Scoping Study Report:

Micro-Emissions Inventory Update for the Bulkley Valley – Lakes District

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List of Acronyms and Abbreviations

AERMOD – American Meteorological Society/Environmental Protection Agency Regulatory Model

AMPA – Airshed Management Plan Area as defined by the AMS (see below)

AMS – Airshed Management Society

AURAMS – A Unified Regional Air-Quality Modelling System; a Canadian model similar to CMAQ (see below).

BC – British Columbia

BC MOE – British Columbia Ministry of Environment

BVLD – Bulkley Valley – Lakes District

BVRC – Bulkley Valley Research Centre

C – Carbon

CAC – Criteria Air Contaminants

CALPUFF – California Puff Model; models emissions as "puffs" rather than plumes

Cd – cadmium

CMAQ – Community Multi-scale Air Quality model; a comprehensive dispersion model requiring extensive datasets, and coding languages; that resolves air quality chemistry, deposition and other factors much better than AERMOD or CALPUFF. It is used for more regional (e.g. nation-, or province-wide) air quality modelling.

CO – Carbon Monoxide

COPERT – Computer Program to Calculate Emissions from Road Transport

ECCC – Environment and Climate Change Canada

EI – Emissions Inventory

EIA – Environmental Impact Assessment

EF – Emission Factors; used to estimate emissions from sources with known characteristics

GHG – Greenhouse Gases

IARC – International Agency for Research on Cancer

IC – Industry Canada

HNO_3 – Nitric Acid

MEI – Micro Emissions Inventory

MS – Microsoft

nm – nanometre

µm – micrometres; one millionth of a meter (m), or 1 x 10^{-6} m

µg/m^3 – micrograms per cubic metre; how particulate matter (PM) is usally measured; because PM is composed of multiple elements and compounds, it cannot be measured on a ppb basis (see below).

MOA – (BC) Ministry of Agriculture

MOT – (BC) Ministry of Transport

MOFLNR – (BC) Ministry of Forests, Lands and Natural Resource Operations

NH_3 – Ammonia

nm – nanometres

nmVOC – non-methane volatile organic compounds (VOC; see below)

NO_x – Oxides of Nitrogen; including NO, NO_2, NO_3^-, etc.

NPRI – (Canada's) National Pollutant Release Inventory

NRCan – Natural Resources Canada

OHNOPRO – 'Oh no pro', a local blog providing information on the 'NewPro' (Northern Engineered Wood Products) facility in Smithers, BC

OPTS – (BC's) Open Fire Tracking System

PAH – polycyclic aromatic hydrocarbons; some of which may be carcinogenic; including benzo(a)pyrene, fluoranthene, etc.

PIR – Pacific Inland Resources sawmill in Smithers

Pb – lead

PM – Particulate Matter; including PM_{10}, $PM_{2.5}$, $PM_{1,}$ etc.

ppb – parts per billion; a common way to quantity air contaminants

ppm – parts per million; although not used in this report, it is added here as a common measure of gaseous pollutants—1 ppm is equal to 1000 ppb (see above), so measurements in ppb are much more precise and a more appropriate measure of lower-level chronic biological effect/outcomes of pollutants.

Se – selenium

SiO_2 – Silicon dioxide, silica or quartz; commonly found in soil and road dust

SO_2 – Sulphur Dioxide

SO_x – Oxides of Sulphur; including SO_2, SO_3^-, SO_4^{2-}, etc.

TPM – Total Particulate Matter; can include particles larger than 10 microns (i.e. PM_{10})

UNFCCC – United Nations' Framework Convention on Climate Change

UFP – PM_1 or particles < 1 μm in aerodynamic diameter

US EPA – United States Environmental Protection Agency

USFS – United States Forest Service

VOC – Volatile Organic Compounds; these are carbon-based compounds that easily volatilize (or evaporate into gases/vapours) in air at regular temperature and pressure

WFM – West Fraser Mills Ltd. sawmill in Fraser Lake

Summary

This document represents a report on the scoping study conducted to estimate the needs and limitations of a Micro-Emissions Inventory (MEI) update for the Bulkley Valley – Lakes District (BVLD) airshed in west-central British Columbia (BC); on behalf of the BVLD Airshed Management Society (AMS). Various elements of inventory scope are discussed and analyzed with particular emphasis on relevance to the BVLD and the needs of inventory end-users. Different inventory scenarios are presented and their strengths/weaknesses weighed, with the intention of providing a number of realistic options for the development of an accurate and up-to-date MEI for the airshed.

1. Introduction

Of all the necessities of life—air, water, and food—air is perhaps the most important. While we can go hours or days without water or food, respectively, we can only be minutes without air. However, the quality of the air we breathe depends on its composition, which is affected by the emissions of numerous substances, originating from a variety of industrial, commercial, residential and biological activities.

Detailed information regarding atmospheric emissions is required for: airshed planning, human health protection or risk assessment, environmental and conservation efforts, source permitting and project approvals, community education, and local interest—to name a few. This information is typically given in the form of an emissions inventory (EI) that can vary significantly in terms of scale, detail, source/contaminant inclusion, accuracy, and format, depending on the purpose for which the inventory is developed.

For instance inventories of atmospheric emissions are often created for regulatory purposes. In these cases lower jurisdictional levels often report their emissions to higher jurisdictional levels. An example would be federal governments' reporting of greenhouse gas (GHG) emissions to the United Nations' Framework Convention on Climate Change (UNFCCC)—information that is initially supplied by each individual province/territory, who get their information from individual sources/emitters. While GHG are reported for the purposes of tracking adherence with the UNFCCC and its related emission reduction protocols to mitigate and slow the speed of global atmospheric warming, other atmospheric emissions (i.e. air pollutants) can have more direct biological impacts, and at more local scales.

Typically inventoried atmospheric pollutants are known collectively as 'criteria air contaminants' (CAC) and include carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulphur (SO_x), volatile organic compounds (VOC), and particulate matter (PM). These are considered 'criteria' pollutants due to their direct impacts on human and environmental health, and their contributions to acid deposition ('acid rain') and photochemical smog formation. Ammonia (NH_3) is also a commonly inventoried pollutant, particularly in agricultural areas; and some regions may experience unique problems with additional specific pollutants.

In the Bulkley Valley – Lakes District (BVLD) of British Columbia, PM is the CAC of greatest concern. This concern led to the formation of a micro-emissions inventory (MEI) of PM prepared for the region's Airshed Management Society (AMS) in 2005, based on year 2001 and 2002 data (Weinstein 2005). The inventory was considered 'micro' for two main reasons: first, it represented emissions from a localized area—the BVLD (≈35,000 km^2); and second, it only quantified emissions of PM.

Twelve years later, this MEI is severely out-of-date. The use of 2001 and 2002 emissions means that 15 years has passed since the data presented in the inventory were accurate. Even within a localized area such as the BVLD, a great deal can change in 15 years; large emitters open or close their doors, policies change, habits change, the population changes, etc. It is for this reason that the AMS approached Krzyzanowski Consulting asking for assistance in developing an updated MEI for the BVLD. Dr. Judi Krzyzanowski obliged the request, and this document represents the initial phase in developing an updated MEI for the region. Specifically, this document represents a 'scoping' study that can be used by the AMS, potential funding bodies, and additional stakeholders, in determining the required 'scope' of a final inventory report and related data.

The following sections begin by describing the various elements of project scope that need to be considered, including how or whether they may have changed over-time (i.e. since the last inventory). It then offers a number of different inventorying scenarios that differ in their respective scoping elements, and discusses the relevance of each element to the BVLD—or more specifically to the needs and expectations of the AMS in relation to an updated MEI for the region. The purpose of this document is to describe potential options, not to limit them; and there are alternative options/element combinations not provided that may be of benefit to the AMS.

2. Inventories and Scoping Elements

The purpose of the overall project is to develop an updated MEI that is up-to-date and more relevant to existing circumstances in the BVLD than the MEI developed by Weinstein (2005). Any emissions inventory, whether 'micro' or comprehensive and broad in scale (e.g. national), is essentially a collection of data. While specific data elements relevant to scoping are discussed below, there are some general means by which data are evaluated, many of which gave rise to the need for an updated MEI.

