Guide to Airshed Planning in British Columbia

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Executive Summary

Air pollution can have a number of adverse impacts on the community. Poor air quality can be a significant health risk, degrade visibility and seriously impact community tourism. The cumulative impacts of air emission sources can prohibit or limit opportunities for local or regional economic expansion.

Historically, the major sources of air pollution in British Columbia have been large industrial operations that the province has regulated through permits. However, over the past two decades, more and more restrictions have been placed on these facilities, and the relative contributions from other sources such as motor vehicles and biomass (primarily wood) burning have increased. As a result, cooperation among federal, provincial, regional and/or local authorities may be required to manage such diverse source types. "Airshed planning" is one process that can be used to address these issues.

Also known as "air quality management planning," airshed planning takes a multistakeholder, multisource approach to coordinating actions within a distinct geographical area or "airshed." An airshed is generally described as 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. The most obvious example in British Columbia would be a mountain valley.

Since air pollution knows no political boundaries, airshed activities may be focused on a single community or on a number of neighbouring communities faced with similar air quality problems and requiring similar action. The airshed plan provides a blueprint to help communities manage development and control air contaminant sources. It also provides stakeholders with a clear understanding of community air quality priorities and how future growth may be accommodated. In addition, it will ensure that the air quality goals of various levels of government are met.

This guide is intended to help local governments understand the benefits associated with the airshed planning process and the possible steps involved. These steps fall into three main categories:

- Problem identification: Does current air quality monitoring suggest that there is a problem? What factors or sources are contributing to this problem?

- Plan development: What are the most appropriate air-emission reduction measures to achieve local goals, and what are the relative priorities?

- Implementation and reporting: How and when will the measures be implemented, and by whom? How often will progress be reviewed and reported upon?

Although airshed planning is not explicitly undertaken in most British Columbia communities, many community-planning processes often have direct and indirect impacts on air emissions, and local or regional air quality. In smaller communities without major air quality concerns, an early action may be to recognize air quality goals in these planning processes. In more complex airsheds with significant air quality concerns, the actions may span the entire range of the steps described above. Regardless of approach, public education and involvement are important keys to achieving local air quality goals.

This guide is not intended to be prescriptive or suggest that there is a "one-size-fits-all" approach. The complexity, speed of development and implementation of an airshed plan will be dictated by a number of factors, including:

- the potential health risk to the community;
- the level of scientific information and expertise available;
- the complexity of the air emission source mix;
- resource constraints; and
- specific community goals.

The plan will need to reflect the sources and air contaminants of concern to the area. This might be ground-level ozone in urban areas or particulate matter (PM) in rural communities where wood combustion is a large source of air pollution.

Steps taken today to develop an airshed plan will help ensure that future community air quality goals are met, while coordinating with other community growth goals.

Introduction

The movement of air within an airshed is not constrained by political boundaries, but it is often hindered by terrain such as mountains and by weather conditions. This means that air pollutants released within the airshed tend to linger. The most obvious example of an airshed would be a mountain valley, typical of many British Columbia communities, which limits the influence of winds and the circulation of air.

Poor air quality can have an adverse impact on human health, degrade visibility and have an impact on future economic development. An airshed plan provides the necessary tools to ensure that air quality impacts are identified and addressed. It can allow the community to continue to grow and develop, while maintaining or improving air quality in the airshed. In addition, an airshed plan can be integrated with other, ongoing planning processes to help ensure that co-benefits of all planning processes are understood and optimized.

Airshed planning, also known as "air quality management planning," is the process of coordinating activities in an airshed, and ensuring that federal, provincial and local air quality goals are achieved. The airshed plan provides a blueprint to help communities manage development and control air contaminant sources, so as to maintain or improve air quality for the protection of human health and the environment in an airshed.

This guide shows many links between air quality and community planning processes that may already be underway. The airshed planning process is not new or unique and similar processes are underway in some regions of British Columbia, other parts of North America and around the world.

This guide is written for local authorities, community leaders and staff interested in local and regional air quality. It is divided into two parts: Chapters 1 to 6 provide a general overview of what is involved in developing and implementing an airshed plan. (Technical language in this portion of the document has been kept to a minimum.) Chapter 7 contains detailed appendices, and a glossary of terms.

Appendix A offers more technical background material on the first two phases of developing an airshed plan (i.e., problem identification, plan development and plan implementation and updating). In addition, this appendix presents further details on airshed monitoring, inventories and modelling underway in British Columbia.

Appendices B through E provide numerous web sites and, in some cases, a list of reading materials for those considering the development of an airshed plan. Appendix F includes a list of acronyms and a glossary of terms.

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Chapter 1 Why should the community be concerned about air quality (and what can it do)?

Communities in British Columbia protect their watersheds, aware of the importance of water to the health of their citizens. The American Lung Association motto, "When you can't breathe, nothing else matters," suggests that good air quality is vital to us as individuals. Yet few communities endeavour to protect their airsheds.

What is an airshed? The term "airshed" is used to describe an area where the movement of air tends to be hindered by the local geography and by weather conditions and is not constrained by political boundaries. The most obvious example of an airshed would be a mountain valley, typical of many British Columbia communities, which limits the influence of winds and the circulation of air. During temperature inversions – a common event in British Columbia's many mountain valleys – the air near the ground is very stable and winds are light. These conditions prevent the escape of pollutants from the airshed, and may result in particularly high levels of air pollution.

In contrast, when the air is well mixed and winds are moderate, pollutants are quickly dispersed. In some cases, the pollutants and their byproducts may be transported long distances beyond the airshed. As air pollution is not confined to political boundaries, this is a reminder that everyone and their activities are globally interconnected.

For the above reasons, many British Columbia communities are prone to periods of unacceptable air quality. This can have numerous kinds of impacts on the community. It can adversely effect human health, the environment and visibility. It can also limit a community's ability to attract or accommodate new growth.

Human Health
The air pollutant posing the greatest risk to human health in British Columbia is particulate matter (PM). Particles less than 2.5 µm in diameter are of greatest concern, as they are small enough to be inhaled and then lodged in the lungs, which can lead to lung and heart disease.

Major sources include combustion in motor vehicles, agricultural and forestry burning, industrial activities, woodstoves and fireplaces. Researchers have found that there are no safe levels of PM, and that health effects increase with rising pollutant levels. Health effects may be reflected in increased incidents of asthma, chronic lung disease, heart disease, and even premature death. The elderly, the very young, and people with pre-existing heart and lung problems are most at risk. Further details on the health effects and sources of PM and other common air pollutants are provided in Table 1.

Table 1: What are the Main Pollutants?

The two air pollutants of greatest concern in British Columbia are particulate matter (PM) and ozone (O_3) because they are widespread and can have serious impacts on our health and environment. There are also several other pollutants to be concerned about.

Pollutant	Description and Sources		Health Impact	Environment
Particulate Matter (PM) Dust, soot, and tiny bits of solid material.	**PM_{10}** Particles smaller than 10μm in diameter*	• Road dust; road construction • Mixing and applying fertilizers/ pesticides • (see $PM_{2.5}$ below)	• Coarse particles irritate the nose and throat, but do not normally penetrate deep into the lungs.	• PM is the main source of haze that reduces visibility. • It takes hours to days for PM_{10} to settle out of the air. • Because they are so small, $PM_{2.5}$ stay in the air much longer than PM_{10}, taking days to weeks to be removed. • Can make lakes and other sensitive areas more acidic, causing changes to the nutrient balance and harming aquatic life.
	$PM_{2.5}$ Particles smaller than 2.5μm in diameter	• Combustion (motor vehicles, forest fires, woodstoves and fireplaces) • Industrial activity • Garbage incineration • Agricultural burning	• Fine particles enter the lungs, making it difficult to breathe, and lead to diseases such as bronchitis. Depending on the source and chemical composition of the fine particles, effects can be severe enough to cause cancer and premature death. • $PM_{2.5}$ is the worst public health problem from air pollution in BC (Research indicates the number of hospital visits increases on days with increased PM levels).	
Ground-Level Ozone (O_3) Bluish gas with a pungent odour	• At ground level, ozone is formed by chemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. • VOCs and NO_x are released by burning coal, gasoline, and other fuels; and VOCs naturally by vegetation (e.g., the smell from evergreen sap/needles).		• Exposure for 6-7 hours, even at low concentrations, significantly reduces lung function and causes respiratory inflammation in healthy people during periods of moderate exercise. Can be accompanied by symptoms such as chest pain, coughing, nausea, and pulmonary congestion. Impacts on individuals with pre-existing heart or respiratory conditions can be very serious. • Ozone exposure can contribute to asthma, and reduced resistance to colds and other infections.	• Can damage plants and trees, leading to reduced yields. • Leads to lung and respiratory damage in animals. • Ozone occurs naturally high above the Earth (in the stratosphere) where it protects us from harmful ultraviolet rays.
Other Pollutants	• SO_2: sulphur dioxide • CO: carbon monoxide • NO_2: nitrogen dioxide • TRS: total reduced sulphur • VOCs: volatile organic compounds • POPs: persistent organic pollutants • Pb: lead Most of these come from combustion and industrial processes or the evaporation of paints and common chemical products.		The health impacts of these pollutants are varied.	While some of these pollutants have a local impact on the environment (e.g., heavy metals such as lead) or are relatively short-lived (NO_2), some are long-lived (POPs), and can travel the world on wind currents in the upper atmosphere.

*Far too small to see: ~1/8th the width of a human hair.

Reduced Visibility
The haziness of the atmosphere typical along the horizon is often associated with air pollution. Visibility is affected by the presence of fine particles and gases in the atmosphere. These substances, because of their small size, scatter and absorb visible light. It is the resultant changes in the clarity, contrast and colour of the images that cause a reduction in visibility.

Impact on Economic Development and Tourism
More and more business endeavours are becoming mobile and less resource-extraction-based. These businesses can locate almost anywhere and seek out communities where their employees will be comfortable and healthy. A good air quality management plan can help ensure the health of a community.

Healthy communities with clean air often benefit from other economic spin-offs. In communities with an airshed plan, industry has a degree of certainty as to the future air quality requirements they will face. They become aware that change and uncertainty related to regulatory requirements can be reduced in this environment. In addition, airshed planning is an indicator of local partnerships and stakeholder cooperation that outlines a community-based process to ensure future community growth, while maintaining acceptable air quality.

> ***Airshed planning***, also know as air quality management planning, is the process of coordinating activities within an airshed, and ensuring that federal, provincial and local air quality objectives are achieved. The airshed plan provides a blueprint to help communities manage development and control air contaminant sources, so as to maintain or improve air quality for the protection of human health and the environment in an airshed.

As well, air quality is often linked to tourism throughout British Columbia. Degradation in visibility or a perceived health risk from poor air quality may have an adverse effect on local or regional tourism.

Addressing Community Air Quality Concerns
Communities can do planning to minimize many of the impacts of current and future air emissions generated in the airshed they occupy. The process of airshed planning and how it relates to other community planning processes will be discussed in Chapter 3**.** This includes official community plans, community energy planning, municipal planning and regional growth strategies.

The boundaries of the airshed often cross political boundaries. As a result, airshed planning often involves more than one community. Coordination between communities in the airshed, and with other levels of government, will be necessary to complete and implement an effective airshed plan. Airshed planning can provide communities with the necessary tools to address local air quality concerns and their impact on human health, visibility and economic development.

Chapter 2 Who has the responsibility for protecting community airsheds?

Air quality in British Columbia is managed by the combination of several laws and levels of government. No one level of government has sole jurisdiction over air emissions, as shown in Table 2, suggesting the need for cooperation between jurisdictions. In addition, efforts to improve local air quality are linked to a number of other issues, including greenhouse gases (GHGs) and health concerns. For these reasons, there are many benefits to a multipollutant, multisource approach to airshed management. Airshed planning, which began in a number of British Columbia communities in the 1990s, takes such an approach – to address local air quality issues by engaging all relevant stakeholders, including multiple levels of government, industrial stakeholders, health authorities, academia, and the public.

Globally, a range of airshed management plans have been tried and implemented in numerous jurisdictions. In some cases, the permitting of sources has been completely delegated to regional air quality authorities. Local authorities may be required by law to assess air quality in their region. In such instances, additional resources such as funding, guidance on air quality modelling, and land-use and transportation planning are often made available. Many of these approaches have already been incorporated into the airshed plans developed or under development in British Columbia.

Federal Role

The federal government's role in addressing air quality issues is largely, though not entirely, defined through the *Canadian Environmental Protection Act* (CEPA). A number of emission sources are subject to federal, rather than provincial, regulation. These include marine vessels, aircraft, railways, and offroad engines, among others. Both the federal and provincial government have regulations pertaining to motor vehicles and fuels, but the province is seeking to harmonize with federal requirements. The federal government also has authority for international aspects of air quality issues. It has the ability to intervene in environmental matters if the provinces do not act. Within the Lower Fraser Valley and elsewhere in Canada, the federal government has been heavily involved in scientific research to support air management.

