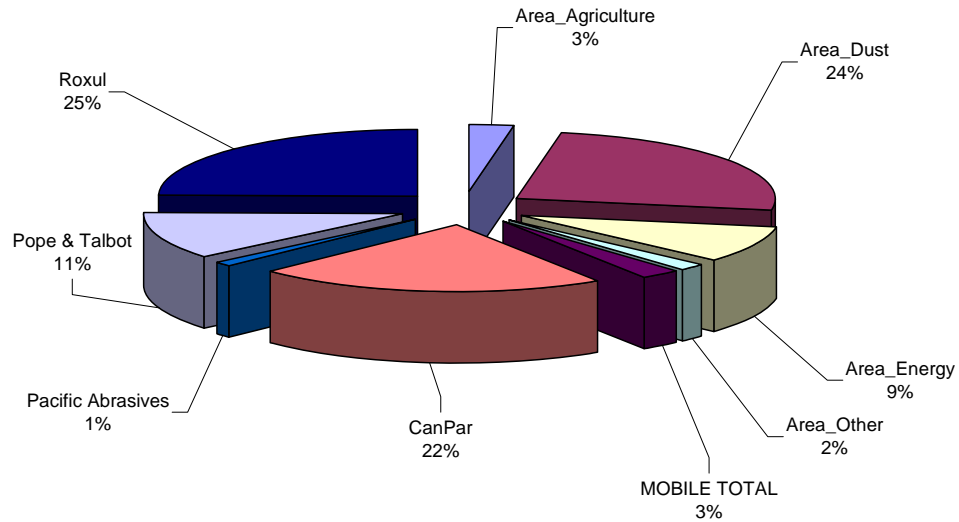


Figure ES-3: Primary TSP Emissions by Source Type (total = 1259 tonnes)*



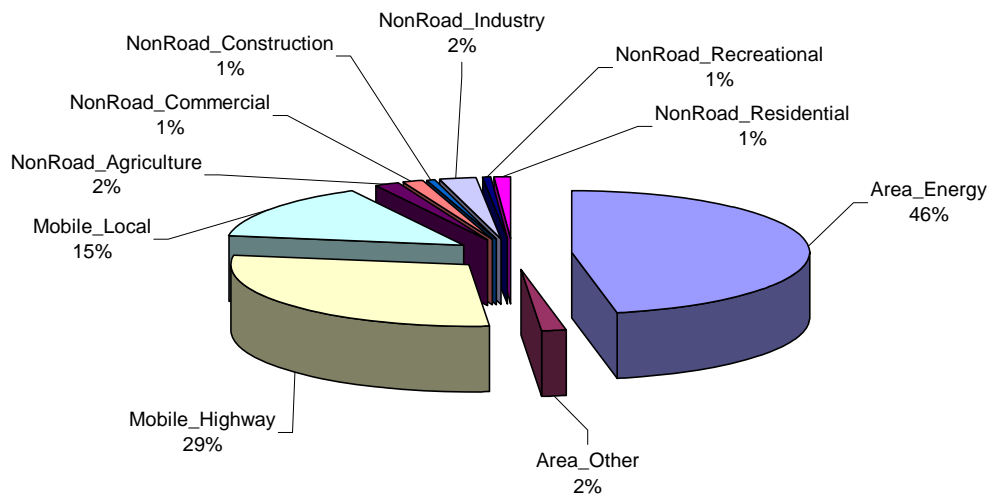
*Includes transportable dust emissions only