For instance, in Fall 2009 Canada's Commissioner for Sustainable Development and the Environment, Scott Vaughan, criticized the quality of data contained in Canada's National Pollutant Release Inventory (NPRI) (Office of the Auditor General 2009). The NPRI is a publicly accessible database containing self-reported emissions' information for large emitters (i.e. major sources) across Canada. In addition to some sector- or intensity-based source exemptions (e.g. agriculture or tonnage of produced pollutant(s), respectively), as well as exemptions for smaller operations (< 20 000 employee hours/year) (*Canada Gazette*, Part 1 February 27, 2016; Schedule 3), the Commissioner made a number of critiques related to the accuracy, completeness and communication of data contained in Canada's NPRI. In response to the Commissioner's recommendations, Environment and Climate Change Canada (ECCC) set out to improve measures for emissions reporting, including the adoption of a multi-dimensional approach to emissions data quality (ECCC 2016) based on 'the Six Dimensions of Information Quality' developed by Statistics Canada (2002), and paraphrased below.

1) Relevance: the degree to which data meet the actual needs of users.

2) Accuracy: the degree to which data correctly describe the phenomena they were designed to measure.
3) Reliability: the degree to which data can be confidently used alongside other information.
4) Completeness: the extent to which the expected attributes of data are provided.
5) Understandability: the availability of the supplementary information and metadata necessary to interpret and utilize the data appropriately.
6) Accessibility: the ease to which the information can be obtained from the inventory.
7) Timeliness: the delay between the end of the reporting period and the date on which the information becomes available.

Each of these 'dimensions' will be accounted for and optimized within the final MEI dataset and report, and used as measures of overall data/inventory quality. In addition, these dimensions are discussed individually and collectively in regards to the elements of scoping discussed below. However, other elements limit these ideal dimensions of data quality, particularly data availability (the 'practical' element) and funding (the 'financial' element).

This document was developed to describe the potential 'scope' of an updated MEI and to offer alternative options for such an endeavour. According to Google (2017), 'scope' is defined as: "*1. the extent of the area or subject matter that something deals with or to which it is relevant", and "2. the opportunity or possibility to do or deal with something*". Generally speaking, a 'scoping study' is used as a preliminary assessment tool. Scoping provides information for researchers, research funders, and project partners; and can provide a broad range of potential study designs of relevance. Consultation (in this case with the AMS) can be used to ensure scoping relevance, determine the desired course of action, and can significantly enhance the results of a scoping exercise (Arksey and O'Malley 2005).

The research question being asked here is: "what is the 'best' emissions inventory that can be developed based on the resources and information available?" This question covers both the definitions of 'scope' given above. In this case 'best' may mean most effective, informative, accurate, precise or any other qualifier determined by the AMS; but must also be subject matter relevant and mindful of available resources. Although similar to a 'systematic review', a scoping study addresses the subject matter more broadly, particularly when many study designs are applicable to the topic at hand. Scoping studies are also more flexible in their evaluation of differing methodologies (Arksey and O'Malley 2005).

For the purpose of the MEI Scoping conducted here, seven different scoping measures or 'elements' were chosen: spatial, temporal, chemical, causal, utilizational, financial and practical. Each of these elements is discussed in more detail below; including their importance in MEI development, how each element was approached in the previous MEI, and the various (yet realistic ways) that the element can be approached in an updated emissions inventory for the BVLD AMS. However, this is a discussion piece, and nothing is set in stone. The intention of this document is to lay out issues at hand and determine a scope that is achievable, while meeting the needs of end-users. Although not all information may be clear at this time, this document is intended to allow the AMS to determine the desired scope of an emissions inventory to be updated/developed by Krzyzanowski Consulting.

2.1 Spatial Scoping Element

The spatial elements of an EI are perhaps some of the most important. Despite other confining elements of an inventory—be they related to the specific chemical compounds being emitted, the size of sources, etc.—spatial boundaries are of utmost importance.

In the previous MEI conducted for the AMS by Weinstein (2005) the spatial boundaries were the BVLD, or more specifically determined by the boundaries of the AMS' Airshed Management Plan Area (AMPA)—an area of 35,000 km^2 (AMS 2012) as shown in Figure 1.

Despite the existing size of this airshed of interest, topography and meteorology both affect the way pollutants disperse and eventually settle in any given area. As such, spatial aspects also influence biological outcome and impacts—i.e. whether or not a biological receptor will be influenced by a specific source, combination of sources, etc. It is possible that the AMS would like to expand or change the current airshed boundaries for the purpose of the updated MEI. In particular, it may be necessary to include upwind emission sources that, despite being outside of the defined boundary, may influence air quality within the BVLD/AMPA and lead to biological or health outcomes within the AMPA. This would be particularly true of larger (regulated or spatially aggregated) sources that emit pollutants year-round in all conditions of atmospheric stability, and whose plumes may enter the airshed leading to the degradation of overall air quality under certain meteorological/atmospheric conditions. Being a valley, the Bulkley is prone to the accumulation of pollutants, particularly during times of atmospheric stability (i.e. temperature inversions, when cold air sits below the warmer above it—inhibiting mixing; when usually the atmospheric temperature decreases with height and promotes mixing) (BC MOE 2017a). Pollutant accumulation may be of particular concern in the low-lying areas of the valley where agriculture dominates (Figure 1) and may lead to a decline in human- and/or crop-health in these areas (depending on meteorology and the pollutants or sources in question).

Although, it is beyond the scope of this document to determine which, if any, sources may influence the airshed from outside the AMPA, some of the 'Output Scenarios' presented in Section 3.0 (Table 2) allow for the addition of external sources that may influence the BLVD airshed and be relevant for the purpose of air quality characterization, background monitoring and other applications. Air knows no boundaries, and 'airsheds' are typically characterized by the highest points of terrain in a region, similar to how a 'watershed' is characterized. The AMPA is rectangular, and although developed for ease of mapping and assessment, the true boundary of an airshed is not linear, but generally describes an area "where the movement of air (and, therefore, air pollutants) can be hindered by local geographical features such as mountains, and by weather conditions." (BC MOE 2017b).

I addition, the location of sensitive receptors—be them human, agricultural, habitat or wildlife—may be of interest to the AMS in terms of the biological relevance of emissions' data. For instance if there is a retirement home, elementary school, or wildlife refuge just on the edges of the AMPA, these receptors may call for the expansion of the study area (AMPA) to allow for their inclusion. This is particularly important in terms MEI data utilization and end-use (sub-section 2.5); such as dispersion modelling, should the data be used that way.