In 2000, the Canadian Council of Ministers of Environment (CCME) ratified a harmonized set of *Canada-wide Standards* (CWS) for PM and ozone. (Available on the Internet at http://www.ccme.ca/initiatives/standards.html .) Critical aspects of the CWS are provisions for "continuous improvement" and for "keeping clean areas clean" for regions that are already in compliance with the numerical targets. That is, the standards should not act as a plateau for air quality performance. Instead, air quality improvements should continue beyond the requirements of the standards.

Table 2: Examples of the Regulatory Authority Delegated to Different Levels of Government for the Control of Various Pollutants

Air Issue	International	Federal	Provincial	Regional / Local
Wood Combustion	• Canada US Air Quality Agreement (visibility degradation)	• Open burning on federal lands • Woodstove regulations development under consideration	• Provincial PM_{10} standards • Prescribed burning • Open burning of wood residues • Woodstove emission regulations	• Backyard burning • Approval of incinerators including "burn barrels" • Inspection of woodstove installations to ensure they meet air quality emission and fire-safety standards
Ozone- Depleting Substances	• Montreal Protocol	• Montreal Protocol	• Enhanced regulations governing ozone- depleting substances	
Greenhouse Gases (GHGs)	• Kyoto Protocol	• Kyoto Protocol	• Provincial climate change policy	• FCM Partners for Climate Change
Acid Rain, Ground-Level Ozone, and Fine Particles	• Long-range transport of air-pollution • Canada US Air Quality Agreement	• Canada-wide Standards (CWS)	• Achieve CWS and meet CWS provisions for continuous improvement and keeping clean areas clean	• Local bylaws • CWS provisions for continuous improvement of air quality
Transportation	• Marine emissions for PM currently unregulated. Need to be addressed at national and international level by Canada, in co-operation with the US and through the International Maritime Organization	• Vehicle emission standards • Fuel standards • Regulations re. rail, aircraft and marine sources	• Vehicle and fuel quality regulations • Roads, engineering and traffic control • Construction specifications	• Zoning and community planning • Transportation planning • Transit and transportation-demand-management programs
Industrial Point Sources	• Notification requirements under *Canada/US Air Quality Agreement Act*	• Specific air quality objectives for specific industries • Environmental assessment process	• Specific air quality objectives for specific industries • Environmental assessment process • Permits	• Zoning and community planning
Miscellaneous	• Canada US Air Quality Agreement	• Air quality objectives • Building codes	• Air quality objectives • Building codes	• Zoning and community planning • Local bylaws • Building codes

The federal government and the provinces are also subject to a number of international commitments, including the *Montreal Protocol on Substances that Deplete the Ozone Layer*, the *Kyoto Protocol on Climate Chang*e, the *Canada-US Air Quality Agreement*, and various protocols under the *1987 Convention for the Long-Range Transport of Air Pollution*. For a number of these commitments, the final objective has been identified but the path to implementation or achievement of targets is yet to be finalized. Additional commitments may result due to actions by the CCME, the Georgia Basin Action Plan and the International Airshed Strategy, under development in the Georgia Basin/Puget Sound airshed. The province has also entered into air quality memoranda of understanding with the states of Washington and Idaho.

Provincial Role

The *Environmental Management Act* (EMA) – the successor to the *Waste Management Act* – gives the province the overall responsibility for waste management, including air emissions, in British Columbia and provides the underlying legislation to air-quality-related regulations, including:

- Industrial point sources (e.g., Sulphur Content of Fuel Regulation, Wood Residue Burner and Incinerator Regulation, and Asphalt Plant Regulation)
- Some area sources (e.g., Open Burning Smoke Control Regulation, Ozone Depleting Substances and Other Halocarbons Regulation, and Solid Fuel Burning Domestic Appliance Regulation)
- Motor vehicle emissions and fuel quality (e.g., Gasoline Vapour Control Regulation, Cleaner Gasoline Regulation, and Motor Vehicle Emission Control Regulation)

Under the EMA, many industrial point sources are regulated by the conditions of site-specific permits. Commonly, the conditions include limits on emission rates and concentrations of specific pollutants. In airsheds with multiple pollutant sources, permits have been one of the few tools with the flexibility required to set emission controls and other conditions that are consistent with airshed-wide management plans. In general, however, examining releases on a case-by-case basis may fail to provide for considering the cumulative impact of emissions from several emission sources.

To help address this issue, the EMA includes provisions for area-based planning. This will allow the province to better address the cumulative impacts of discharges to the environment for both point sources and nonpoint sources. Under the EMA, the minister can designate an area for the purpose of developing an area-based management plan, and establish a process for the development of the area-based management plan for designated areas.

Additional provincial responsibilities include setting environmental quality benchmarks targets and standards; developing strategies to reduce pollution; developing partnerships with stakeholders; monitoring and reporting on environmental quality; and inspecting, auditing and enforcing provincial legislation. Air quality objectives can be used as benchmarks to determine the acceptability of contaminant levels in ambient air.

As a signatory to the CWS, British Columbia must address how compliance and continuous improvement are to be achieved for both particulate matter (PM) and ground-level ozone. Keeping clean areas clean, and continuous improvement, are additionally important, given that health effects findings indicate a range of impacts at any ambient concentration for PM and ozone. British Columbia's performance target for $PM_{2.5}$ – to meet the CWS requirements – is currently being met in most major communities.

Local and Regional Governments' Role
Local and regional governments throughout the province have the authority to pass bylaws that may restrict certain emission-causing activities in their regions. These include nonpoint sources such as backyard burning and residential wood combustion. Indirectly, local authorities can influence the type and location of emission sources and their future growth through land-use zoning, transportation and land-use planning, regional growth strategies and sustainability plans.

Under the EMA, the Greater Vancouver Regional District (GVRD) has been given delegated authority to control and manage air quality within its boundaries. The Fraser Valley Regional District (FVRD) has delegated authority, under ministerial order, to conduct airshed planning, but has no delegated authority to manage air quality.

Given the size of the population affected by its policies and permitting decisions, the GVRD plays a critical part in the overall air quality management system in British Columbia. In addition to the delegated authority under the EMA, the GVRD has also added key pieces to the air quality management system. These include the development of a formal airshed plan, with specific goals, timelines, and emission reduction measures to meet the goals. The FVRD is collaborating with GVRD to develop an airshed-wide plan.

The *Growth Strategies Act* complements the province's clean air initiatives, ensuring that growth can take place while maintaining clean air, affordable housing, clean drinking water, protected farmland, wilderness and unique natural areas. This web site focuses on the *Growth Strategies Act*:

http://www.cserv.gov.bc.ca/lgd/irpd/growth/PUBLICATIONS/expguide/gsagui2.html

Regional growth strategies are providing a formal framework under which some communities are developing general plans to prevent pollution (air, land and water).

Summary
It is important to note that **all** levels of government have a role to play in airshed planning.

Chapter 3 How does airshed planning relate to and complement other community planning processes?

Many local governments are already involved in numerous planning processes that may address community development, growth, transportation and other infrastructure, as well as energy use. However, with some exceptions, air quality planning is rarely undertaken separately or even included in these ongoing planning processes. Yet much of this planning can have a direct impact on local and regional air quality and contribute to global air concerns such as climate change and ozone layer depletion. In some instances the authorities may be developing plans that will inadvertently degrade air quality within the airshed, while at the same time meeting other local objectives.

Regional growth strategies, developed at the regional district level, address critical issues that cannot adequately be addressed by individual municipalities. They provide local government with a strategic planning vision for achieving common economic, social and environmental goals. Goals of continued growth while maintaining a current or better standard of living often do not consider air emissions. Emissions from vehicles and industry may be on the agenda but these must be considered in a broader airshed-wide context.

Official community plans (OCPs) guide all development, land-use and transportation activities in an area. Although rarely considered, these plans have a significant impact on future air emissions within a community. OCPs identify where significant emission sources may be situated. In addition, a community's growth and development will often have significant impact beyond political boundaries when air emissions are considered.

Additional **municipal planning** functions incorporate expansion in population and the industrial tax base, and ensure that adequate infrastructure is maintained. Rarely, if ever, are air emissions resulting from municipal planning decisions considered.

In recent years some communities have developed **community energy plans** (CEPs) in an effort to address community energy supply, demand and overall costs. Many of the decisions made about how or what source of energy supply a community will use, or how to become more energy efficient, can have a positive impact on air emissions and overall airshed health. Several communities, including Kamloops, Lillooett, Whistler, and Quesnel, have undertaken community energy plans or CEP-related projects. See this web site:

http://www.energyaware.bc.ca/tk_cases.htm

Other planning endeavours have been directed at air emissions. These include the preparation of **greenhouse gas (GHG) action plans** and additional actions taken through the *Federation of Canadian Municipalities* (FCM) Partners for Climate Protection Program.

Each of these planning processes has been established to achieve specific, yet varied, community objectives. However, all of these planning processes have one thing in common. They all have an impact on community air emissions. The impacts may be direct or indirect. They may be positive or negative.

Why Do an Airshed Plan?

An airshed plan can be used to help integrate the air quality components of these other planning processes to ensure that community air quality objectives are met. An airshed plan should be part of community efforts to protect human health, maintain and improve visibility, while supporting and improving economic development.

Chapter 4 How is airshed planning initiated?

An airshed is a natural resource that is shared by all living within it; therefore, everyone has a stake in the quality of air he or she breathes. A major component of developing and implementing an effective and supportable airshed plan is stakeholder consultation and partnership throughout the entire process. An important part of community involvement is the formation of a multistakeholder airshed-planning committee that will set local goals and guide the planning process through to implementation. The airshed-planning committee should represent the needs of the specific community, be empowered to make the necessary decisions, and include both technical and nontechnical members.

> An airshed plan should be considered as a document of actions developed by its citizens for their own benefit.

Stakeholders include industry and government representatives, politicians, environmental organizations, First Nations and members of the general public. They should be given an opportunity to voice their concerns and offer any new information through participation in the plan's development and later in its implementation. In turn, this will ensure their ownership, buy-in and trust in the process.

Most important, the stakeholder participation and public consultation process must be fair, transparent, efficient and timely, accountable, and accessible. The participants must also be listened to, their input responded to through regular feedback, and fairly considered in the development of the airshed plan. In addition, whenever necessary, the stakeholders should be given access to information and resources for full participation in the process.

A variety of methods exist to involve stakeholders – including meetings, committees, advisory groups, questionnaires, and interviews, to mention a few. Each method has advantages and disadvantages in terms of the level of interaction, the type and quality of information collected, and associated time and costs. Therefore, individual airshed authorities need to determine the extent of stakeholder participation required for airshed plan development and implementation.

> Urban airshed planning requires an integrated approach that determines which are the most serious problems; identifies the measures that offer cost-effective and feasible solutions across a range of economic sectors and pollution sources; and builds a consensus among key stakeholders concerning environmental objectives, policies, implementation measures, and responsibilities.

An informed citizenry is capable of assisting in making informed decisions. Recognizing that the subject of air pollution is primarily a technical topic, a proactive public education, awareness and communication campaign will likely be needed well before the start of the plan development process. In addition, an outreach program should be maintained throughout the airshed planning process. Not only will this make it easier for the community to participate in the process, but also encourage people to do so.

A good airshed plan requires shared responsibility and stewardship, and full community ownership. Such multistakeholder partnerships can help bring together the financial and technical resources to initiate monitoring and collect the necessary air quality data. Local government has a major role in the airshed planning process but needs to include others to ensure collective community needs are met. The local authority can have a significant impact through bylaws and zoning. It also may wish to consider taking on the role of champion for community air quality.

An integrated approach to airshed planning requires coordination and consensus building across sectors and among affected stakeholders. Airshed planning in other jurisdictions has been undertaken for many types of topography, air pollutants and related health concerns. Often these actions are based on strong legislated requirements, while in other cases they are voluntary in nature. Successful planning processes underway in other jurisdictions build on these key ingredients.

Airshed Planning in Several Jurisdictions

The following is a brief overview of some of the airshed planning activities underway in British Columbia. Airshed planning is being undertaken in other parts of Canada (including Alberta and Ontario), the United States, Europe, Australia and New Zealand. (Additional details on the airshed planning in jurisdictions other than British Columbia can be found in Chapter 7 – Appendix E.) The experience of others suggests that an airshed plan is made up of several common foundation components. The scope of a plan will depend on the community size and available resources, and the degree of community concern with airshed health.

British Columbia

Air quality concerns are often associated with large urban centres, and the Lower Mainland of British Columbia is no exception. Because they share the same Lower Fraser Valley (LFV) airshed, the **Greater Vancouver Regional District** and **Fraser Valley Regional District** have developed a coordinated approach to air quality management.

