Recommendations for the Management of Air Contaminant Emissions in the Regional Municipality of Wood Buffalo

September, 2009

Trace Metals and Air Contaminants (TMAC) Working Group of the Cumulative Environmental Management Association (CEMA)

Executive Summary

The Regional Sustainable Development Strategy for the Regional Municipality of Wood Buffalo was developed by the Government of Alberta, in cooperation with federal and municipal government agencies and regional stakeholders, to address the cumulative effects on the environment and human health of developing the Athabasca oil sands. The strategy is being implemented in partnership with the Cumulative Environmental Management Association, a multi-stakeholder not-for-profit organization. Effects of air emissions on human health, wildlife, and vegetation were identified as one of five priority themes to be immediately addressed. The Cumulative Environmental Management Association established the Trace Metals and Air Contaminants Working Group to develop management frameworks to manage and control regional trace metals and air contaminants and protect human and ecosystem health. This document recommends a framework for managing air contaminants in the Regional Municipality of Wood Buffalo. Air contaminants managed under this framework should include trace metals, which are currently managed under a framework developed by the Cumulative Environmental Management Association in 2002.

Management Recommendation

A formal comprehensive review of regional air quality will be conducted when the Air Contaminant Management Framework recommendation is adopted and approximately every five years, following a process summarized in Figure 1 and Table 1. The review will be undertaken by a Multistakeholder Regional Advisory Panel, led and appointed by the Government of Alberta. The review will identify regional priority air contaminants for management consideration. Criteria for selection of priority air contaminants need not be limited to human health but, at the discretion of the Panel, may include ecological health risk, odours, and cumulative effects of multiple air contaminants. The Multistakeholder Regional Advisory Panel will recommend to the Government of Alberta's Ambient Air Quality Objectives Stakeholder Advisory Council that provincial objectives be developed for priority air contaminants. For priority air contaminants not selected for development of provincial objectives the Panel will determine whether or not to proceed with a regional risk assessment. Emissions of priority air contaminants with provincial air quality objectives or a provincial or regional management framework will continue to be managed following existing Alberta Environment management practices, policies, and procedures. The risk assessment will lead to regional emissions management recommendations, as summarized in Figure 1 and Table 1.

Figure 1. Flow diagram for prioritization and management of air contaminants.