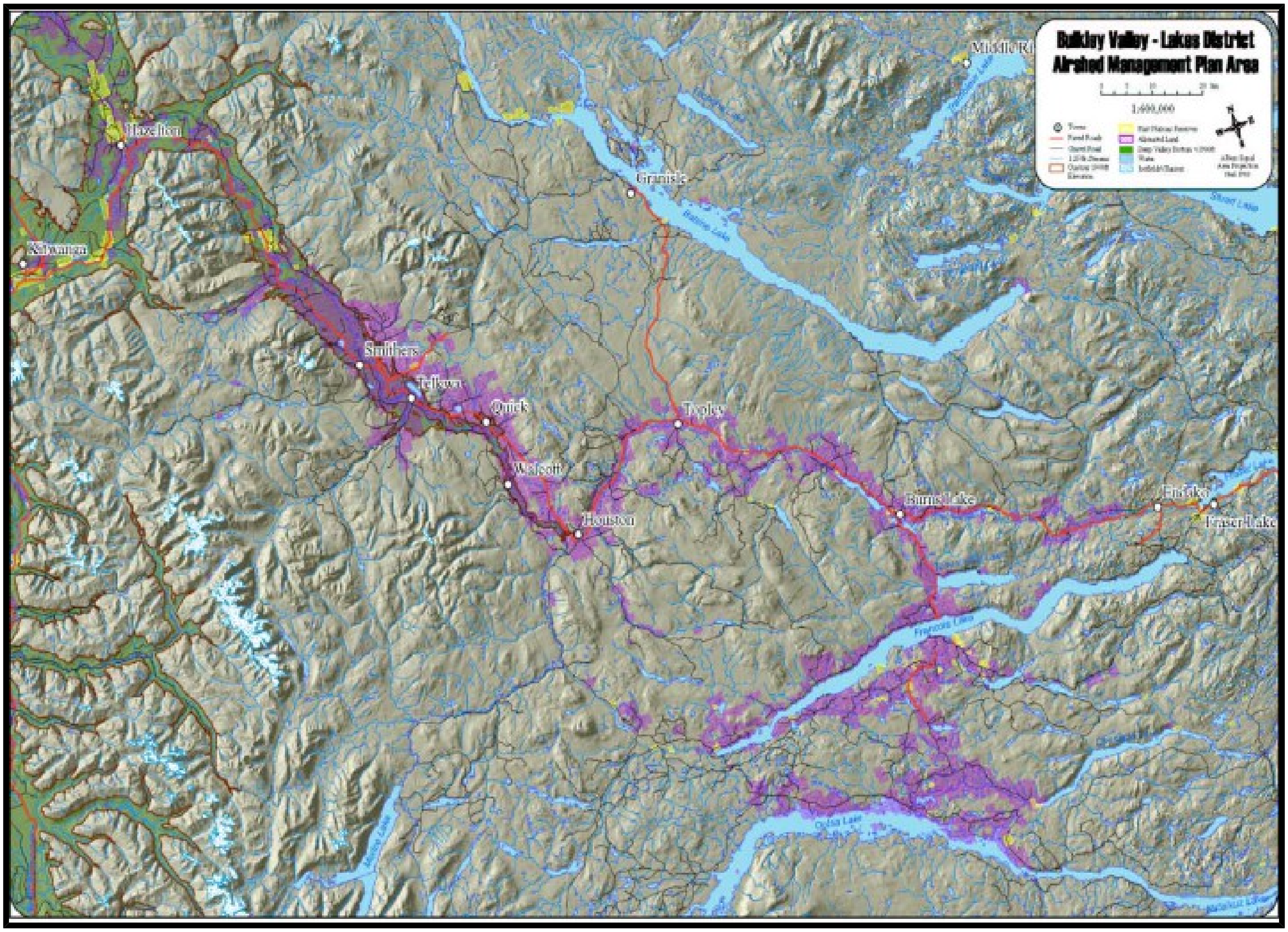

Figure 1. A map of the Airshed Management Plan Area (AMPA) reproduced from Weinstein (2005) and AMS (2012). The legend is considered irrelevant for the purposes of this scoping document, but the purple shows areas dominated by agriculture.

Because winds in the 'Skeena' region are influenced by, not only the prevailing westerly winds (from the Pacific coast), but also by local complex terrain (mountains); according to BC's Ministry of Environment's (BC MOE)'s monitoring stations, winds in the region tend to be either north-westerly (270-360°) or southerly (160-215°) (BC MOE 2017c), with some variation due to the influences of local and synoptic weather systems, complex terrain, and other barriers (e.g. buildings, forests). As such, emission sources from outside of the AMPA may also influence the air quality within it. Therefore, the spatial aspects of emissions and their influence are important in considering the desired scope of an emissions inventory. Figure 2 shows a wind rose of average wind direction and wind-speed for the year 2015 for the Smithers meteorological station at St. Josephs (OHNOPRO 2017). Information on wind direction can help determine, whether and if, sources from outside the AMPA should be included in the updated inventory. At the same time, a spatial boundary must be determined despite that some pollutants, including PM, may travel globally—including the Asian dust that reaches BC (Zhao et al. 2006).

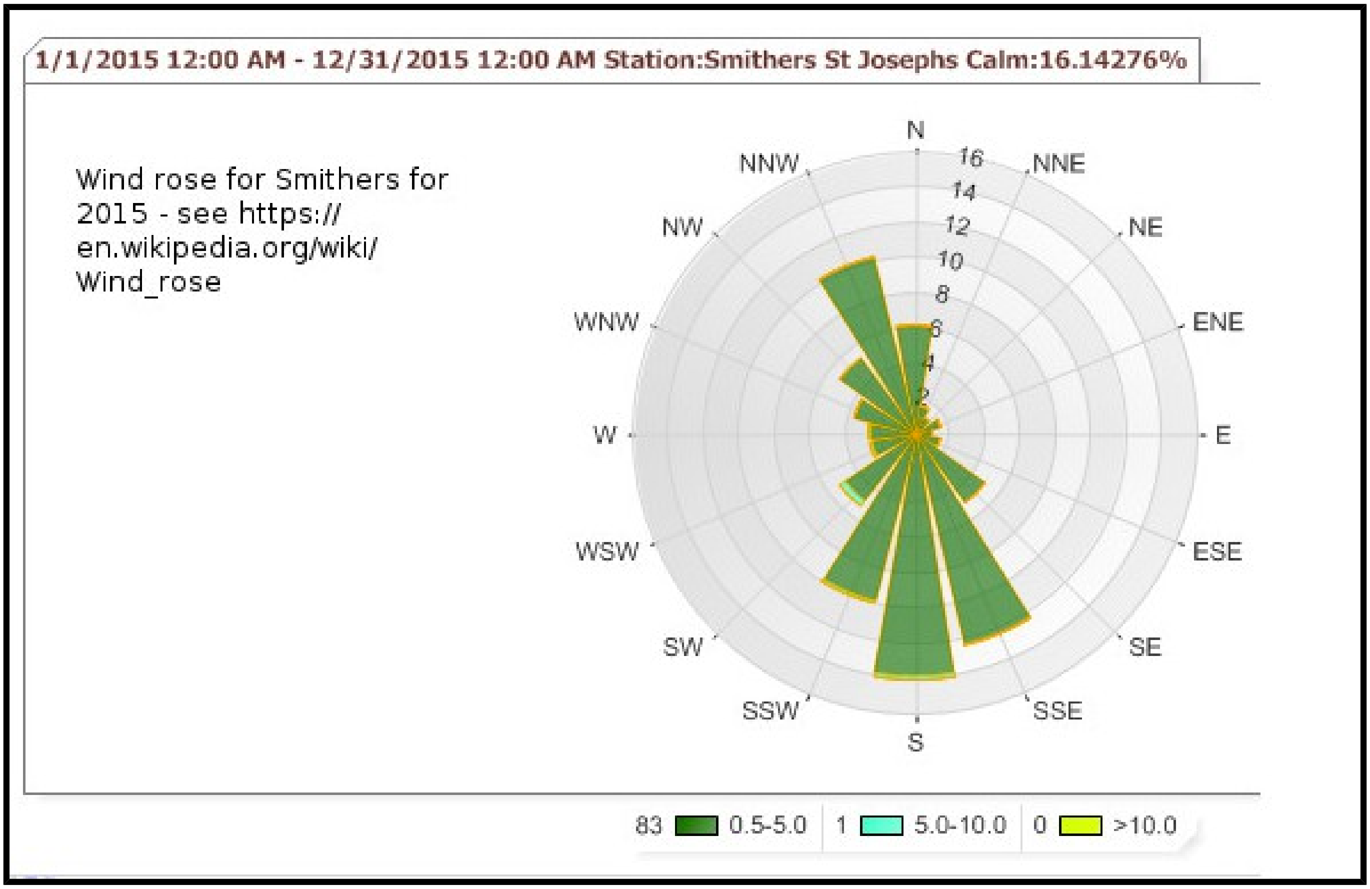

Figure 2. A wind rose showing annual average wind direction and speed at the BC MOE's St. Josephs meteorological station in Smithers, BC (OHNOPRO 2017).