The GVRD has legislative authority for air quality similar to the province. As a result, GVRD has enacted strong bylaws to ensure that air quality goals put forward in their airshed plan are within reach. In addition to being the largest urban community in the province, the airshed is shared with another jurisdiction across an international border.

Smaller urban centres in the province also have air quality issues that need to be addressed.

The **Prince George** airshed contains many large industrial point sources in an area with a smaller, but significant population. One of the issues in Prince George is how to balance the air quality implications of maintaining the productive industrial base with acceptable air quality for residents. To this end, planning activities have included siting a new industrial area outside the main airshed of concern (but still within regional boundaries).

Prince George stakeholders have collaborated over the years to manage local air quality. Implementation of the region's air quality management plan began in 1998, with a focus on controlling particulate matter, which frequently exceeds provincial objectives. Source:

http://wlapwww.gov.bc.ca/nor/pollution/environmental/air

Air quality problems affecting the physical and economic health of **Quesnel** and **Williams Lake** are of great concern to residents, local environmental societies, health professionals, local government, the business community and industry. The airshed planning process, which was officially launched in December 1999, addresses community air quality concerns related to the health of local residents, and to the future economic development of the region. See this web site:

http://wlapwww.gov.bc.ca/car/env_protection/index.html#airshed

Other areas of British Columbia are also in the process of developing airshed plans to address specific air quality issues. For example, during the 1990s the **Bulkley Valley-Lakes District** began an episode-management plan to control emissions from open burning and wood smoke. It has recently drafted a new strategy to address air quality issues in the corridor stretching from Kitwanga to Endako. Available on this web site:

http://www.bvldamp.ca/html/current.htm

Areas including the **Okanagan Valley**, **Golden** and the **Capital Regional District** are proceeding with significant airshed-related activities, such as expanded monitoring and special studies to better characterize the sources of PM in an airshed.

Summary

Airshed planning in many jurisdictions has demonstrated that success is built on strong local support, involving key stakeholders in the planning decisions led by a representative airshed-planning committee.

Chapter 5 What are the components of an airshed plan?

Not all communities and areas are faced with the same air pollution challenges. However, in order to achieve improved air quality, clear goals are required and each local or regional airshed planning committee should design its process in accordance with specific local needs and requirements.

The basic steps involved in developing and implementing an airshed plan typically include those shown in Figure 1.

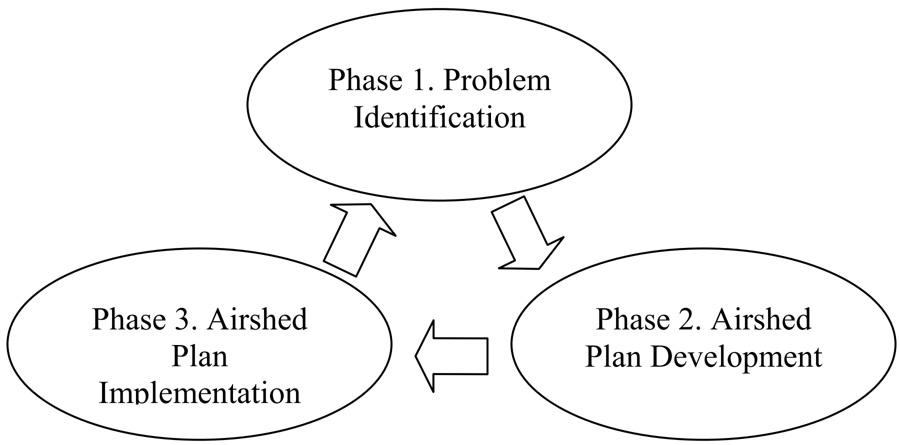

Figure 1: Phases of an Airshed Planning Process

Phase 1 – Problem Identification

The goal of problem identification is to determine if there is an air quality problem and establish what is causing it. This would include consideration of current air quality levels, the meteorological factors that affect air quality, and source emissions (i.e., through an emission inventory). It may also include modelling to pull all the pieces together and better understand the movement of pollutants in the airshed. Fundamental to the problem identification phase is providing the science-based foundation on which to base decisions in the subsequent planning phases. It should also be noted that it will take time and technical "know-how" to collect representative data.

Monitoring is a major tool in problem identification. However, due to cost constraints, monitoring is usually undertaken in areas where an air quality problem is known to exist or is anticipated. This is often the case in areas with emissions resulting from large "point source" industrial operations. In recent years, area-wide emission sources (e.g., automobiles and wood-burning stoves) have become a greater concern to public health, and monitoring in nonindustrial areas has increased.

Whether or not monitoring data are available, it may be necessary to prepare an inventory of emission sources in the airshed. In some circumstances, it may be necessary to forecast the ambient concentration of airborne pollutants using computer-based modelling techniques. In general, the more complex the problem and/or the greater the level of certainty needed to proceed with reduction measures, the more detailed the scientific and technical studies needed to support decision making.

No single jurisdiction has all the resources to undertake problem identification alone. The province has a significant role to play and can assist in identifying partners, encouraging representative stakeholders and providing technical expertise.

Even if all current air quality standards and objectives are being met, communities may wish to proceed with developing an airshed plan. An airshed plan will help ensure that as the community grows ***clean areas are kept clean***, and ***air quality in the airshed is maintained or improved*** for future generations.

Does your community have the tools needed to develop an airshed plan?

The province maintains an archive of air quality and meteorological data. In addition, the Ministry of Water, Land and Air Protection (WLAP) has much of the technical expertise needed to support airshed plan development. Provincial staff can help communities obtain air quality data, and/or evaluate the current data and determine if additional information or studies are required.

Phase 2 – Airshed Plan Development

The development of an airshed plan involves several steps as shown in Figure 2. The purpose of Phase 2 is to take the science gathered in Phase 1 and make informed decisions about the priority sources, and emission reduction measures that are needed.

Develop Airshed Plan Goals and Objectives

Like any other planning process, the effectiveness of an airshed plan depends on its foundation, i.e., on the policies and goals it sets out to achieve. Given that the provincial and national legislation and international commitments (described above) provide the overall framework for air quality management, it is becoming apparent that local initiatives can be an effective way to address air quality problems within particular airsheds. However, in order to achieve an improvement in the quality, clear goals are required to guide the process of airshed plan development.

Phase 2

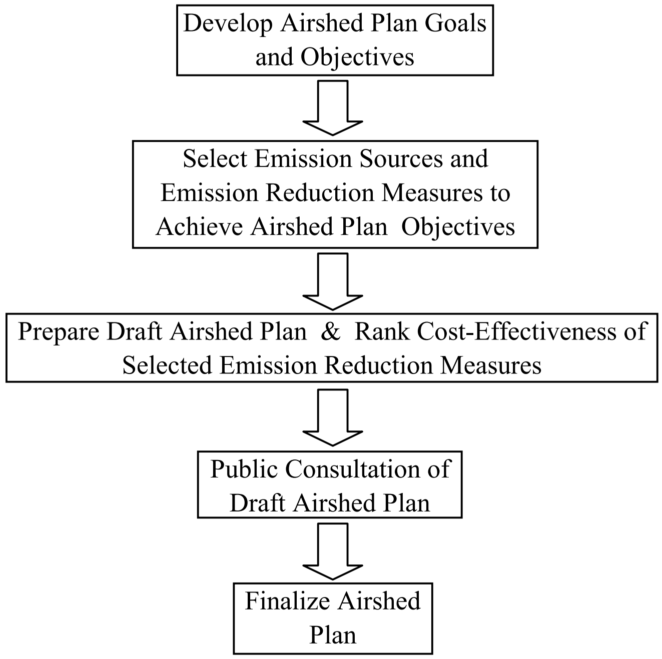

Figure 2: Phase 2 – Airshed Plan Development Process

The goals of an airshed plan should be based on a number of criteria to reflect the community's concerns and values about the quality of the ambient air, potential for its improvement, as well as the socioeconomic realities. They should also reflect provisions under the CWS for PM and ozone of continuous improvement and keeping clean areas clean – recognizing that it is unacceptable to pollute up to the standards, and that below the standards, reasonable efforts should be made to minimize the risk of PM and ozone to human health and the environment. Airshed planning criteria that have been considered by others are listed below as a guide. However, each community will need to develop its own list that is deemed appropriate for the local airshed.

- Air emissions must be considered in an integrated, multipollutant approach.
- Emission reductions should be optimized to ensure that they are made in a fair, just and cost-effective manner.
- The reduction of emissions may have significant co-benefits (i.e., reduction of other air emissions in the airshed, such as hazardous air pollutants and greenhouse gases) that should be optimized.
- Local actions to improve air quality may have regional and even global impacts.
- Development of an airshed plan should be based on best available science.

The selected airshed plan goals will influence the choice of emission reduction measures (ERMs), and be the yardstick by which success will eventually be measured. The initial airshed plan must therefore be developed with a realistic schedule for its implementation. Although typically, the first plan is developed with an implementation schedule of five or more years, this period should be determined by the local authority based on the airshed plan goals. However, an airshed plan should be considered as a "living" guide for achieving its goals. As the goals may be altered due to changing community circumstances, the airshed plan will require regular review and updating.

Select Emission Sources and Prioritize Emission Reduction Measures to Achieve Airshed Plan Objectives

This is one of the major technical components of the airshed plan development process. Each situation presents its own challenges as well as opportunities that should be addressed at the local level.

However, several key general criteria can be considered by local authorities to form a general premise for selection of sources to be addressed. The local authorities should also consider any other factors specific to particular airsheds.

Questions for Consideration
• What are the priority issues? • What are the priority pollutants? • What co-benefits are sought? • What are the priority sources / activities for action? • What reductions are technologically and economically feasible, now and in the future? • Who has responsibility for these reductions? • Are voluntary reductions needed? Legislative requirements? • Will proposed reductions have negative impacts on other parts of the environment?

Emission reduction measures are the tools and tactics used to reduce the amount of pollutants discharged into the environment. In general, ERMs fall into two broad categories: technical and nontechnical types. As the name implies, technical ERMs are based on particular technologies for pollution control from various sources. Nontechnical ERMs are concerned with influencing changes in individual and societal behaviours to reduce air pollution within an airshed (e.g., reduced energy consumption; more compact communities; and the use of clean-burning woodstoves, more fuel-efficient vehicles, and alternate transportation sources).

Prepare Draft Airshed Plan and Rank Cost-Effectiveness of Selected Emission Reduction Measures

The air quality model can be used to determine whether the selected ERMs will achieve the plan goals. In smaller, less complex airsheds, models may not be required, but without them, it is difficult to provide the quantitative estimates to support decisions. In some situations, the next stage of the planning process may require the preparation of a detailed cost-benefit analysis, i.e., a socioeconomic evaluation of implementing the recommended emission reduction measures.

> ***What is the role of a model in the development and implementation of an airshed plan?***
> - Air quality problem identification - characterization
> - Selection and optimization of emission reduction measures for airshed plan development
> - Tool for periodic assessment of the plan after implementation

Carry Out Public Consultation on Draft Airshed Plan / Finalize Airshed Plan

Once the ERMs are selected, the draft airshed plan should be given broader public review. The broader public consultation may bring additional ERMs or other issues to the attention of the airshed-planning committee and the plan may need to be adjusted accordingly before being finalized.

Phase 3 – Implementation and Updating

In more complex airsheds, there may be a number of airshed-committee-selected ERMs to be implemented, but limited resources for action. This requires a strategy for implementation on a priority basis, as illustrated in Figure 3.

Phase 3

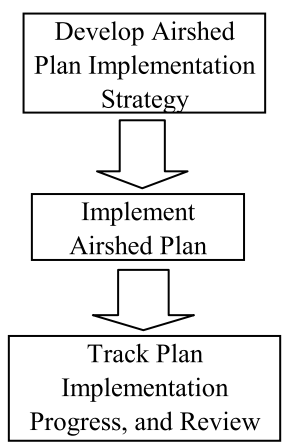

Figure 3: Phase 3 – Airshed Plan Implementation and Updating Phase

Implementation of an airshed plan is an involved exercise, similar to the plan's development. It is a multiagency task, as no single agency in British Columbia has either the authority or responsibility for implementing and/or enforcing all types of ERMs. A coordinated, cooperative strategy – involving all agencies and stakeholders – is needed to successfully implement a plan. In addition to prioritizing ERMs for implementation, the implementation strategy should set appropriate milestones, and identify the roles and responsibilities of those who will be involved in the process.

Determine Implementation Priority and Schedule

As there are a number of ERMs that have been selected for implementation, it is likely that not all have to be – or can be – put in place at the same time. Therefore, it is necessary to develop some criteria for a prioritized and phased-in implementation. (Less complex airsheds may have fewer ERMs to evaluate and a phased-in approach may not be necessary.) The principal criteria for ERM prioritization should be the air quality situation in the particular airshed and the overall effectiveness of the selected ERMs in achieving the plan goals.