Figure ES-4: Primary PM_{2.5} Emissions by Source Type (total = 301 tonnes)*



*Does not include secondary particulate matter

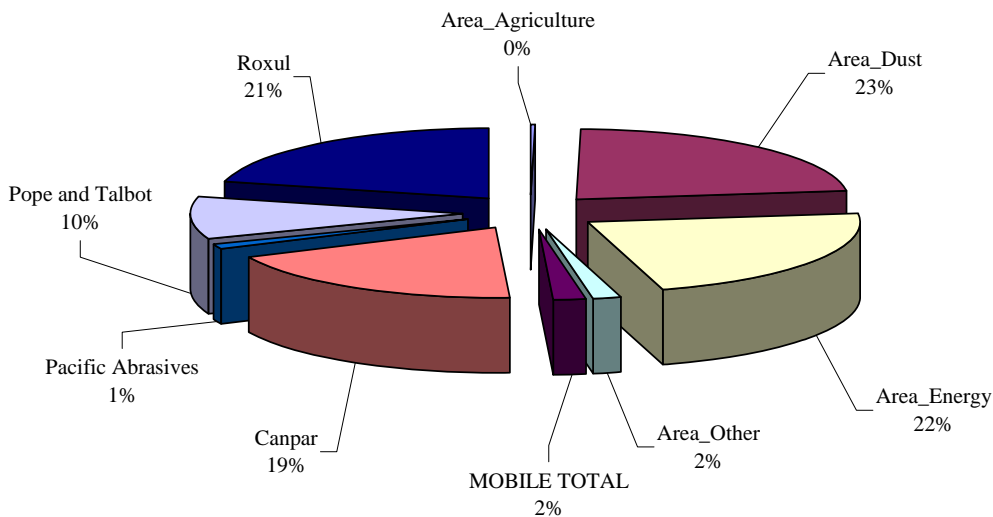
Figure ES-5: CO₂ Emissions by Source Type (total = 72,171 tonnes)*



*Point Source (Industry) CO₂ emissions are included with the 'Area_Energy' source group.

The GFEI was developed within an emissions inventory database. The database allows the user control over both activity rates (such as kms of vehicle travel, cords of wood use etc) and seasonal adjustment rates. The database can be used by the BAQC to accomplish many other types of relative comparisons of interest. For example, selecting 'winter' in the database shows that winter-time emissions of VOC and PM differ substantially from emissions in other seasons (VOC lower and PM higher). Figure ES-6 provides the relative source contributions to total winter PM_{2.5} emissions in the airshed. It can be seen that Area_Energy emissions, which primarily relate to woodstove use, are much more significant to the inventory total during this season.

Figure ES-6
Primary PM_{2.5} Emissions by Source Type in Winter (total = 88 tonnes)



Over time, the BAQC may in fact develop improved or adjusted activity estimates for some of the emission sources. For example, the database will support testing of different ‘scenarios’, such as the replacement of older wood stoves with more advanced stoves.

However, the following cautions are necessary to consider when using or adjusting the database:

- Each source has an associated uncertainty. For those sources with relatively high uncertainty (for example, wind erosion from the slag piles), scenario testing has limited relevance. The uncertainties should always be considered before making adjustments to the activity rates.
- Some sources require an associated activity assumption such as average engine size. These assumptions are visible in the activity entry form. Such parameters may not be intuitive and should not be changed based on ‘common sense’. The parameters are based on emissions modelling and represent harmonized conditions (for example, average hp inherently relies on typical usage patterns including idling periods).
- The upper and lower bounds shown in the reporting should not be added linearly to estimate an upper or lower bound for the entire inventory. Instead, they may be considered on an individual source basis (for example, ‘what are the maximum possible annual emissions from highway road dust within the methodology used?’). The individual estimates in the inventory are based on professional judgment of the authors, and the total inventory uncertainty levels are estimated (and presented) using a non-linear approach described in Appendix A.
- Should the inventory be used for future dispersion modelling, the issue of suspendable versus transportable fugitive dust must be revisited. In effect, a dispersion model may or may not be able to reasonably account for the fraction of fugitive dust that is able to travel beyond the immediate vicinity of the source.

The GFEI is based on the current understanding of feasible air emissions estimation methodologies. For some sources, improved methodologies may become available in the future. The GFEI was constructed in such a way that updates can be achieved relatively easily.