In addition to the size of the study area, the spatial element comes into play in terms of emissions inventory resolution. For instance when estimating emissions from an industrial source plant—is the plant average sufficient, or is it necessary to estimate each discrete source at the plant individually (e.g. boilers, process stacks, road dust, vehicles)? If and when estimating area-based emissions, is it enough to estimate them for the entire study area or should they be more spatially resolved (e.g. on a grid-scale of 1000 km^2; 100 km^2)? Some options for spatial resolution are also presented in Section 3.0 (Table 2) and will be discussed with AMS following document review. Ideally the updated inventory will be developed in a spatial (mapping) database (or Geographic Information System [GIS]) that can be easily updated by users, and will spatially resolve sources on a point, or gridded (for area and mobile sources) level. This will also help with data visualisation, providing maps of sources and their intensity throughout the AMPA. The grid size used for area and mobile sources will ultimately depend on the data available and the software used to develop the spatial database (e.g. 100 m x 100 m grid versus 10 km x 10 km grid) should that option be chosen and available. Furthermore, by averaging emissions over the study area, or a large grid cell size, biological impacts may be missed. For instance, the emissions of dust from a single road will become much more diluted at a 10 x 10 km grid size than they would when using a 100 x 100 m grid—and the significance of these emissions, in terms of biological impacts, will also be impacted (reduced) when averaged over a larger area. However, the finer the spatial resolution, the more effort and data required.

2.2 Temporal

Emissions are typically estimated/quantified on an annual basis for all sources. This is true of EI prepared at various scales (including for instance the GHG Canada reports to the UNFCCC), the NPRI (ECCC 2016a), provincial EI (BC MOE 2017d), emissions permits, and the previous MEI developed for AMS (Weinstein 2005).

However, despite that emissions are generally reported annually, many sources do not operate at the same level all 365 days/year. An example would be a plant that only operates Monday to Friday but is closed on weekends and holidays; or a gas plant that my have required emergency venting for a three-day period; or residential wood-smoke that is emitted predominantly in the winter months. By reporting emission annually, although a standard practice, more intense periods of emission releases get diluted, and annual averages do not reflect the potential biological or human health outcomes associated with larger releases over a shorter period of time. For instance a release of 1000 tonnes of PM over one week of the year (say from agricultural burning) ends up being only 19.2 t/wk or 2.7 t/day when averaged annually, which doesn't capture the local/regional impact of this release over the week it actually occurred. This release may be expected to cause biological impacts in the time it was released, but these impacts would not be reflected by an annual average.

The previous MEI (Weinstein 2005) was able to temporally (and spatially) allocate burning because the information was known (it was reported by licensees) and it is anticipated that such information will still be available (see Subsection 2.7.2).

Although most regulatory exercises, including modelling, rely on annual emissions, some higher-level exercises, such as dispersion modelling (using AERMOD, CALPUFF, or regional CMAQ or AURAMS), require the temporal allocation of emissions. This means determining when emissions occur: do they occur from 9:00am to 5:00pm, or for 24 hours each day? Do they occur from Monday to Friday or seven days a week? Is the source closed for holidays? Did the emissions occur as a one-time emergency release, or out of seasonal necessity?

Due to the importance of temporal emissions variation in determining biological ambient air quality outcomes (through modelling or otherwise) some of the options provided in Section 3.0 (Table 2) include the possibility for the development of temporal allocation tables for inventoried sources. These tables can then be used in regional modelling to provide more accurate estimates of daily or even hourly emissions throughout the year. These temporal allocation tables would include activity information on an hourly, daily, weekly and/or monthly basis; and allocate activity data by source type or individual source. Database programs are an ideal way to do this (due to the link available between tables), but it can also be done using MS Excel in a format that can be read, or readily formatted, for most purposes. Without such temporal allocation tables/factors, all sources are assumed to emit the same amount of a given contaminant each hour/day/week of the year, and when used in a model, meteorology will be the only factor leading to variations in concentration at receptors. While this may be sufficient for permitting purposes—that also require emissions and/or resulting concentrations on an annual basis—for complete airshed management, policy development and a general understanding of 'bad air days', more detailed temporal information may be desired. However, this endeavour, like higher spatial resolution mentioned above, will obviously require an increased level of effort and cost. That being said, spatial and temporal resolution are considered key in determining the biological outcome of pollutants—few if any sources are accurately represented by an average across time or space.

2.3 Chemical

The previously produced MEI (Weinstein 2005) accounted for emissions of particles only (PM, PM_{10} and $PM_{2.5}$). This is because PM is the primary CAC of concern in the region due to the nature of sources. In 2005 burning from the forestry and agricultural industries (including beehive burning), household/residential burning (woodstoves, backyard burning of wastes, etc.), and road dust, represented sources of most concern in the airshed. However, the nature of sources in the AMPA or the BVLD in general (see Section 2.4), as well as changes in sources over-time, may justify the inclusion of additional pollutants to the updated MEI.

Each pollutant has its own unique impacts in terms of human and environmental health. Furthermore, primary pollutants (those emitted directly from stacks and other exhaust systems) react with one another in the atmosphere to form additional pollutants that may impact human and/or environmental health. Pollutants may also interact within biological systems (e.g. the human body) leading to synergistic effects—a line of research that is unfortunately in its infancy. To complicate matters further, PM itself is not a single pollutant, but rather made up of 1000s of potential ingredients that can exist in solid or liquid form, or both. Solid PM includes pollutants such as black carbon (soot) or silica dust (from roads, mining or agriculture). Liquid PM is composed of fine liquid droplets. In addition, solid particles can act as condensation nuclei for liquid droplets creating a mixed-phase solid/liquid particle. The term 'aerosol' is also often used to describe airborne particles in solid or liquid state due to the nature of equipment used to measure them.

When measuring PM in the field, usually with a form of light scattering/absorption technology, both solid and liquid PM are measured; in fact ice crystal formation/measurement is one of the most common PM monitoring complaints in cold winter months, and can falsely make air appear to be very polluted. However, despite both solid and liquid particles being measured during monitoring campaigns, only the solid particle portion of PM is usually inventoried in terms of emissions. The reason for this is that most liquid aerosols are 'secondary' pollutants (not emitted directly) such that emitters are not responsible for their formation. Rather the atmosphere and additional pollutants, or air components, determine the formation of aerosols from primary emissions. One example of relevance would be the formation of nitric acid (HNO_3) from emissions of NO_x, which are emitted from the combustion of anything in Earth's nitrogen-dominated atmosphere. However, considering the complexity involved in the chemistry of atmospheric aerosol formation, and that liquid aerosols are primarily a secondary pollutant and not inventoried, the following focuses on solid particles only when referring to 'PM'.

Particulate matter is generally divided into two categories: PM_{10}—that includes particles less than or equal to 10 microns (micrometres or µm) in aerodynamic diameter; and $PM_{2.5}$—including particles less than or equal to 2.5 µm in aerodynamic diameter. Due to the nature of these definitions, $PM_{2.5}$ is always included in measurements of PM_{10}, and therefore PM_{10} measurements or emissions estimates should always exceed those of $PM_{2.5}$. Total particulate matter (TPM) is also used and can include particles larger than PM_{10}. As such TPM should have a higher value than either PM_{10} (or $PM_{2.5}$) when measuring PM in the atmosphere or estimating PM emissions for inventory purposes. More recently 'ultrafine particles' (UFP or PM_1; particles < 1 µm) have been garnering interest due to new technologies that have not only lead to sources of finer and finer particles, but have also allowed us to measure particles at finer and finer scales (particularly at the nano-scale:

one thousandth of a micron, or 0.001 μm). It is unlikely that data will be available to precisely determine the size of particles down to the nano-scale within the BVLD; however, ultra-fine particles are quickly becoming a global problem.

Of interest may be that particles are not measured by concentration or even count in a volume of air (e.g. parts per billion/ppb; or number per cubic meter). Rather, PM is measured in micrograms per cubic metre ($\mu g/m^3$). But, since larger particles weigh more than smaller particles, a measure in $\mu g/m^3$ could mean 10,000 times more nanometre (nm) sized particles than 10 μm sized particles of the same composition. As fine particles are more harmful from a health perspective, finding their way much deeper into the human respiratory tract (Kampa and Castanas 2008), the quantification of particles by mass, although standard, deserves to be revisited. It is beyond the scope of this document or the resulting MEI to take on this task; however, the relevance and implications of measurement units (in addition to other sources of error) will be disclosed and explained in the final MEI update.