As a general guide, the "low-hanging fruit," or those ERMs that are relatively easy to implement with a minimum cost, and yield maximum co-benefits of emission reduction, are the prime targets for early implementation. However, selection of those ERMs as the first priority will leave some difficult, but often essential, ERMs for implementation at a later time. Also, implementing all easy measures may not achieve the overall emission-reduction target. A realistic implementation schedule for prioritized ERMs is, therefore, a practical and necessary step, and should include a series of milestones from which to track progress.

Once started, the development and implementation of an airshed plan becomes a continuous multiagency effort with the involvement of stakeholders. To make such an ongoing, multiparty effort a success, it is essential that someone coordinate the various activities. Local government is in a unique position to assume the responsibility of a coordinator for the local airshed plan development and implementation.

In British Columbia, the responsibilities for various commercial and industrial air-pollution sources and their control are held primarily by the provincial and federal governments. With the exception of the Greater Vancouver Regional District and to a lesser extent the Fraser Valley Regional District, no other regional governments in British Columbia have legislated authority to manage air quality in their jurisdictions. Although most local governments do not have specific powers for air quality management, they have a large influence on air management through planning, zoning and bylaw powers. In cooperation with community stakeholders and senior levels of government, development and implementation of a comprehensive airshed plan is feasible.

Conduct Airshed Plan Tracking and Periodic Review

An airshed plan must undergo continuous tracking and review in order to confirm its relevance and effectiveness in meeting the objectives and milestones. The plan should undergo a formal review (e.g., every five years), and regular updates on implementation status. Stakeholders should review all reports to ensure that the implementation schedules and plan objectives are being met.

Informal forums on tracking and reviewing an airshed plan involve ongoing opportunities for stakeholder feedback. These forums provide information about research on various aspects of air pollution – in particular, its impacts on health and the environment, and emerging tools for controlling air pollution. This could be achieved through regular meetings of a stakeholder advisory committee. In this way, the air-quality-management planning process never really ends. It remains relevant and responsive to improving air quality.

Chapter 6 Summary

> An airshed plan sets a course of action that will result in the attainment of local and regional air quality goals. It will require actions by government, business, industry, and the population at large, and its success will depend on cooperation of all segments of society.

Community air quality is a concern for all. It has implications for community health, environmental health and business development.

Meeting federal and provincial air quality standards and objectives may not be enough to maintain air quality at a level that is acceptable to community stakeholders.

An airshed plan provides the necessary tools to ensure that air quality can be better protected. It allows the community to continue to grow and develop while maintaining and improving air quality in the airshed. In addition, an airshed plan can integrate with other ongoing planning processes to ensure that co-benefits of all planning processes are optimized.

The new *Environmental Management Act* will ensure that sensitive airsheds are protected and, where necessary, airshed plans are prepared.

Preparation of an airshed plan is a complex endeavour requiring coordination and cooperation of all stakeholders within the airshed. A properly designed and implemented airshed plan will be built on community stakeholder support. An airshed plan provides a community with goals and objectives that may help direct growth. Finally, it will provide new industry with needed guidelines and a degree of certainty in the level of effort required to meet community air quality concerns.

Chapter 7 Appendices

Appendices A through F:

Additional Background Information
and
Supporting Reference Materials

Appendix A Additional information: What are the components of an airshed plan?

An airshed plan is typically developed using a phased approach that includes *Problem Identification*, the *Development of an Airshed Management Plan* and *Implementation*. This appendix provides additional background information on the first two phases of airshed plan development. Much of the information is highly technical and intended for those seeking to explore many of the scientific aspects of airshed planning.

Phase 1 – Problem Identification

Further information on the process of developing and implementing an air quality management plan is available from the following sources:

1. Bates, D.V., and R. B. Caton, eds., for the David Suzuki Foundation. 2002. Chapter 9, in: *A Citizen's Guide to Air Pollution,* (2nd ed) [online]. Available on the Internet: http://www.davidsuzuki.org/ (David Suzuki Foundation: 2211 West 4th Avenue, Suite 219, Vancouver BC, V6K 4S2)

2. WHO/SDE/OEH/00/02, World Health Organization. 2000. *Guidelines for Air Quality* [partially online]. Geneva. Part of this document is available on WHO's Internet web site: http://www.who.int/phe/health_topics/air/en/

3. Bhattacharyya, K. K. Outreach Series publication of the Canadian Universities Consortium Urban Environmental Management Project at the Asian Institute of Technology. 1999. *Urban Air Quality Management Plan: A Framework for Development and Implementation* [online]. Bangkok, Thailand. Available on the Internet at: http://www.ucalgary.ca/UofC/faculties/EV/designresearch/projects/2000/cuc/tp/outreach/bhattacharya%20paper.pdf

4. Shah, J.J., T. Nagpal, and C. J. Brandon, eds. 1997. *Urban Air Quality Management Strategy in Asia – Guidebook*. Washington D.C.: The World Bank.

Information is provided below on: (i) the status of air quality and meteorological monitoring in British Columbia; (ii) the basic method of estimating emissions and the status of emission inventories in British Columbia; and (iii) types of air quality models, and the status of air quality modelling in British Columbia.

(i) Status of Air Quality and Meteorological Monitoring in British Columbia (outside the Lower Fraser Valley)

The monitoring of ambient air quality in the province has been a cooperative effort of the provincial ministry, Environment Canada and several industries since the 1980s. The primary objectives for establishing monitoring stations at various locations have been to obtain information on air quality status for the provincial and federal "state of the environment reports," assessing air quality trends in the communities, and determining compliance by the industry with the permit conditions. Consequently, depending on the location and the pollutant of interest, one or more air pollutants are monitored at various stations in British Columbia. In recent years, because of increasing concern about health impacts, the focus has shifted to monitoring PM_{10}, $PM_{2.5}$, ground-level ozone and their precursor pollutants in several airsheds.

Currently, 93 ambient air monitoring stations are operating in the province, but outside the Lower Fraser Valley. Of these, 34 stations are operated by WLAP (Ministry of Water, Land and Air Protection), including several stations in different communities as a part of the National Air Pollutants Surveillance (NAPS) network in partnership with Environment Canada. Fifty-four stations are operated by industry to measure only specific pollutants of interest as required by their waste management permits. In addition, WLAP maintains additional monitors at six of the permittee monitoring stations.

Meteorological Monitoring

For a number of years, Environment Canada has been monitoring meteorological parameters in a number of locations in British Columbia. Several other national and provincial agencies also operate meteorological stations in different parts of the province. For air quality evaluation, the Ministry of Water, Land and Air Protection has been operating a "meteorological information system" for the past two decades. There are now 46 meteorological stations operating under the provincial program in 39 cities and towns. Some of these stations are either operated by industry, or as stations shared by WLAP and industry. While all stations measure common meteorological parameters such as temperature, wind speed and wind direction, at some locations other parameters like relative humidity, solar radiation, precipitation and visibility are also monitored.

Sources for Monitoring Guidance and Assistance

In order to address specific air quality concerns in an airshed, it is necessary to establish an adequate monitoring program that would provide the data requirement for airshed management plan development. The local authorities need to review the existing monitoring networks in their areas and determine additional monitoring requirements. Any new monitoring of air quality and meteorology should conform to established protocols with respect to station siting, monitoring instruments, and data quality and management. Additional information on ambient air quality monitoring is available from:

> Ministry of Water, Land and Air Protection, Water, Air and Climate Change Branch: http://wlapwww.gov.bc.ca/wat/wamr/

Environment Canada, Air pollution monitoring and atmospheric science, Systematic Measurements Activities: http://www.msc.ec.gc.ca/aqrb/activitiesmeasure_e.cfm

The US Environmental Protection Agency (EPA) operates the Ambient Monitoring Technology Information Center (AMTIC) through its Monitoring and Quality Assurance Group (MQAG). AMTIC contains information on federal regulations related to ambient air quality monitoring and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles: http://www.epa.gov/ttn/amtic/

(ii) Basic Emission Estimation Method

An emission inventory is an accounting of all sources of air pollution within a defined geographic area. The provincial emission inventory has been developed and updated through cooperative efforts of the GVRD, Environment Canada, and WLAP. The GVRD is responsible for preparing estimates for the Lower Fraser Valley. Environment Canada has been responsible for preparing national area and mobile emission estimates that can be applied to all provinces including British Columbia. The ministry (WLAP) compiles emission estimates for sources that operate under its authorization (e.g., permit, approval or regulation), and other sources that are dominant in British Columbia.

Common air contaminants (CACs) inventoried for each update include:

- carbon monoxide (CO);
- nitrogen oxides (NO_x);
- sulphur oxides (SO_x);
- total reduced sulphur (TRS);
- volatile organic compounds (VOCs); and
- particulates with PM_{10} and $PM_{2.5}$ size breakdowns.

Ammonia and greenhouse gases are also included in the inventory for the Lower Fraser Valley.

Emission estimation techniques may vary, depending on the source type. The basic formula used for estimation of the quantity of an air pollutant emitted from a source is:

$$E = BQ \times EF \times (1 - C)$$

where E = emission (kg of pollutant/year)
BQ = base quantity of the source activity (activity of the source/year)
EF = uncontrolled emission factor (kg of pollutant emission/activity)
C = control efficiency of any external pollutant control equipment

The measuring unit of the source activity rate (BQ) varies from one category of source to another. Typical examples of BQ are: fuel consumption rate for boilers and heaters, rate of production, rates of raw materials used or goods produced for industrial and commercial processing units, vehicle distance travelled for motor vehicles, etc..

If actual emission monitoring data are available for an emission source, then such data are the most preferred choice for estimating emissions rather than the source activity rate.

Limitations of an Emission Inventory

An emission inventory does not provide estimates of secondary pollutants such as ozone and fractions of PM_{10} and $PM_{2.5}$.

An emission inventory provides only estimates of primary pollutants that are directly emitted from various sources. It does not provide any estimates of emissions of secondary air pollutants, such as ozone, and fractions of PM_{10} and $PM_{2.5}$, which are formed in the atmosphere. In most airsheds a considerable portion of $PM_{2.5}$ in the ambient air is of the secondary type. This is a major drawback of an emission inventory, and this fact must be kept in mind while developing an airshed plan to reduce ambient levels of ozone or inhalable particles.

Status of Emission Inventories in British Columbia

The Water, Air and Climate Change Branch (WACC) of WLAP has been involved in compiling a provincial emission inventory of common air contaminants (CACs) since the early 1980s. To date, it has prepared emission inventories for the years 1985, 1990, 1995 and 2000 on a five-year cycle. Each inventory has been done in cooperation with the Greater Vancouver Regional District and Environment Canada. The responsibility for compiling emission inventories for the Lower Fraser Valley lies with the GVRD.

Because of the growing concern and the need for detailed information on PM_{10} and $PM_{2.5}$, WACC expanded the list of pollutants to include these two pollutants since the 1990 emission inventory. Environment Canada compiles an annual national inventory of emissions, with provincial breakdowns, of greenhouse gases from all sources and hazardous air pollutants from industrial facilities.

From time to time, special projects have been undertaken either singly by WACC, or jointly with the GVRD and Environment Canada, to prepare detailed inventories of emissions of specific source categories or specific pollutants, and to enhance emission-estimation methods.

Emissions Inventory Forecasts

Since 1990, the Water, Air and Climate Change Branch has prepared emissions forecasts for the areas outside the LFV based on the latest emission inventory data, and population and economic growth information. The forecasts data provide future emission levels from different sources, and are necessary for identifying future air quality scenarios in different airsheds.

Inventory Data Accessibility

WACC has developed two emission inventory GIS tools to enable end users to generate emission inventory estimates for any defined area of BC.

> ***Where to go for technical information and assistance?***
> Local authorities should approach the WACC through the Regional Offices of the WLAP for information on local emission inventory data.

The first tool, Air Emissions Inventory (AEI), is an Internet-mapping application that allows the joining of geographic information with emission inventory databases to make interactive maps on the Internet. The AEI currently contains year-2000 emission data for point sources; 1995 to 2001 data for prescribed burns; and 1999 to 2001 data for forest wildfires. The second GIS tool, Air Contaminant Emissions (ACE), is more complicated than AEI, as it is used for analyzing area and mobile sources that are not fixed to one location. ACE is currently loaded with the 1995 emission inventory dataset. With ACE it is possible to generate emission estimates for any defined area to gridded resolutions of either 1 km or 5 km. Obvious tradeoffs between speed and acuracy occur between these two resolutions. Future GIS work will focus on loading the year-2000 data into ACE; refining the allocation techniques for area and mobile sources; and making data more accessible to the public.

Emission Inventory Data Quality and Requirements for Airshed Management Plan Development

An emission inventory is a compilation of estimated emissions from a variety of sources. As the word "estimate" implies, the inventory data will always have some inherent uncertainties. One of the causes of these uncertainties is the overall approach in determining the source activity rates. The national or provincial emission estimates are done by using a "top-down" approach. This approach uses the total activity rate of a particular type of source throughout the country to estimate the total national emissions from that sector. The national emissions data are then prorated to the provinces, based on a parameter such as population, fuel consumption, etc.. The provincial emissions data can then be prorated to its various regions using a similar approach.

Although this top-down approach to estimating emissions is useful for general purposes, the data accuracy is hardly suitable for the local airshed-management-plan development purposes. A better alternative to the above method is to estimate emissions for the local airshed using a "bottom-up" approach, i.e., by using locally procured activity-rate data for particular source categories within the airsheds and then estimating emissions from those sources.

Sources of Information on Emission Inventory Preparation and Emission Factors

BC Water, Air and Climate Change Branch, Ministry of Water, Land and Air Protection: The Water, Air and Climate Change Branch (WLAP) should be contacted for all emission-inventory-related matters:
http://wlapwww.gov.bc.ca/air/

The information on the provincial emission inventory is on the web site of the Water, Air and Climate Change Branch:
http://wlapwww.gov.bc.ca/air/airquality/inventory/subindex.html

Other useful sources for information on emission inventories:

Greater Vancouver Regional District: The GVRD has one of the most well-resourced emission inventory programs in Canada. It maintains a comprehensive computer database of emissions information on common air contaminants, ammonia and greenhouse gases emitted from the many sources in the Lower Fraser Valley. Here is the web site:
http://www.gvrd.bc.ca/air/emission_inventories.htm

Environment Canada: The following web sites provide information on Canada's emission inventory programs:

Common air contaminants: http://www.ec.gc.ca/pdb/ape/cape_home_e.cfm
GHG sources and sinks: http://www.ec.gc.ca/pdb/ghg/ghg_home_e.cfm
Air toxics: http://www.ec.gc.ca/pdb/npri/npri_links_e.cfm, and Accelerated Reduction/elimination of toxics: http://www.ec.gc.ca/nopp/aret/en/index.cfm
Dioxin and furans: http://www.ec.gc.ca/pdb/npri/npri_dioxins_e.cfm, and Polyaromatic hydrocarbons: http://www.ec.gc.ca/pdb/npri/npri_pah_e.cfm

Natural Resources Canada: The agency maintains information on energy use in Canada, and prepares reports on Canada's emissions outlook; and tables for provincial and territorial results and emissions, available at this web site:
http://nrcan.gc.ca/es/ceo/update.htm

The Canadian Council of the Ministers of Environment (CCME): The CCME, through the National Air Issues Coordinating Committee (NAICC-A) directs a multigovernmental body of emissions inventory and projection practitioners called the Emissions and Projections Working Group (EPWG). The EPWG is involved in coordinating various emission inventory activities of the provincial and territorial governments. The Water, Air and Climate Change Branch (WLAP) is a member of EPWG. Information on EPWG's programs, initiatives and reports are on this web site:
http://www.ccme.ca/initiatives/climate.html?category_id=34

US Environmental Protection Agency: The US Environmental Protection Agency's web site offers general information on emission inventory, including emission-inventory guidance documents and emission factors: http://www.epa.gov/ttn/chief/ap42/ch13/

(iii) Air Quality Model Types
Although models are sometimes difficult to understand, they do not have to be. Essentially they are a "best scientific guess" at how to connect the dots between pollutants emitted from their sources and dispersion of those pollutants in the atmosphere. Several air quality models have been developed, most of which are variants of the following basic types: dispersion, receptor, and statistical models.

Dispersion Models – In simple terms, this type of model mathematically tracks an air pollutant emitted from a source and estimates its ambient concentration along the path of its travel. This class of model takes into account the emission source characteristics, local meteorology and topography. It assumes that the pollutant is dispersed in the vertical, lateral and horizontal directions as it is transported by the wind.

Traditionally, dispersion models have been used to predict ambient concentrations of nonreactive particles or gases in relatively flat terrain with simple flow patterns. In recent years, sophisticated dispersion models have been developed to overcome several limitations of original models. The later models incorporate meteorological models and other techniques to account for complex flow solutions that are experienced in mountainous terrain and the chemical transformation of reactive pollutants into secondary air pollutants in the atmosphere.

Receptor Models – As opposed to dispersion models, receptor models start with measured levels of air pollutants at a receptor site. Receptor models seek to identify the possible emission sources of these measured pollutants, on the basis of the pollutants' characteristics. The models provide a "real-world" picture of emissions and their sources by adopting an inward-looking approach. They take into account the physical and chemical characteristics of pollutants measured at emission sources and at receptors. Also, they are generally applied to complicated source-mix airsheds.

Generally there are two basic types of receptor models: those that consider a single-sample or variable (e.g., Chemical Mass Balance), and those that consider many variables at the same time (e.g., Principal Component Analysis, Positive Matrix Factorization and UNMIX target transformation factor analysis.)

Statistical Models – A statistical air quality modelling technique takes a pragmatic approach by reviewing previously monitored air quality data, and uses statistics to determine the cause-and-effect patterns between emissions and the ambient concentrations of pollutants within an airshed. There are several statistical approaches – from simple to complex – including linear equations, nonlinear equations, cluster analysis, data mining and neural nets.

> ***How reliable is an air quality model?***
> Given that there is a solid science behind the understanding of physical and chemical processes within the model, the credibility of an air quality model will be as good as the quality of its input data.

A good statistical model requires long historical data sets of air quality monitoring and other parameters. The larger the data sets are, the better will be the model. However, statistical models are inherently limited as they do not determine the underlying physical processes that result in the cause-effect relationships between air pollutants emitted from sources and their concentrations measured at receptor sites.

Status of Air Quality Modelling in British Columbia
To date in British Columbia an “urban airshed model” (UAM) – a type of dispersion model for ground-level ozone – has been applied in the Lower Fraser Valley (LFV) through a multiagency effort led by Environment Canada. These efforts have now given way to the Community Multiscale Air Quality (CMAQ) model which is being run by UBC in forecast mode. The National Research Council of Canada has also developed a dispersion model for estimating of ground-level ozone in the LFV. Only a few attempts have been made to demonstrate the application of receptor models in the LFV to identify the emission sources contributing to fine particulate matter. To date, these latter attempts have produced encouraging results.

These models, though very powerful, can only be applied to the study of episodes (e.g., a few days) over a wide area, at space resolutions that are too coarse to provide the required detail needed for complex airsheds (similar to those found in interior British Columbia) due to computer-resource limitations. Consequently, other simpler, less computer-resource-intensive models, such as the California Puff Model (CALPUFF), have been applied so that both episodes and long-term averages (e.g., annual exposures) can be estimated with the necessary spatial detail required for interior British Columbia airsheds. Efforts to apply CALPUFF have been made in Prince George, Bulkley Valley and Quesnel airsheds with varying success. However, the limiting factors in these efforts appears to be the availability of necessary and detailed meteorological monitoring and emission inventory data for the local airsheds.

Resource Requirements and Funding Sources

The application of an air quality model for airshed planning purposes has been, and still is, a resource- and time-intensive exercise. (If you are considering the application of any type of air quality model to assist in the development of an airshed plan, an excellent start would be to contact your WLAP regional office.) The major factors that determine these requirements include:

> ***Where to go for modelling information?***
> Although there are numerous kinds of models developed and in use in several countries, historically Canada and British Columbia have relied on the models approved by the US Environmental Protection Agency (USEPA) for its regulatory purposes. Guidelines for air quality modelling are being developed by WLAP.

- the availability of the basic model and its input data for the desired pollutant(s);
- expertise in modelling;
- the ease of adaptation of the basic model to the airshed conditions; and
- the required degree of sophistication of the model.

> ***Where to look for funding assistance?***
>
> - British Columbia Ministry of Water, Land and Air Protection; Water, Air and Climate Change Branch
> - Environment Canada, Pacific and Yukon Region
> - Georgia Basin Ecosystems Initiatives (for Vancouver Island Region and a part of the Lower Mainland Region): http://www.pyr.ec.gc.ca/georgiabasin/index_e.htm
> - British Columbia Clean Air Research Fund: http://wlapwww.gov.bc.ca/air/airquality/carf/index.html)

Depending on these factors, the total costs of applying a region-specific air quality model from "scratch" could range from a few thousands to millions of dollars. Recognizing the specialized nature of the air quality model development work and the relatively high costs it entails for airshed planning related applications, a local authority may require funding assistance from other governments and agencies. Fortunately, because of the efforts of air quality model developers and their users over the past few decades, the present day costs of applying air quality model may not be that high.

Once an air quality model is successfully applied, its routine application for the development of an airshed management plan and subsequent revisions become relatively inexpensive.

Sources of Information on Air Quality Modelling

The **Water, Air and Climate Change Branch of the Ministry of Water, Land and Air Protection** should be contacted for general and specific information on air quality modelling: http://wlapwww.gov.bc.ca/air/airquality/index.html

Environment Canada, Pacific and Yukon Region:
http://www.pyr.ec.gc.ca/EN/Air/index.shtml

National Research Council of Canada
http://icpet-itpce.nrc-cnrc.gc.ca/research_md_aq.html.

The US EPA has a number of approved regulatory air quality models for assessing air quality impacts to comply with the requirements under the *Clean Air Act* amendments of 1990. The information on these models and users guides is available at: http://www.epa.gov/ttn/scram/

Phase 2 – Development of Airshed Management Plan

The selection and prioritization of emission sources and emission reduction measures (ERMs) are in general quite involved and repetitious; however, it primarily depends on the air quality situation and emission sources within a particular airshed. The experience gained by other agencies during their airshed management plan development will be useful to those who plan to embark on such an exercise. Information on the process of selecting and prioritizing emission sources and ERMs (see Table 3 below) is available from the following sources:

1. The Greater Vancouver Regional District developed its airshed management plan in 1994. Through the plan's implementation, emissions of most common air contaminants have been reduced by about 40%, despite the growth in population and economic activity that has occurred in recent years. The GVRD is working on an updated airshed management plan to implement new innovative measures for reducing local air pollution and greenhouse gas emissions: http://www.gvrd.bc.ca/air/planning.htm

2. The first edition of a *Handbook for Air Quality Management Plans Slovak Republic,* prepared by WS Atkins International Limited for the Municipal Authorities in the Slovak Republic, was published as consultation draft in July 2001. It provides information on the tools necessary for developing an airshed management plan and guidance on how to use these tools: http://www.shmu.sk/twinning_internal/Report8_final_eng.pdf

3. The Province of Ontario recently developed *Ontario's Smog Plan: A Partnership for Collective Action,* which contains recommendations on actions by virtually every sector of the society to reduce emissions of air pollution. The plan was developed by representatives from government agencies, industry, public utilities, health groups, the scientific community, academics and environmental organizations: http://www.ene.gov.on.ca/programs/3573e.pdf

4. The Department of Ecology, State of Washington, USA has developed the State Implementation Plan (SIP) for approval by the US Environmental Protection Agency, as required under the *Clean Air Act*: http://www.ecy.wa.gov/programs/air/airhome.html

5. The South Coast Air Quality Management District, California, USA has been in the forefront of air quality management plan development and implementation because of its unique air quality situation. Its regional airshed management plan is the blueprint for actions. An overall plan for a 20-year horizon is developed every three years by updating the previous plan, available on this web site: http://www.aqmd.gov/aqmp/

6. The Bay Area Air Quality Management District (BAAQMD) prepares and updates airshed management plans to improve air quality within its jurisdiction (San Francisco metropolitan area), in cooperation with stakeholders, the Metropolitan Transportation Commission, and the Association of Bay Area Governments. These plans include emission reduction measures from industrial and commercial facilities, motor vehicles, and other sources: http://www.baaqmd.gov/pln/plans/index.asp

Cost-Benefit Analysis

In some complex airsheds, it may be necessary to consider or undertake a cost-benefit analysis (as a part of *Phase 2*) of possible emission reduction measures (ERMs). Cost-benefit is a complex process in which current costs of reducing emission are analyzed in terms of future costs and benefits if specific ERMs are implemented. A detailed review of cost-benefit analysis is beyond the scope of this report. However, the following sources will provide the reader with appropriate background information:

1. *Air Quality Management in the Year 2020: Airshed Emission Limits for the Lower Fraser Valley,* B.H. Levelton and Associates Ltd in association with Margee Consultants, Toronto, Ontario and Cantor Fitzgerald, Larkspu, California. 1996: http://www.rem.sfu.ca/FRAP/9705.pdf

2. *Analytical Tools for Cost-Benefit Analysis*, World Bank: http://www.worldbank.org/html/fpd/esmap/pdfs/airquality_c.pdf

Table 3: Typical Examples of Technical and Nontechnical Emission Reduction Measures (ERMs)

Technical ERMs	• Application of best available technology to all emission sources within an facility in the airshed, e.g., pulp and paper production, nonferrous smelting, cement manufacturing, natural gas processing plant and petroleum refining and storage facilities • Development and enforcement of more stringent emission standards for specific industrial sources, wherever applicable • Control of emissions from industrial and commercial boilers and heaters • Switch to cleaner fuels • Energy and resource conservation measures • Strict schedule for phasing out of beehive burners for wood waste • Enforcement of regulations on residential wood burning heating appliances • Restrictions on open burning of biomass and wastes • Gasoline vapour recovery at bulk transfer and service stations • Requirement of low-sulphur diesel oil, cleaner gasoline and alternative fuels for motor vehicles • Motor vehicle emissions inspection and maintenance program
Nontechnical ERMs	• Public awareness and communication programs • Restrictions on wood burning appliances on poor air quality days • Replacement program for inefficient, high-polluting, wood-burning appliances • Environmental stewardship programs by local authorities, major employers and community organizations • Land-use and transportation planning by local authorities • Development of pedestrian-friendly regional city/town centres and other major activity centres • Provisions for carpooling/ridesharing and bicycling for employees by major employers • Employer-based incentive programs to reduce commuting to and from working place (such as telecommuting, flexible work days and hours, transit-use incentives) • Introduction or improvement of public transit system, wherever possible • Transportation control measures of any appropriate kind, wherever possible (these measures include: route and vehicle restrictions, parking management and restrictions, traffic flow improvements, etc.) • Vehicle use restrictions on poor air quality days • Scrapping program for old, high-polluting vehicles

Appendix B Additional Information: Why should the community be concerned about air quality (and what can it do)?