In addition to being large or small, liquid or solid, PM may be chemically composed of virtually anything and take on an infinite number of shapes. Thousands of different compounds and elements can exist as airborne particles; and particle composition, as well as additional physiochemical properties such as crystal or aggregate structure, can have a significant influence on the biological results of PM exposure (Bølling et al. 2009). Take the example of soot (pure carbon, or C) and road dust (silica, SiO_2) from above. Not only do they have different sources—soot from (incomplete) combustion and silica from the mechanical wear of substrate—but they also have very different health impacts. Soot, although composed mainly of elemental carbon, is often associated with additional hydrocarbons condensed on its surface, including polycyclic aromatic hydrocarbons (PAH)—some of which may be carcinogenic (e.g. benzo(a)pyrene or fluoranthene). Soot also often forms an aggregated structure of many finer particles stuck together (AMS 2012). In contrast, silica-based dusts (from road, mining, and other geological disturbances) may vary in crystal structure depending on their form (clay, quartz, tridymite, etc.) but are less likely to contain PAH or other hydrocarbons on the surface. That being said, silica from road dust can contain fuel or motor oil deposits, as well as salts and wetting/dust-control agents. Furthermore, silica on its own has been linked to cancer (IARC 1997), and compound specific ailments such as silicosis and silico-tuberculosis—particularly in miners (Bhagia 2012).

Particles may also be composed of, or contain, heavy metals and other elements. According to the Canada's NPRI, there are some such sources of atmospheric heavy metals within the airshed. In particular the Pacific Inland Resources (PIR) sawmill in Smithers, and the West Fraser Mills Ltd. (WFM) sawmill in Fraser Lake, both within the AMPA, are reported to emit cadmium (Cd), lead (Pb) and selenium (Se) and/or their compounds (ECCC 2016b). Both are also reported to emit methanol, which can exist as either a vapour (gaseous) or liquid aerosol (particle) emissions. However, this distinction is rarely, if ever, reported in EI due to the complex chemistry and other physical/chemical factors involved in the processes of particle formation. For instance liquid methanol may dissolve substances that water vapour cannot, thereby creating additional PM emissions; including those containing the water-insoluble fraction of organic matter (Verma et al. 2012).

The PIR and WFM sawmills are also reported to emit manganese and acetaldehyde, respectively, both of which have their own impacts on air quality and human or environmental health. Manganese, a metal, is an important dietary trace element, but at higher doses leads to neurotoxicity (Silva Avila et al. 2013). Similarly, the inhalation of manganese dust (PM) leads to similar neurotoxic impacts depending on the chemical and ionic form (Sullivan 1969). Therefore the AMS may find it beneficial for the updated MEI to speciate between the chemical compositions of particles being emitted AMPA, particularly in terms of determining potential human health protection and overall biological outcomes. Acetaldehyde, a VOC, is a known carcinogen (US EPA 2000) and contributes to the formation of tropospheric ozone (Carter 1994)—the main component of photochemical smog that has well known impacts on both plant and animal health.

Additional pollutants, particularly CACs are also emitted in the airshed. For instance NO_x is the product of combusting anything in an nitrogen-dominated atmosphere such as Earth's and is therefore associated with any emission source that involves combustion (commercial/residential wood or biomass burning, natural gas- or diesel-fired boilers and furnaces, diesel- or gasoline-fuelled vehicles, etc.). Carbon monoxide (CO) is emitted when anything 'organic' (carbon-based) is combusted (i.e. oxidised) including: wood, biomass, natural gas, gasoline, diesel, propane, etc. However, CO is quickly oxidised to CO_2 in the atmosphere and despite being a commonly emitted CAC, CO will rarely, if ever, reach harmful levels in an outdoor open-air environment. VOCs are emitted from sawmills (e.g. acetaldehyde discussed above), the combustion of wood and other biomass, the household or industrial use of solvents, fuel leaks, etc. Methane (CH_4 or 'natural gas') is also a VOC, but due to its minimal atmospheric reactivity (Carter 1994) and low toxicity, it is often removed from VOC inventorying. As such inventories, etc. often refer to non-methane VOC (nmVOC). Emissions of SO_2 are associated with sulphured diesel fuel (now rare and largely unavailable), coal mining/combustion, and the extraction/processing of sour gas (i.e. natural gas containing hydrogen sulphide [H_2S]); emissions that are unlikely to be of importance in the BVLD. However it is possible that nearby coal mines may contribute to SO_2 as well as other pollutants (BC Ministry of Energy and Mines 2017), and that gas plants may also emit additional SO_2 or CACs (Weinstein 2005).

2.4 Causal (source)

The causal element is related to the emissions' source, or the activity that causes them. For inventorying purposes emissions are generally divided into three different source categories:

1) Point sources – larger sources that usually require a regulatory permit or some type of emissions reporting. Examples include mines, sawmills and wood product manufacturers.
2) Area sources –made up of many small point sources, that don't have individual emissions data, averaged over a given area (e.g. a grid cell, or airshed). Examples include residential woodstoves and agricultural/forest sector burning.
3) Mobile sources – include emissions that move over time. Usually limited to vehicles (cars, trucks, trains, tractors), but can also include road dust.

Sometimes, when data are available, 'small' individual sources not usually reported or inventoried individually, can be estimated as individual sources. These sources, usually included as area sources, if at all, may represent a large portion of total emissions in areas with many smaller industrial/commercial sources (Krzyzanowski 2009). However, to resolve these emissions as point sources requires expert knowledge of source location (see subsection 2.1) and the source's emissions (see subsection 2.4), which are not always available. In addition, the effort and time spent preparing an inventory of this detail may be beyond the scope of this MEI update (see Section 3.0).

In addition to area sources potentially being inventoried as point sources, other area emissions may actually be mobile in nature. Mobile emissions usually include the obvious automobiles and airplanes, but road (or construction) dust can also be considered a mobile emission because its emissions move along with the vehicle (car, tractor, grader, etc.)—as acknowledged by the AMS in their 2012 Clean Air Plan (AMS 2012). However, unless high-level regional modelling is conducted on emissions (see subsection 2.5) mobile emissions are generally considered in the same way as area sources—per specified unit area (grid cell or airshed), over a defined period of time. The previous MEI prepared by Weinstein (2005) did not consider vehicular emissions but did consider road dust; road dust was accounted for using the BC's year 2000 emissions inventory spatially allocated using year 2001 census information (Weinstein 2005).

The previous MEI (Weinstein 2005) included seven dominant PM source categories, including:

1. Beehive Burners
2. Other Regulated Industrial Sources
3. Forest Harvest Debris Burning
4. Agricultural, Land Development and Small Sawmill Debris Burning
5. Residential and Commercial Space Heating
6. Backyard Burning
7. Road Dust (from traction materials used on paved roads)

While the most relevant sources at the time, things have changes since 2001/2002 (the years for which the MEI was relevant). For instance many beehive burners have been shut-down; industrial sources have opened, closed, or altered their processes; and the local woodstove exchange program has modified the nature/intensity of residential heating (AMS-2012). Also, Burns Lake recently enacted a, *Open Air Burning By-Law* in 2010 that restricts what can be burned, where and when (Caron 2015).

In response to the changing emissions environment in the BVLD, the AMS (2012) has since updated emission source categories of interest as:

1. Open Burning
2. Industrial Sources
3. Wood Burning Appliances
4. Backyard Burning
5. Transportation – Road Dust
6. Transportation – Vehicle emissions

The updated MEI will focus on these source categories. Also, the AMS on review of this scoping document may wish to remove and/or add source categories as they see fit, and as fits within the other scoping elements. For instance, spatial (2.1), chemical (2.3), end use (2.5) and data availability (2.7) need to be considered in the addition of new source categories, and with the realization that some elements—for instance spatial resolution—may need to be sacrificed due to a lack of data availability. In addition, other categories of pollutants may also be of interest. For instance agricultural land in the valley may provide a source of PM (from dust and burning) as well as ammonia emissions from fertilizer/manure use. There may be an interest in NO_x emissions from forest/agricultural/residential burning, vehicle exhaust, etc.; and coal mining may be an additional source of PM, SO_2, VOC and vehicular pollutants. The addition of other pollutants and their sources in the revised MEI are provided as options in Section 3.0.