Sources of Information

1. American Lung Association. 2004. [online]. Available on the Internet at: http://www.lungusa.org/

2. Bates, D. V., J. Koenig, and M. Brauer. RWDI West Inc., for the BC Lung Association. 2003. *Health and Air Quality 2002, Phase 1: Methods for Estimating and Applying Relationships between Air Pollution and Health Effects*.

3. CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. 2003. *National Ambient Air Quality Objectives for Particulate Matter. Part 1: Science Assessment Document* [online]. Available on the Internet at: http://www.hc-sc.gc.ca/hecs-sesc/air_quality/publications/particule_matter.htm

4. Bates, D.V. 1994. *Environmental Health Risks and Public Policy: Decision Making in Free Societies.* University of Washington Press, pg. 117.

5. Bates, D. V., and R. B. Caton, eds., for the David Suzuki Foundation. 2002. *A Citizen's Guide to Air Pollution,* (2nd ed). [online]. Available on the Internet at [1]: http://www.davidsuzuki.org/

6. United States Environmental Protection Agency. 2003. *Air Quality Criteria for Particulate Matter* [online]. Available on the Internet at: http://cfpub1.epa.gov/ncea/cfm/partmatt.cfm?ActType=default

7. United States Environmental Protection Agency. 2002. *The Plain English Guide to the Clean Air Act* [online]. Available on the Internet at: http://www.epa.gov/oar/oaqps/peg_caa/pegcaa10.html

8. World Resources Institute. 2004. [online]. Available on the Internet at: http://www.wri.org/

A summary of effects, sources and control methods of several air pollutants is provided in Table 4.

[1] There are a number of textbooks on air pollution available. Comprehensive updated information on air pollutants, air quality issues and effects of air pollution is provided in chapters 2, 4, 6, 7 and 11 of *A Citizen's Guide to Air Pollution (2nd Edition).*

Table 4: Air Pollutant Sources, Effects and Control

Pollutant	Sources	Effects	Major Control Methods
Ozone (O_3)	Formed when reactive volatile organic compounds (VOCs) and nitrogen oxides (NO_x) react in the presence of sunlight. VOC and NO_x sources include any source that burns fossil fuels, wood and waste; and industrial processes. VOC emissions also come from petroleum refining and products storage; solvents; consumer products, pesticides use and vegetation.	Respiratory problems and lung tissue damage; and damage to vegetation, rubber and some plastics.	• Energy conservation. • Reduction in motor vehicle use, vehicle emissions inspection-and-maintenance programs, use of cleaner fuels, and more stringent vehicle emissions standards. • Limiting VOC and NO_x emissions from fossil fuel burning sources. • Limiting VOC emissions from industrial and commercial operations, and consumer products.
Inhalable/Respirable Particulate Matter (PM_{10} and $PM_{2.5}$)	Incomplete combustion of fossil fuel and waste; open burning; fireplaces and woodstoves; motor vehicles use; road dust; industrial processes; windblown dust from agriculture and construction activities. Also formed from other pollutants (NO_x, SO_x, organics and ammonia).	Increased respiratory disease, lung damage, cancer, and premature death; reduced visibility; and soiling of buildings and materials.	• Energy conservation. • Control of industrial and commercial emissions, wood-burning stoves and fireplaces; and fugitive dust sources. • Reduction in motor vehicle use, emissions of particulates and precursor pollutants that react to form PM_{10} and $PM_{2.5}$.
Carbon Monoxide (CO)	All fossil fuel, wood and waste burning sources.	Chest pain in heart patients, headaches, reduced mental alertness.	• Energy conservation. • Control of motor vehicle and industrial emissions. • Use of oxygenated gasoline during winter months.
Nitrogen Dioxide (NO_2)	All fossil fuel, wood and waste burning sources. Industrial sources such as cement plants and nitric acid and glass production.	Lung irritation and damage. Reacts in the atmosphere to form ozone, acid rain and PM_{10} and $PM_{2.5}$.	• Energy conservation. • Control of motor vehicle and industrial emissions.

Table 4: Air Pollutant Sources, Effects and Control (contd.)

Pollutant	Sources	Effects	Major Control Methods
Lead	Metal smelters, resource recovery, leaded gasoline, deterioration of lead paint.	Learning disabilities, brain and kidney damage.	• Control of emissions from metal smelters. • Use of nonleaded gasoline, where it is still in use. • Replacing leaded paint with nonlead substitutes.
Sulphur Dioxide (SO_2)	Oil, diesel fuel and coal burning in power plants and industries, petroleum refineries, diesel engines and motor vehicles.	Increases lung disease and breathing problems for asthmatics. Reacts in the atmosphere to form acid rain, PM_{10} and $PM_{2.5}$. Damages vegetation, environment and materials.	• Energy conservation. • Reduction in the use of high sulphur fuels and raw materials in industrial processes.
Sulphates	Produced from SO_2 by the reaction in the atmosphere.	Breathing difficulties, aggravates asthma, reduced visibility, damage to vegetation, environment and materials.	• See SO_2.
Hydrogen Sulphide	Oil and gas exploration, processing and petroleum refining; pulp and paper production, sewage treatment plants and sewers.	Nuisance odour, headache and breathing difficulties at higher concentrations.	• Control of emissions from oil and gas exploration and petroleum refining; pulp and paper mills; sewage treatment plants and sewers.

Adapted from California Air Resources Board's fact sheet: "Air Pollution Sources, Effects and Control," October 29, 2001: http://www.arb.ca.gov/research/health/fs/fs2/fs2.htm .

Appendix C Additional Information: Who has the responsibility for protecting community airsheds?

Sources of Information

No one level of government has sole jurisdiction over air emissions in British Columbia. The following are selected detailed sources that outline various air quality regulations and standards applicable in British Columbia.

1. Caton, R.B, and D.M. Crawley, for the BC Ministry of Water, Land and Air Protection. 2003. *Clean Air Issues in British Columbia* [online]. Vancouver: RWDI West. Available on the Internet at: http://wlapwww.gov.bc.ca/epd/waste_mgt_review/pdf_files/clean_air.pdf

2. Canadian Council of Ministers of Environment (CCME). *Canada-wide Standards* [online]. Available on the Internet at: http://www.ccme.ca/initiatives/standards.html

   Canadian Council of Ministers of Environment (CCME). *Particulate Matter and Ground-Level Ozone – Overview/Rationale* [online]. Available on the Internet at: http://www.ccme.ca/initiatives/standards.html?category_id=5

3. *Canadian Environmental Protection Act* (CEPA) *Act* [online]. Available on the Internet at: http://www.ec.gc.ca/CEPARegistry/the_act/

4. *Priority Substances List* [online]
   Identifies substances to be assessed on a priority basis to determine whether they are toxic (as defined under Section 64 of the act) and pose a significant risk to the health of Canadians or to environment. Available on the Internet at: http://www.ec.gc.ca/CEPARegistry/subs_list/Priority.cfm

5. Province of British Columbia *Environmental Management Act* and associated air quality regulations [online]. Available on the Internet at:

   Act: http://www.qp.gov.bc.ca/statreg/list_statreg_e.htm
   Regulations: http://wlapwww.gov.bc.ca/air/airregs.html

6. *Canada-wide Standards* – British Columbia [online]
   This report is a preliminary overview of the achievement of Canada-wide Standards (CWS) in British Columbia for particulate matter (PM) and ozone. It also describes the status of British Columbia's implementation-planning activities concerning the CWS. In addition, the report identifies geographical considerations based on separate analyses of provincial air quality data that are not included in the current update. Available on the Internet at: http://wlapwww.gov.bc.ca/air/airquality/pdfs/bccws_update_jan_03%20.pdf

7. British Columbia – State of Washington:
   Under the Environmental Cooperation Agreement (signed May 7, 1992), the province and State of Washington have agreed to coordinate action and information-sharing between the state and province on environmental matters of mutual concern.

   A memorandum of understanding (MOU) related to air quality was signed April 4, 1994 between the province, State of Washington, North West Air Pollution Authority and the GVRD. The purpose of the MOU is to define the respective roles and responsibilities of the four signatory agencies in ensuring timely prior consultation on air permitting, and specify procedures, schedules and appropriate contacts within each agency to facilitate the timely sharing of the above information. This includes providing prior consultation on air permits that are deemed to have significant cross-border air quality impacts.

   Under this MOU, British Columbia has agreed to forward permit applications or permit-amendment applications to Washington agencies for specified air emission sources within 100 kilometres of the border. Washington authorities have agreed to forward copies of draft operating permits and permit modifications to the nearest ministry regional office and/or the GVRD, where appropriate, at the start of the public comment period.

8. British Columbia – State of Idaho:
   In September 2003, the Governor of Idaho and the Premier of British Columbia signed an Environmental Cooperation Arrangement. The agreement commits the two jurisdictions to "identify, coordinate and promote mutual efforts to ensure the protection, conservation and enhancement of our shared environment for the benefit of current and future generations." The Idaho Department of Environmental Quality and the British Columbia Ministry of Water, Land and Air Protection are the agencies responsible for implementation.

   The purpose of this agreement is to set out an action plan to give effect to the Environmental Cooperation Arrangement. The general concern is smoke management, and a specific focus on agricultural burning in the Creston Valley airshed.

Appendix D Additional Information: How does airshed planning relate to and complement other community planning processes?

Sources of Information

Many local governments are already involved in numerous planning processes. Several of these processes may have a direct and/or an indirect impact on local air quality. To adequately meet local air quality goals, an understanding of the impacts and interactions between the various planning processes is needed. Coordinating these planning processes with airshed planning can lead to significant co-benefits at minimal cost.

British Columbia Energy Aware Committee:
http://www.energyaware.bc.ca/welcome.htm

Community Charter:
http://www.cserv.gov.bc.ca/charter/legislation/FAQs.htm

Federation of Canadian Municipalities – Sustainable Communities:
http://www.fcm.ca/newfcm/Java/frame.htm

Regional Growth Strategies:
http://www.cserv.gov.bc.ca/lgd/irpd/growth/about_growth.html

Appendix E Additional Information: How is airshed planning initiated?

Sources of Information

Airshed planning is underway in several jurisdictions around the world. Many countries have legislated air quality requirements (e.g., United States, United Kingdom, New Zealand). Most, including Canada, are bound by several international agreements and protocols. Other jurisdictions, including several BC communities, are focussed more locally – developing and implementing airshed plans to protect health, and improve or maintain current levels of air quality.

The information below outlines some of the activities in British Columbia and other jurisdictions. Links to specific global air quality issues, such as climate change and stratospheric ozone depletion are included. Also listed are links outlining the approaches to stakeholder consultation and public outreach used by others in Canada and BC.