2.5. Utilizational (or institutional)

Here the terms 'utilizational' or 'institutional' refer to how the inventory will be used. Ideally an inventory should be developed so as to support a variety of different applications and end-users. However, sometimes the information required for different purposes may vary, in terms of scale, sources, pollutants, and even inventory format.

Emissions inventories are used for a variety of purposes and it will be up to the AMS, through the consultation that this document facilitates, to determine the purpose of the inventory, and as a result, determine the scope of MEI that best suits their needs.

Emissions inventories are often used to predict air pollution's fate using dispersion models: for regulatory, business, and academic endeavours. For instance, the federal government may run a large-scale regional model, such as AURAMS or CMAQ, to identify areas of concern or gain an idea of the state of air quality within a region of interest (e.g. province, country, or airshed). Proponents of new (industrial/commercial) developments may also use emissions inventories to determine 'background' concentrations (i.e. those of existing sources), in order to determine cumulative effects as part of an Environmental Impact Assessments (EIA), and/or emissions permits for federal and provincial requirements. Furthermore, the Bulkley Valley Research Centre (BVRC), who is administering this project, has stated their interest in using the updated MEI for modelling exercises within the BVLD/AMPA (BVRC 2016).

Different air dispersion models all require uniquely formatted inventory files. However, some formats may be easier to use (and require less modification) when used for modelling purposes than others, and the final MEI product will aim to accommodate as many models, and other uses as possible—through meta-data, linked tables, etc.

Members of the AMS have mentioned that the previous MEI is still being used in regulatory settings, and by project proponents, despite being severely out-of-date. The purpose of this inventory update will be to provide, at the very least, an up-to-date version of the MEI that will, at the very minimum, provide an inventory of equal utility to Weinstein (2005).

Every possible inventorying option listed in Section 3 (Table 2) will provide two primary deliverables:

1) an emissions inventory in the form of an MS Excel workbook, MS Outlook Database, or other tabular format;
2) a report that includes the background and methods used to create the inventory, as well as general summary statistics, figures, a trend analysis (since the last MEI), a discussion, recommendations, etc.

It is also possible, as illustrated in Table 2, that some of the options will include travel to give a presentation to the AMS and/or the BVRC of the MEI results, as well as initial ground truthing to confirm the inclusion of all local and relevant sources. Another option is a spatial database, using some form of Geographic Information System (GIS) database, that will be more of a ‘living’ inventory that can be updated by end-users (e.g. AMS) while also providing spatial data visualisation and mapping. This can aid in airshed management, without the need for modelling (see subsection 2.1).

Emissions inventories may also be used for policy purposes, and this may be the end goal for some of the various levels of government funders/partners. Enhanced spatial and source related details, particularly information that is not readily available in government emissions data, may be key to these applications. In addition, the level of analysis, discussion, presentation and visualisation of resulting emissions data, will aim to provide innovative insights to aid in steering pollution-related policy and airshed management in general. In particular, the biological relevance and human health aspects of emissions will be emphasized. Some of the resulting report recommendations will be directed specifically to emissions reporting and data management, or to emissions ‘hotspots’ and problem areas, or towards specific sources and source categories that may be of particular biological significance in the airshed.

2.6 Financial

The financial scoping element is essentially the cost of conducting the MEI at different scopes compared with the funds available to do so. It is anticipated that the existence of this scoping document may supply the additional information required by funding bodies to support the MEI. The cost of each potential MEI scenario/scope is provided in the next section (3.0).

Everything costs money. With unlimited financial resources every single source in the desired study area could be assessed, or even measured individually, for every possible air pollutant, removing any need for area sources or emission factors. However, this situation is not anticipated, and as such, more realistic/practical alternatives are provided.

The majority of costs are for professional fees. These fees include all overhead expenses and materials, including access to software and computing materials, all journal articles/references, comprehensive insurance coverage ($1 million coverage in each professional liability and error & omissions policies), and more. Rather than being estimated based on usual hourly or daily rates, flat rates are provided for the entire project and end up providing a rate significantly lower than the standard rate for non-profit organizations. Despite being primarily fee-based, one of the options includes travel to the region for ground-truthing and data gathering, and another considers a visit to the region to present final results to the AMS and to the BVRC.

2.7 Practical

The practical scoping element is related to two different factors: 1) the availability of data; and 2) the availability of methods to quantify or estimate emissions. Each of these are discussed individually below. The practical element and the financial element (see above) are the two scoping elements considered to be most limiting in the general scope.

2.7.1 Data Sources

The table below (Table 1) provides an overview of some of the data sources that may be available for the development of an updated MEI. It is not an exclusive list, as during the development of the inventory itself new data sources may be found/arise.

Table 1. Examples of data sources for the updated MEI. Sources are in no particular order; they will be used in combination and to compliment one another in the development of the most accurate and comprehensive inventory possible based on the available data.

Data Source	**Description**
Canada's NPRI	Although the NPRI has been criticized in terms of its (in)completeness and (in)accuracy, it provides information on large emission sources throughout Canada and can be used to help determine the major emitters that exist within the determined study area.
BC Permit Data	In BC large- and medium-sized sources generally require an 'emissions permit' to operate as stipulated by the *Environmental Management Act* and *Waste Discharge Regulation*. Although most information in permits is an estimate made prior to operating, rather than an actual measure of emissions amount/intensity, this information can be used to identify sources and fill in data gaps when other sources of information are lacking or unclear.
Statistics Canada/Census Data	Information from Stats Can or the Canadian Census can be used to determine the number of households in the area and to support estimates of emissions from furnaces, woodstoves, fireplaces, and other household-based activities (e.g. VOCs from paint and solvents) should such information be considered relevant or necessary.
Federal Departments: Natural Resources Canada (NRCan), Industry Canada (IC), etc.	There is a local NRCan office in Smithers that likely has information regarding natural resource activity within the airshed (AMPA) that may be of use in the inventory update. In addition IC and other federal agencies keep information on industrial activities that may not normally be required to report emissions (based on legislative reporting thresholds, etc.), but may still contribute to PM and other atmospheric emissions in the airshed. These sources, despite being below reporting thresholds, will be included in the revised inventory to the best of the researcher's abilities, and be based on the best (and most up-to-date) information available.
Individual Emitters	Contact with actual emitters is considered to be an ideal source of information. Unlike data contained in emission permits, which are granted prior to operation and represent 'worst case scenarios' based on estimates, emitters often adjust their activities after operation and sometimes even measure emissions at the stack or fence-line (sometimes as a permit requirement), allowing for more accurate emissions data to sometimes be available from the emitter themselves. Although not all emitters may be willing to share such information, or even have such

	information, this source of data is considered extremely valuable. Emitters can also provide temporal information on operation schedules, unscheduled releases, etc.
Residential Surveys	For sources such as backyard burning and residential heating, local surveys would be an ideal source of information. The plausibility of these surveys is being explored. The town of Smithers conducted a door-to-door woodstove questionnaire in 2008, with results available (to be requested) in 2016 (see: http://www.smithers.ca/uploads/Annotated_ToC_Survey.pdf)
BC Ministries	In addition to the Ministry of Environment (MOE) being an obvious source of emissions data in terms of permits and provincial inventories, depending on the desired MEI scope in terms of sources and contaminants, other provincial ministries may be able to provide additional and relevant information. For example: • The Ministry of Transport (MOT) may provide information on road networks and traffic, assisting with the estimation of emissions associated with vehicles, road dust, road construction and rail transport. • The Ministry of Agriculture (MOA) can provide information on agricultural activities to assist in the estimate of emissions from agricultural burning, livestock, manure and fertilizer use, pesticide application, dust from land-clearing and tilling, etc. • The Ministry of Forests, Lands and Natural Resource Operations (MOFLNR) may provide information on emissions from burning or dust related to forest harvesting activities and vehicular or road dust emissions from the transport of timber and non-timber forest resources; off-road vehicle emissions, etc. • The Ministry of Energy and Mines (MOEM) may provide information on mining and energy activities in the region including information related to the extraction, transport and processing of resources that may be missing from either permitting or inventory sources.
AMS	The AMS has gathered a plethora of information on things such as slash burning with data available from: http://cleanairplan.ca/BOF2016/ These data, as well as all others, will be used to assist in inventory development.