Airshed Planning in British Columbia:

- GVRD: http://www.gvrd.bc.ca/air/planning.htm
- Prince George: http://wlapwww.gov.bc.ca/nor/pollution/environmental/air
- Quesnel / Williams Lake: http://wlapwww.gov.bc.ca/car/env_protection/index.html#airshed
- Bulkley Valley: http://www.bvldamp.ca/html/current.htm
- Additional initiatives are underway in the Okanagan Valley, Golden, Sea-to-Sky corridor and the Capital Regional District. For more information on these initiatives, contact the appropriate regional office of the Ministry of Water, Land and Air Protection: http://wlapwww.gov.bc.ca/main/prgs/regions.htm

Some International Agreements, Protocols and Canadian Legislation on Air Quality

- Canada and the Kyoto Protocol: http://www.climatechange.gc.ca/english/whats_new/overview_e.html
- *Canada Environmental Protection Act*: http://www.ec.gc.ca/CEPARegistry/
- Canada-US Air Quality Agreement: http://www.ec.gc.ca/pdb/can_us/canus_links_e.cfm
- Other Canada – US Air Quality Agreements: http://www.ec.gc.ca/pdb/can_us/canus_trans_e.cfm
- Kyoto Protocol (complete United Nations document): http://unfccc.int/resource/docs/convkp/kpeng.html
- Montreal Protocol on Substances that Deplete the Ozone Layer: http://www.unep.org/ozone/montreal.shtml

Airshed Planning in Other Parts of Canada

Elsewhere in Canada airshed planning is less prominent. In **Alberta** the Clean Air Strategic Alliance (CASA) http://www.casahome.org/ was established in March 1994 as a new way to manage air quality issues of concern, such as smog, acid rain and air toxics, based on a consensus decision-making process.

In **Ontario**, the majority of the airshed planning efforts are concentrated around metropolitan Toronto. The Toronto strategy is based on an airshed approach. It includes a focus on cumulative emissions, impacts and pollution prevention, along with integration of contributions and expertise across city departments, other government levels, the private sector, community and environmental groups, and the broader public. Air quality issues of concern include smog, acid rain and air toxics, and atmospheric change (e.g., climate change and stratospheric ozone depletion): http://www.city.toronto.on.ca/eia/pdf/air_strategy.pdf

In addition, the Federation of Canadian Municipalities, through its Partners for Climate Protection program, has developed tools for use by local government including:

Identification of Potential GHG Emission Reductions of Infrastructure Guide Best Practices:
http://kn.fcm.ca/ev.php?URL_ID=3500&URL_DO=DO_TOPIC&URL_SECTION=201&reload=1048824789

Airshed Planning in the United States

The major impetus behind improving air quality in the **United States** is the US Environmental Protection Agency. Under the *Clean Air Act*, passed by Congress in 1970 and amended in 1990, the EPA sets and enforces the National Ambient Air Quality Standards for various pollutants – as well as limits on emissions from all varieties of sources – to help protect against harmful health and environmental effects. Although the *Clean Air Act* is a federal law, state and local agencies are responsible for implementing many of its requirements. These include determining how the agencies will reach the federal standards. A state implementation plan (SIP) outlines the steps the state will take to do this. Failure to meet federal requirements will be met by sanctions against the state. Resolving air pollution control issues often requires state and local governments to work together to reduce air emissions.

In addition to air quality actions legislated under the *Clean Air Act*, states may also impose air quality requirements beyond those required by the federal government. The financial implication of the federal legislation for areas in "non-attainment" ("nonattainment") has caused some states to develop innovative approaches to emission reduction. Foremost among these is California, which has been developing legislation and implementing air quality management plans for all nonattainment areas for decades.

California's Air Resources Board is currently developing a *Draft Air Quality Handbook for Land Use*. The draft handbook is an informational document with recommendations that are not requirements or mandates for land-use agencies or local air districts. It describes tools that can be used to support land-use decision makers in addressing the potential for cumulative emissions, exposure, and health risk: http://www.arb.ca.gov/ch/aqhandbook.htm

Another example of airshed planning undertaken in the United States is the **Columbia River Gorge** Air Quality Project, *Process for Developing a Regional Air Quality Strategy*: http://www.gorgeair.org/images/AQPlanProcess.pdf

Airshed Planning in Australia and New Zealand

New Zealand has many air quality issues similar to BC, including vehicle emission problems in urban centres and particulate loading from domestic fires in rural areas. The management options available to local government include regional plans, educational programs, and economic incentives. Together with an estimate of the costs and benefits of each method, the most cost-effective and appropriate methods can be devised, discussed with the local community, chosen and then implemented:
http://www.mfe.govt.nz/publications/air/prelim-review-air-qual-mgmt-oct00.pdf

In **Australia,** the **New South Wales** Action Plan focuses primarily on the greater Sydney metropolitan region. The plan contains diverse strategies and actions, approaching the problem on many fronts. It links state and local government, industry and individual actions for an integrated attack on air pollution:
http://www.epa.nsw.gov.au/air/actionforair/index.htm

In 1996 the Government of **Western Australia** announced a four-year program to develop and implement a management strategy for Perth's air quality. An air quality coordinating committee developed the Perth plan with the assistance of representatives from government, industry and the community.

Airshed Planning in the United Kingdom

The main considerations for developing local air quality action plans are put forth in guideline documents prepared by **England, Scotland, Wales and Northern Ireland**: http://www.defra.gov.uk/environment/airquality/strategy/
The guidelines outline the process for developing an air quality management strategy. They demonstrate that local input, cooperation and partnerships are critical in the development and success of an air quality management plan. The Scottish guideline is located at:
http://www.scotland.gov.uk/library5/environment/laqmg.pdf

Department of the Environment, Transport and the Regions: London, National Assembly for Wales. 2000. *Developing Local Air Quality Action Plans and Strategies: The Main Considerations*. pp. 19.

Department of the Environment, Transport and the Regions: London, National Assembly for Wales. 2000. *Air Quality and Land Use Planning*. pp. 15.

Other Countries in the European Union

WS Atkins International Limited in 2001 developed a *Handbook for Air Quality Management Plans* for the **Slovak Republic**. This document describes a detailed structure for preparing air quality management plans. Although much of the detailed information is not applicable to British Columbia, the basic structure of the plan is easily transportable.

W.S. Atkins International Ltd. 2001. *Handbook for Air Quality Management Plans: Slovak Republic* [online]. Available on the Internet at: http://www.shmu.sk/twinning_internal/Report8_final_eng.pdf

Additional Airshed Planning Reference Material

United Nations Division for Sustainable Development. 2003. Protection of the Atmosphere (chapter 9), in *Agenda 21* [online]. Available on the Internet at: http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter9.htm

K. K. Bhattacharyya. Outreach Series publication of the Canadian Universities Consortium Urban Environmental Management Project at the Asian Institute of Technology. 1999. *Urban Air Quality Management Plan: A Framework for Development and Implementation* [online]. Bangkok, Thailand. Available on the Internet at: http://www.ucalgary.ca/UofC/faculties/EV/designresearch/projects/cuc/tp/outreach/bhattacharya%20paper.pdf

World Bank. 1998. *Urban Air Quality Management (Pollution Prevention Handbook)* [online]. Available on the Internet at: http://lnweb18.worldbank.org/essd/envext.nsf/51ByDocName/UrbanAirQualityManagement/$FILE/HandbookUrbanAirQualityManagement.pdf

World Health Organization, Environmental Health Information. Internet sites:
http://www.who.int/phe/health_topics/air/en/
http://www.euro.who.int/air/Activities/20020620_1

Stakeholder consultation and public outreach

Information on stakeholder consultation and public outreach programs are available from the following sources:

Canadian Council of the Ministers of Environment. 1993. *Guidelines for Consultations and Partnerships: Involving Stakeholders in CCME,* 1993 [online]. Available on the Internet at: http://www.ccme.ca/assets/pdf/cat_eng.pdf

Greater Vancouver Regional District. 1993. *Guidelines for Public Consultation and Advisory Committees, 1993*.

Greater Vancouver Regional District, Policy and Planning Department. *Air – Stakeholder Consultation – Lower Fraser Valley Air Quality Advisory Committee Terms of Reference (981006),*

Marcos Silva. The Commission for Environmental Cooperation's Information Dissemination and Public Outreach Programs, NAFTA Commission for Environmental Cooperation. 1996. *Government Information in Canada / Information gouvernementale au Canada*, vol. 3, no. 2 [online]. Montreal, PQ. Available on the Internet at: http://www.usask.ca/library/gic/v3n2/silva/silva.html

Appendix F Acronyms and Glossary

Acronyms

AQMP	Air Quality Management Plan
BAAQMD	Bay Area Air Quality Management District
CAC	Common air contaminants
CARB	California Air Resources Board
CCME	Canadian Council of the Ministers of the Environment
CEPA	*Canadian Environmental Protection Act*
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CWS	Canada-wide Standards
EC	Environment Canada
EPWG	Emissions Projection Working Group
ERM	Emission reduction measure
FVRD	Fraser Valley Regional District
GBEI	Georgia Basin Ecosystems Initiatives
GHG	Greenhouse gas
GVRD	Greater Vancouver Regional District
GWP	Global warming potential
H_2S	Hydrogen sulphide
HAPs	Hazardous air pollutants
LFV	Lower Fraser Valley
NH_3	Ammonia
NO	Nitric oxide
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
N_2O	Nitrous Oxide
NPRI	National Pollutant Release Inventory
O_3	Ozone
ODS	Ozone-depleting substances
PM	Particulate matter
PM_{10}	Particulate matter of size 10 microns and smaller
$PM_{2.5}$	Particulate matter of size 2.5 microns and smaller
SCAQMD	South Coast Air Quality Management District
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
TCM	Transportation control measures
US EPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds
WACC	Water, Air and Climate Change Branch, Ministry of Water, Land and Air Protection
WHO	World Health Organization
WLAP	Ministry of Water, Land and Air Protection

Glossary of Terms

This list of terms and their definitions was adapted primarily from the following sources:

http://glossary.eea.eu.int/EEAGlossary/E/Environmental_Programme_for_Europe
http://www.epa.gov/oar/oaqps/peg_caa/pegcaa10.html
http://toxics.usgs.gov/definitions/ddt.html
http://www.euro.who.int/air/Activities/20020620_1

A

Acidic Deposition: refers to the deposition of acidic compounds, produced in the atmosphere from pollutants such as oxides of sulphur and nitrogen, to the earth – either dry particles, or with rain, snow or fog.

Aerosol: a suspension in a gaseous medium of solid and/or liquid particles having a negligible falling velocity.

Air Quality: the state of the polluted ambient air within an area.

Airshed (also air basin): an area where the movement of air tends to be limited to the bounds of that area, as a result of specific geographical or meteorological conditions.

Air Toxics: air pollutants that are toxic to humans, fish, wildlife and marine animals. (See Hazardous Air Pollutants.)

Ambient Air: outside air, surrounding air, air occurring at a particular time and place outside of structures. All living beings are exposed to the ambient air.

Ambient Air Quality Objectives or Standards: air quality levels for specific pollutants that are determined to be necessary to protect human health and/or the environment. Typically consists of a numeric pollutant concentration, averaging time, and rules or guidance on sampling methodology and how the objectives or standards are to be applied. May also be referred to as ambient air quality criteria or guidelines.

Ammonia (NH_3): a compound containing nitrogen and hydrogen, and known for a sharp, pungent smell. It is emitted mostly from agricultural and animal husbandry activities. Other sources of ammonia are fuel and waste combustion, chemical industry and refrigeration facilities. It contributes to the formation of inhalable particulates and visibility-reducing particles.

Anthropogenic: made by humans.

Area Source: a term generally used in emission inventories for sources that are not classified as specific point, mobile or natural sources. Some agencies include mobile and/or natural sources in this category.

Asthma: chronic lung disease caused by increased sensitivity and inflammation of the lower parts of the lungs, leading to airflow restriction.

Attainment Areas: those areas that meet the ambient air quality criteria.

B

Bottom-up Approach: an approach that uses locally collected information as the basis for estimation, assessment or evaluation, as opposed to information from a larger geographic area and then prorating it to the local area.

Bronchitis: inflammation of the mucous membrane of the main airways of the lung, or the bronchial tubes.

C

Carbon Dioxide (CO_2): a colourless, odourless, noncombustible gas and a normal constituent of air. This gas is formed by certain natural processes, the burning of fuels and wastes containing carbon, and heating of minerals or products containing carbonate.

Carbon Monoxide (CO): a colourless, almost odourless, tasteless, flammable gas produced by incomplete combustion of fossil fuels, wastes and organic substances. At a high concentration it reduces the oxygen-transport capacity of haemoglobin, leading to death by asphyxiation.

Carcinogen: a substance that causes cancer.

Chemical Mass Balance (CMB): a receptor modelling technique that uses the chemical composition of ambient particulate matter to apportion its mass to specific source types.

Chlorofluorocarbons (CFCs): potent ozone-depleting substances made up of carbon, hydrogen and chlorine atoms. These substances were used as coolants in refrigerators, freezers and air conditioners, foaming agents, solvents, aerosol sprays and propellants until 1987 when their production and use were prohibited under the Montreal Protocol on Substances that Deplete the Air.

Clean Air Strategic Alliance (CASA): a stakeholder group in Alberta that has been given shared responsibility for strategic air quality planning, organizing, and coordinating resources, and evaluating results in the province through a collaborative process. Its members include the Alberta government, industry, businesses, nongovernmental organizations and other community representatives.

Climate Change: in the context of air quality management planning, it refers to any change in the earth's climate system due to human activities.

Common Air Contaminants (CACs): include air pollutants commonly found in the atmosphere, namely carbon monoxide, particulate matter, sulphur oxides, nitrogen oxides and volatile organic compounds.