The list above is not exhaustive. In addition, Ben Weinstein—who completed the previous MEI (Weinstein 2005)— has offered to assist in access to government information such as emissions permits, burn permits, and more. It is anticipated that sufficient data will be made available for the development of an updated MEI regardless of the scope determined by AMS.

2.7.2 Estimation Methods

In some cases data on actual emissions will be available (e.g. permits, emitter data, even the NPRI). However for other activities, such as emissions from residential woodstoves or road dust, other methods need to be used to estimate associated emissions. In addition, data available from permits, the NPRI and provincial inventories are often inaccurate, requiring alternative methods of source estimation; these data will be reviewed for completeness, accuracy etc., and in many cases be recalculated

In general there are six allowable methods of emissions estimation/reporting. These methods are the same as those used by emitters who must report to Canada's NPRI (Office of the Auditor General 2009). These emission estimation methods are shown in Table 2, and are similar to the methods used in other jurisdictions, including the US State of Tennessee and the province of BC for emission permitting purposes.

Table 2. Typical methods for emission estimation and reporting, paraphrased from the Office of the Auditor General (2009).

Estimation Method	**Description**
1) Continuous emission monitoring systems	These use scientific measurement equipment to record substance concentrations in the emitted gas stream over an extended period. Annual releases are then derived by multiplying the average substance concentration by the annual flow rate of the stack.
2) Predictive emission monitoring	Emission estimates are calculated based on a correlation between the release of a substance and a process or activity (e.g. fuel type and usage rate, equipment type and temperature, etc.).
3) Source testing	Samples of the effluent are taken, and concentrations of substances determined in a laboratory. The volume of the sample is then multiplied by the volumetric flow rate of the source to determine emissions annually or over any other specified time period.
4) Mass balance	This method is based on the conservation of matter—what goes in to a process must come out. For instance if the process is fuel combustion, a stoichiometric equation can be used to represent the oxidation of the fuel source. In other cases, there may be removals for the product, or by-product (e.g. wood ash), emission control equipment, etc.; but the method accounts for every mole of each element coming into, and out of, a process.
5) Emission factors	These are a popular method of emission estimation for common source types or sources with a significant amount of data. Emission factors may be site specific (e.g. developed from #1 or #3 above) or based on the industrial classification of the source (e.g. diesel generator). Generally emissions factors relate the quantity of a released substance to some unit of activity (e.g. tonnes of pollutant per cubic metre of fuel).
6) Engineering estimates	Emission estimates based on engineering principles depend on professional judgement and source information, such as facility processes and their efficiency, and the physiochemical properties of produced/emitted substances and their by-products.
7) Models*	Certain models, such as 'Consume', used previously by Weinstein (2005) and now part of 'Fuel and Fire Tools' (USFS 2017) are being explored for multiple emissions sources. Another example would be the COPERT model (etc.) for vehicular emissions (e.g. He et al. 2016) using MOT data. Other vehicular emission models and models to estimates other more wide-scale area-based sources are also available, but their use depends on data availability.

* Models are not listed as an 'approved method', but may be used for emission sources without well-defined source information and are accepted in most jurisdictions.

Any of the first six methods may be used for reporting to the NPRI (Office of the Auditor General 2009). However, the list does to some extent move from the most objective (#1) to the most subjective (#6) method; and in the author's opinion the list of methods should be moved through in sequence, beginning with #1, and ending at the method for which data are available. For example if data from continuous monitoring (#1) at a source are available, then those data should be used in MEI development. However, if direct monitoring data are not available, method #2 will be used; and if data are not available, #3 will be used, and so on. However, any of the seven methods are considered acceptable by regulators and in inventory development. In reality emission factors (EF) (#5) are often used for emission inventorying and estimation, the best source of EF being the United States Environmental Protection Agency's (US EPA's) AP-42 database (US EPA, 2017).

Although emissions estimates do exist for some sources, in for example the NRPI and BC's emission permits, all of these data will be reviewed for accuracy and revised as required using activity data, emission factors, industry/engineering knowledge, etc.

Certain models (#7) may be considered appropriate in some circumstances. Weinstein (2005) estimated resource management debris burning by major licensees using the US Forest Service (USFS) Consume v2.1 model. There is now a v4.2 of the Consume model available for use as part of Fuel and Fire Tools also from the USFS (see: https://www.fs.fed.us/pnw/fera/fft/). The Consume model was used by Weinstein (2005) in conjunction with, and to complement, BC's Open Fire Tracking System (OPTS). Although OPTS still exists, the only data currently available to the public is for active/recently registered burns (see: http://apps.gov.bc.ca/pub/dmf-viewer/?siteid=9116054148712635950). It also provides no information regarding the nature or size of the burns, either individually or collectively. According to the government website describing the OPTS (http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/wildfire-management/prevention/ofts) read-only versions of the data are available to staff from the Ministry of Environment (MoE) and to local fire departments. Therefore, these data will need to be requested through one of those avenues. Additional data sources used in the original MEI are not readily available to someone from outside the government. However, Ben Weinstein has kindly offered access to these data for the purpose of MEI development and updating, and it is anticipated that these data will be readily available.

For sources such as backyard burning and home heating, surveys by mail, phone or door-to-door represent an ideal information source and provide data that are spatially explicit for these residential activities. The province of BC conducted such a survey of residential wood-burning in 2003 that was used in the previous MEI (Weinstein 2005); and an updated door-to-door survey of these activities was conducted in 2012. The results from this survey will be made available for use in the development of an updated MEI.

Major source emitters will also be contacted for information regarding their emissions, operating schedules and other source-based information in order to increase accuracy and resolve emission estimates. Ideally source information will also include stack/emissions height, stack diameter (or area size), flow rate, etc., to aid in proposed modelling uses and to be added as source-specific parameters.

3. Output Scenarios

Based on the scoping elements discussed above, Table 2 presents a number of different options, of different scopes, for the updated MEI.

Table 2. Potential MEI formats—the final/primary deliverable to the AMS—summarized by scoping element.

Name/ Format	**Spatial Scale**	**Time Scale**	**Pollutants**	**Source Inclusion**[a]	**End Use**	**Budget**[b]	**Limitations/ Specifics**
1) Excel Update	AMPA	Annual	PM	Combustion & Road Dust (no vehicles)	Basic Information on what's changed	$6,900	Will provide new information only, updating of original MEI sources
2) Excel PM	AMPA	Annual	PM	Combustion & Road Dust	Information, Modelling – permits (PM)	$25,000	Some data may not be known/available/ accessible
3) Excel PM Chemistry	AMPA	Annual with daily, weekly or monthly tables	PM (by chemical make-up)	Combustion & Road Dust	Health information, Modelling – permits (PM)	$35,000	PM speciation data will be estimated by source type
4) Excel Permit	AMPA	Annual	PM, NOx	Combustion and Road Dust	Information, Modelling – permit (PM & NO_x)	$30,000	Some data may not be known/available/ accessible
5) Excel Airshed Plus	AMPA and relevant downwind sources	Annual with daily, weekly or monthly tables	PM, NO_x, SO_x, VOC, CO	Combustion and Road Dust	Information, Modelling – permit (PM & NO_x)	$35,000	Some data may not be known/available/ accessible May require mapping
6) Excel Airshed Ag	AMPA	Annual with daily, weekly, monthly tables	PM, NO_x, SO_x, VOC, CO, NH_4	Combustion, Road Dust, Agriculture	Information, Modelling – permit or airshed, Airshed planning	$50,000	Some data may not be known/available/ accessible May require mapping
7) Database	AMPA	Annual with daily, weekly, monthly	PM, NO_x, SO_x, VOC, CO	Combustion and Road Dust	Airshed Planning, Policy making	$45,000	Some data may not be known Requires mapping and access to database

		tables					programs
8) Database (user friendly)	AMPA and relevant upwind sources	Annual with daily, weekly, monthly tables	PM, NO_x, SO_x, VOC, CO, NH_4	Combustion, Road Dust, agriculture and all other sources	Reporting and Updating, permanent and evolving	$65,000	May be cost prohibitive, still limited by data availability. Will include training course/presentation and user guide.
9) Spatial Database (user friendly)	AMPA and relevant upwind sources; mapped with spatial visualisation	Annual with daily, weekly, monthly tables	PM	Combustion and Road Dust	Reporting and Updating, permanent and evolving	$55,000	May be cost prohibitive, limited by data availability. Will include training course/presentation and user guide.

[a] 'Combustion' includes all burning and vehicular sources (including rail transport) unless otherwise stated.
[b] Does not include costs associated with scoping, or the 15% fee of the Bulkley Valley Research Centre (BVRC) for administration. The lowest available cost (#1) is the equivalent of $14,000 (in secured funds) minus the costs of the scoping study and the 15% administrative fee of the BVRC.

Table 2 above should be self-explanatory. Any and all of the potential options available can include travel to the area for ground-truthing to ensure that all major source emissions are included, as well as minor/area source emissions represented for an additional $3000. This would include visits to major sources for in-person discussions with emitters, and if necessary some door-to-door surveys of a relevant sample size to understand whether and if backyard burning and home heating habits have changed in the region since the 2012 survey.

The difference between "excel" and "database" is the difference between the inventory being developed in MS Excel versus a database program such as MS Access (or GIS such as ArcView or GeoSuite). Option #9 includes the delivery of a spatial database that will provide maps of sources and spatial data visualisation. The benefits of using a database program (either spatial or MS Access based) include the ability to link between tables—particularly for activity schedules (daily, weekly, monthly operation for each source), and the ability to more easily update source fields without requiring calculations. This is ultimately an increase in 'accessibility' (see Section 2). Although some of the Excel options provide such temporal allocation tables, they will not be directly linked and will require looking up the relevant source code. Options 7, 8 and 9 are the most comprehensive (i.e. accessible), not only because the inventory will be provided in database formats, but also because the database will be designed in an easily updatable format for future use and improvement. This will allow the AMS (or whoever they designate) to update the database as frequently as required, and will include an instruction manual, as well as an in-person presentation on updating and inventory use. The benefits of a spatial database (option #9) are further discussed briefly in the following.

A 'spatial' database is one that provides immediate results in a mapped/spatial format. In an airshed of 35,000 km^2 in size, not all areas will include the same level or density or emissions as others. A spatial database, using a program such as ArvView GIS (http://www.esri.com), or open-source software such as 'OpenGeo Suite' (see: http://workshops.boundlessgeo.com/suiteintro/postgis/spatialdbs.html?gclid=CjwKEAjwoLfHBRD_jLW93remyAQSJABIygGpCgCucVCLs8YpGvnMR0u8W-vwn2KRwnIT5bsr5Cj7vBoCjr7w_wcB) or others, can provide the AMS the ability to visualise emissions' data, recognize specific areas of concern, and make decisions/recommendations—without requiring the use to air quality models. Although the mapping or spatial representation of sources doesn't inform users of where the pollutants will disperse or fall, many pollutants, particularly PM (and its chemical species) are known to have more local effects. Therefore local emission source mapping and visualization can be key to airshed management, based on source density and intensity on a local basis.

All of the options are negotiable and the AMS may chose to exchange one element for another. For instance, the AMS may chose to include speciated PM in a database, but without additional CACs or agricultural emissions. It is anticipated that review of this document with facilitate discussion around the utilizational/end-use aspects of the MEI update.

The payment schedule and deliverables are listed in Appendix A, but due to unknown resource availability, dates are not yet included. It is anticipated that the creation of an updated MEI will take between six and twelve months, depending on the level of effort required (i.e. the options chosen by AMS).

4. Discussion

The previous sections describe particular elements used in scoping the updated MEI for the BVLD as sanctioned by the AMS. The list of potential inventory scopes presented in Section 3 is not exhaustive. In fact, there is a near infinite number of MEI formats and scopes that could be developed. For instance the spatial scale or grid size can be changed indefinitely and additional and specific contaminants can be added. This scoping document is offered for review and discussion to the AMS such that the final MEI product meets the Society's needs, if not exceeding their expectations.

The main factors limiting the scope of such a project are: 1) funding; and 2) data availability. No matter how lofty one's goals may be, technical endeavours such as inventory development require time and resources (human and otherwise) and will only be as good as the available data. For instance, although it may be desirable to speciate each PM particle so that we know whether it is black carbon, metallic dust or an acidic aerosol, the data may not exist. However, estimates of particle ratios can be made based on what is known about the types of PM sources.

Table 3 shows the relationship between Statistic Canada's (2002) Six Dimensions of Information Quality (Section 2.0) and the scoping elements discussed in detail above (subsections 2.1 to 2.7). A capital 'X' in the box shows a particularly strong relationship between the scoping element and the corresponding Statistics Canada Dimension of Information Quality (Statistics Canada 2002). However, it is anticipated that each of the dimensions of information quality can be directly applied to each and every one of the scoping elements as a measure of inventory quality, and the lack of an 'X' does not necessarily indicate a lack of applicability.

Table 2. Matrix of Scoping Elements versus the Six Dimensions of Information Quality (Statistics Canada 2002).

Scoping Elements	Dimensions of Information Quality						
	Relevance	Accuracy	Reliability	Completeness	Understandability	Accessibility	Timeliness
Spatial		X	X	X	X	X	
Temporal		X	X	X	X		X
Chemical		X	X	X	X		
Causal			X	X	X		
Utilizational	X		X	X	X	X	
Financial	X					X	X
Practical	X	X	X	X	X	X	X

For instance the spatial scoping element deals with the size of the overall inventory domain, and the size of grid cells or other units used to average area emissions. Therefore the spatial element is intricately tied to how accurate, reliable, complete and understandable the inventory is. Some emissions may need to be averaged over the entire study area, reducing accuracy; whereas others will be quantified as point sources based on their precise location, increasing accuracy. The spatial representation of emissions will be reliable if the locations of point sources are correct; complete if all emissions from the entire area are included; and understandable if the data can be appropriately locate/mapped. Furthermore, if those spatial data can be added to a user-friendly and updatable spatial database interface, accessibility will also be optimised. The dimensions of information quality as presented in Table 3 and listed in section 2.0 will be used throughout the inventory development process to evaluate data quality, and any limitations to such quality will be clearly disclosed/discussed in the inventory report. In addition, statistical data quality parameters—such as uncertainty, error, and standard deviation (as relevant)—will be fully disclosed and discussed within the final inventory report.

This draft scoping document is provided to the AMS for feedback and input. It is anticipated that this document will provide the background information required to determine the scope of MEI required by the AMS to meet desired goals and needs. Further, the MEI's scope should allow AMS and other stakeholders to understand the current levels of air pollutants of concern in the BVLD/AMPA such that air quality can be appropriately managed, and human health and environmental quality protected—now, and for future generations.

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APPENDIX A

TASK	**DELIVERABLE**	**PAYMENT %**	**DATE***
Phase 1	Outline of MEI; list of emitters, data source, methods to be used—for review	25	
Phase 2	Emissions estimates and detailed outline—for review	25	
Phase 3	Draft report for review	25	
Phase 4	Final Report — including all recommendations, comments, etc. received from AMS and steering committee	25	

*Date of deliverables to be discussed with AMS based on required effort.