Co-benefits: within the context of this report, this term refers to complimentary emission reductions involving other air pollutants or greenhouse gases that result from emission reductions to a targeted air pollutant or greenhouse gas.

D

Dose: the actual amount of a pollutant that is actually absorbed or inhaled by an individual. It is the quantity that determines adverse health outcomes.

E

Economic instruments: market-based economic incentives for controlling air pollution. Typical examples include pollution fees, credits for emission reduction, tax incentives, and tradable emission allowances.

Ecosystems: interacting system of a biological community and its nonliving environmental surroundings.

Emission Reduction Measures (ERMs): technologies or methods that aim to reduce the amount of pollutants emitted into the environment.

Emissions: the discharge of air pollutants from a particular source or group of sources into the environment.

Emission Factor: a factor used to estimate the quantity of a pollutant emitted from an activity at a source. It is often expressed in terms of unit mass of a pollutant/unit of activity at the source. As an example, the activity at a thermal power generation plant is expressed as the quantity of fuel burned, or for an automobile it is expressed in terms of vehicle distance travelled.

Episode Management: a component of an air quality management plan that applies escalating restrictions on air emissions as air quality deteriorates.

Exposure: the amount of time an individual or item is in the presence of certain concentrations of pollutants.

F

Fine Particles or **Particulates:** typically expressed as particles 2.5 micrometres (µm) in diameter and smaller. In previous years, may also have referred to particles of 10 micrometres in diameter or smaller.

G

Global Warming: observed and potential increase in the average temperature of the earth's atmosphere.

Global Warming Potential (GWP): the potential of a greenhouse gas that contributes to global warming. Each of these gases has a different residence time in the atmosphere and ability to trap energy escaping from the earth. For example, while the lifetime of methane in the atmosphere is 11 years, that of ozone depleting substances vary from 10,000 to 50,000 years.

Each gas also has a different ability to trap heat, or global warming potential, which is measured by comparing with the GWP of carbon dioxide. On a unit mass basis, the GWP of methane and nitrous oxide trap 23 and 296 times more heat respectively than carbon dioxide. The heat-trapping ability of several ozone-depleting substances is thousands of times more than that of carbon dioxide.

Greenhouse Gases (GHGs): refers to gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Several ozone-depleting substances are also greenhouse gases. Water vapour is another major GHG, but human activities do not have a direct impact on its emission rate. These gases are natural components of the earth's atmosphere. However, in excessive concentrations they contribute to accelerated global climate change which may adversely affect various aspects of ecosystem.

Natural sources of GHGs include volcanic eruptions, forest fires, lightning, living organisms, decomposition of vegetation and animal material, and soil. The major human-made sources include burning of fossil fuels, biomass and wastes, various industrial and commercial processes, land-clearing and deforestation, and agricultural and animal husbandry practices.

Ground-Level Ozone (O_3): a secondary pollutant formed as a result of atmospheric reactions involving nitrogen oxides (NO_x) and reactive volatile organic compounds (VOCs) in the presence of sunlight.

H

Hazardous Air Pollutants (HAPs): are released into the atmosphere as particles and volatile organic compounds (VOCs) – including the known carcinogens of benzene and toluene – from a variety of sources such as vehicle emissions, petrochemical products, and environmental tobacco smoke. Of particular concern are persistent organic pollutants (POPs) that are not easily broken down, and can therefore travel great distances, as well as accumulate in living organisms.

Haze: airborne particles of extremely small size. These particles are individually not visible to the naked eye. However, in large enough numbers they can result in opalescence in the atmosphere and reduced visibility.

Hydrocarbons: organic compounds containing primarily carbon and hydrogen, but may also contain nitrogen, sulphur, halogens, etc. They are mainly produced from coal, petroleum and natural-gas use; solvent evaporation; and incomplete combustion of fuels, wastes and biomass. Vegetation is a natural source of hydrocarbons.

I

Inhalable Particulate Matter: in the context of this report, refers to particulate matter that is small enough in size to be breathed deep into the lungs. These particles are also referred to as PM_{10} and $PM_{2.5}$. They are comprised of directly emitted particles, and secondary particles formed in the atmosphere through interactions of directly emitted pollutants such as sulphur oxides, nitrogen oxides, ammonia, and volatile organic compounds.

L

Long-Range Transport of Air Pollutants (LRTAP): in the context of this report, refers to the movement of air pollutants over long distances as a result of winds and trade winds.

M

Meteorology: the study of the atmosphere and its weather and climatic conditions.

Methane (CH_4): a colourless, flammable gas produced mainly from coal mining, oil and gas exploration; combustion of fossil fuels, wastes and biomass; petrochemical production; anaerobic decomposition of sewage and organic compounds; and landfills.

Micrometre: one millionth or 10^{-6} of a metre. A unit of size measurement.

Morbidity: the number of sick persons or cases of disease within a particular population group.

Mortality: the death rate, the ratio of the number of deaths to a particular population group.

Multivariate: the consideration of many variables at a single time. The term is often referred to in statistical applications.

N

Nitrate: a substance naturally formed or produced from nitric acid and a base element. In the context of air pollution, ammonium nitrate is a secondary particle formed in the atmosphere from nitrogen oxides, water vapour and ammonia.

Nitric Oxide (NO): a gas containing one atom of nitrogen and one atom of oxygen. It produces a brownish colour when emitted into the atmosphere before it is oxidized relatively quickly to nitrogen dioxide. It is one of the components of nitrogen oxides and takes part in the formation of ozone in the atmosphere.

Nitrogen Dioxide (NO_2): a common pollutant along with particles in the air can often be seen as a reddish-brown layer over many urban areas. It causes lung irritation and damage, and environmental impacts.

Nitrogen Oxides (NO_x): generic term for a group of highly reactive gases which contain nitrogen and oxygen in varying amounts. The primary sources of NO_x are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. NO_x cause a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide and nitric oxide.

Nitrous Oxide (N_2O): a colourless, tasteless gas at room temperature, and 1.5 times denser than air. It is a major contributor to global climate change, 296 times more powerful at retaining heat than carbon dioxide.

Non-attainment (Nonattainment) Areas: areas where the air quality concentration of an air pollutant exceeds its respective ambient air quality criteria.

O

Operational Flexibility: under certain circumstances, a large operation with several emission sources is allowed to be flexible in its efforts to control total emissions from the facility. This approach of emission control, also known as emission cap or bubble, is based on the concept that an imaginary dome is placed over the entire facility and is treated as one emission source. The facility operator determines which individual sources are to be controlled to meet the maximum allowable emissions of pollutants.

Ozone-Depleting Substances (ODS): substances responsible for depletion of the ozone layer in the stratosphere. They primarily contain chlorine, fluorine and/or bromine atoms. A single chlorine or bromine atom can destroy 100,000s of ozone molecules before it becomes inactive. ODS include carbon tetrachloride, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), brominated fluorocarbons (Halons), methyl bromide and methyl chloroform.

These substances are widely used in refrigeration units, insulating foams, as well as cleaning agents, solvents and fire extinguishing agents. The production and use of CFCs have been banned under the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987. Some other substances are being used as transitional substances before their use is phased out because of high global warming potentials.

Ozone Layer Depletion: the depletion of a thin layer of ozone located in the stratosphere that protects the earth from harmful ultraviolet radiation of the sun. (See ODS and Stratospheric Ozone Depletion.)

P

Particulate Matter (PM): airborne particles that include the size fractions PM_{10} and $PM_{2.5}$.

PM_{10}: Particles with a nominal aerodynamic diameter of 10 micrometres or smaller in diameter. PM_{10} is emitted directly from sources, and formed in the atmosphere through interactions of precursor pollutants such as sulphur oxides, nitrogen oxides, volatile organic compounds, and ammonia. PM_{10} can adversely affect human health and the receiving environment.

$PM_{2.5}$: Particles with a nominal aerodynamic diameter of 2.5 micrometres or smaller in diameter. Most $PM_{2.5}$ is emitted directly from combustions sources, or formed in the atmosphere through interactions of precursor pollutants such as sulphur oxides, nitrogen oxides, volatile organic compounds, and ammonia. $PM_{2.5}$ can significantly compromise human health, as well as impede visible light.

Point Source: a commonly used term for emission inventory compilation. It is a single stationary source of pollution, such as a stack or vent. Different agencies define a Point Source differently for the purpose of its emission inventory.

Pollution Prevention: a policy concept based on the fact that, "Prevention is often less expensive than after-the-fact measures." It is a proactive measure of preventing pollution generation at the outset, instead of cleaning-up after producing air pollutants. It includes the use of "win-win" methods such as cleaner production technologies, minimization of wastes, and efficient energy use. All these options offer the prospect of environmental protection at little or no cost.

Primary Pollutants: air pollutants generated during various processes and emitted directly from the sources as such.

Principal Component Analysis (PCA): a statistical method used in receptor modelling that can be used to examine the statistical inter-relationships between ambient air quality data, to produce groupings of elements attributable to major emission source types and/or source regions.

R

Receptor: the receiving medium of an air pollutant, or a location where an air pollutant is measured.

Respirable Particulate Matter: in the context of this report, refers to particles that are small enough in size that they can be taken deep into the lungs and deposited within them. Also referred to as $PM_{2.5}$.

S

Secondary Pollutants: pollutants generated in the atmosphere as a result of chemical reactions involving primary pollutants.

Sinks: in the context of air pollution, the term usually refers to the media that can absorb and retain greenhouse gases.

Smart Growth: an initiative or plan that intends to improve ways in which human settlement occurs for the purpose of reducing impact on the environment, as well as improve quality of life. In particular, Smart Growth initiatives address urban sprawl; motor vehicle use; environmental integrity and food-system security; and affordable housing, among many other topics.

Smog: the word "smog" originated in the UK in the mid-20th century to refer to the unique atmospheric condition resulting from a combination of smoke and fog. In winter the city of London often experienced dense, stagnant fog. The term "photochemical smog' originated in California in the early 1960s to describe the air quality problem caused by ground-level ozone. The most recent definition of "smog" used in Canada includes two main constituents, namely ground-level ozone and $PM_{2.5}$.

Stewardship (Environmental): involves individuals or groups, not normally part of primary management structures, participating in the protection of the natural environment.

Stratosphere: the portion of the atmosphere 10-to-40 km above the earth's surface, and the layer above the troposphere.

Stratospheric Ozone Depletion: the depletion of a thin layer of ozone located in the stratosphere that protects the earth from harmful ultraviolet radiation of the sun.

Sulphur Dioxide (SO_2): a gas released into the atmosphere as a result of the combustion of fossil fuels containing sulphur, as well as production processes using sulphur-containing raw materials, e.g. cement manufacturing and sulphuric acid production.

Sulphur Oxides (SO_x): includes all forms of oxides of sulphur such as sulphur dioxide and sulphur trioxide. Sources are the same as those for sulphur dioxide. These pollutants contribute significantly to inhalable particulate matter, visibility degradation, acid precipitation, and global climate change.

Synergy (also Synergistic): an arrangement or a combination of actions that are mutually beneficial, and in which the resultant effect is greater than the sum of its parts.

T

Top-down: an approach that uses general information about a large area as the basis for proceeding with estimation or evaluation of an occurrence within smaller areas. For instance, using overall national data as the basis for estimating values for different regions by prorating the national values, instead of using regional information for the estimates.

Troposphere: part of the atmosphere that extends from the surface up to about 10 km in altitude. Almost all weather takes place in the troposphere as a result of changes of temperature and the movement of air. This process results in efficient mixing of the troposphere.

U

Ultraviolet Radiation (UV): the portion of the electromagnetic spectrum with wavelengths shorter than visible light. The sun produces UV, which is commonly split into three bands: UV-A, UV-B, and UV-C. UV-A is not absorbed by ozone. UV-B is mostly absorbed by ozone, although some reaches the earth. UV-C is completely absorbed by ozone and normal oxygen. Processes of ozone depletion allow for increased amounts of UV radiation to reach the earth's surface. Increased UV radiation causes adverse effects on human health, plants, marine ecosystem and materials.

V

Visibility: a term used to describe how far or how much an individual is able to see in the ambient atmosphere. Fine particles, aerosols, and some gaseous pollutants contribute to the haziness of the atmosphere and impair the clarity of the visual images in the distance. These pollutants degrade visibility or the clarity of the distant objects, by scattering and absorbing the light in the atmosphere.

Volatile Organic Compounds (VOCs): include a variety of organic compounds – some of which are photochemically reactive – that may contribute to the formation of ozone on warm sunny days. Some hydrocarbons such as methane, ethane, acetone and several others are usually excluded as VOCs, but some of these are toxics or ozone-depleting substances. A number of sources emit VOCs, including fossil fuel combustion; petroleum production and storage facilities; and a wide variety of solvent uses. Some vegetation may also produce photochemically reactive VOCs.