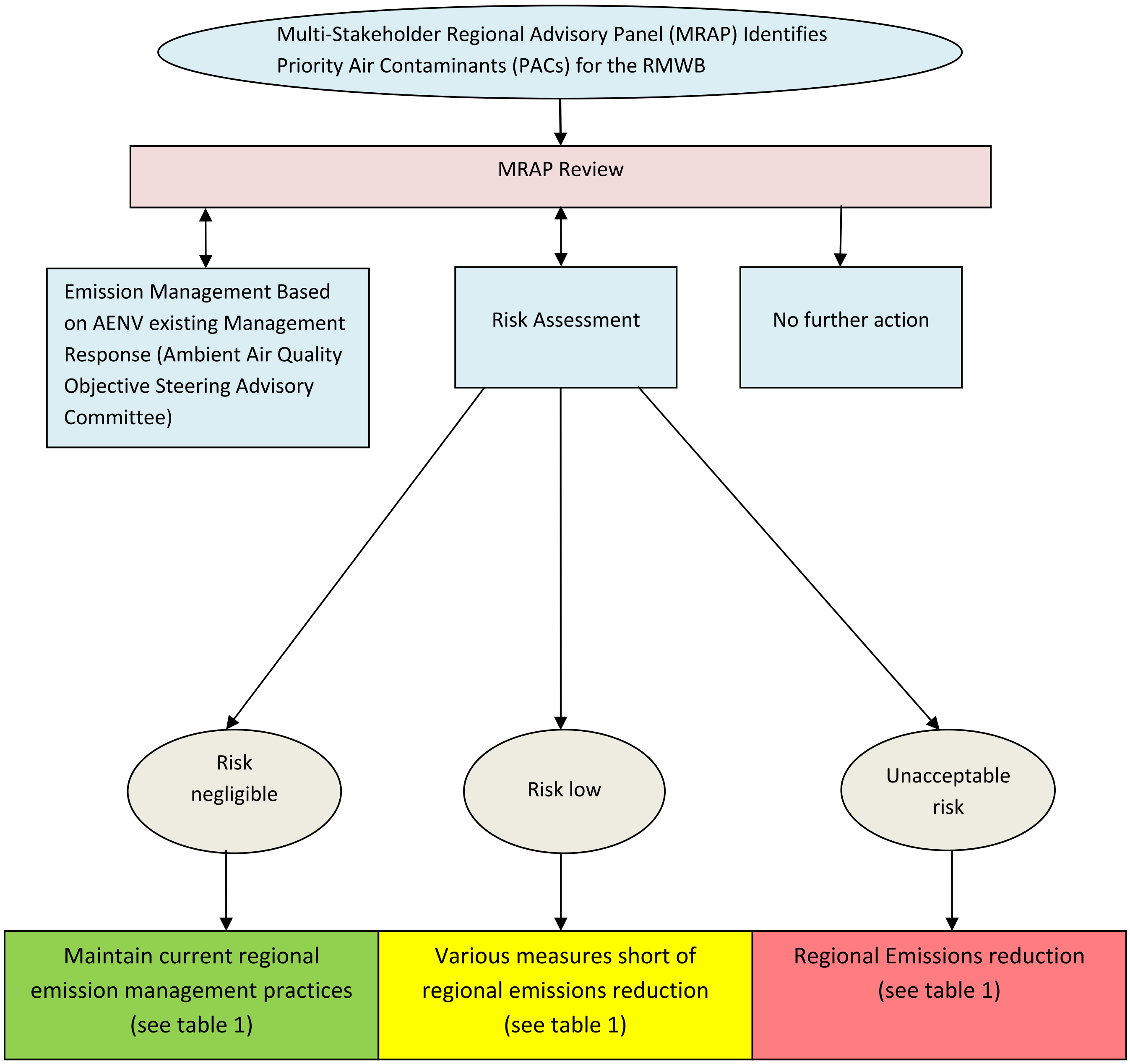

Table 1. Management Categories

Management Zone	Condition	Category	Potential Management Response(s)
Red	Risk is not Acceptable	Emission reduction	Consider additional emission controls for new facilities and opportunities for possible reductions at existing emission sources Set emission reduction targets and timeline for contributing sources to reduce emissions Contributing sources submit management plans with targets and timelines to comply with emission reduction requirement Communicate health risk assessment and management responses
Yellow	Risk is Low	Various measures short of required emission reduction	Identify emission sources Review monitoring and/or modeling of AC concentration Consider revisions to facility emission control requirements and/or codes of practice to minimize and if feasible eliminate health risk Communicate health risk assessment and management responses
Green	Risk is Negligible	No change from current emission management practices	Maintain existing emissions control practices, including continuous improvement (this may include BATEA[1]) Maintain facility emission control requirements and codes of practice Communicate health risk assessment and management responses

[1] BATEA (Best Available Technology Economically Achievable): BATEA refers to technology that can achieve superior emissions performance and that has been demonstrated to be economically feasible through successful commercial application across a range of locations and fuel types. BATEA is used to establish emission control expectations or limits and will be reviewed on a specified timeframe and modified as necessary

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Abbreviations Used

AAAQO	Alberta Ambient Air Quality Objective
AAQOSAC	Ambient Air Quality Objectives Stakeholder Advisory Committee
AC	air contaminant
AENV	Alberta Environment
AHW	Alberta Health and Wellness
BATEA	Best available technology economically achievable
CALPUFF	Non steady state puff dispersion model
CASA	Clear Air Strategic Alliance
CWS	Canada Wide Standard
CO	carbon monoxide
CEMA	Cumulative Environmental Management Association
EIA	Environmental Impact Assessment
GoA	Government of Alberta
H_2S	hydrogen sulphide
MRAP	Multistakeholder Regional Advisory Panel
NH_3	ammonia
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O_3	ozone
PAC	priority air contaminant
PAH	polycyclic aromatic hydrocarbons
PUF	polyurethane foam

$PM_{2.5}$	fine particulate matter (<2.5 micron particle diameter)
PM_{10}	coarse particulate matter (>10 micron particle diameter)
RMWB	Regional Municipality of Wood Buffalo
RSC	reduced sulphur compound
RSDS	Regional Sustainable Development Strategy
SO_2	sulphur dioxide
THC	total hydrocarbon
TMAC	Trace Metals and Air Contaminants Working Group
VOC	volatile organic compound
WBEA	Wood Buffalo Environmental Association

1 History of TMAC

Rapid and large scale oil sands development appeared imminent in the late 1990's and there were concerns regarding its cumulative environmental effects. To address these concerns Alberta Environment (AENV) developed, in collaboration with partners, a Regional Sustainable Development Strategy (RSDS) for the Athabasca Oil Sands Area in 1998 (AENV, 1999). The partners include First Nations and Aboriginal Communities, industry, environmental interest groups and government agencies (provincial [Alberta and Saskatchewan], municipal and federal). The intent of the RSDS was to provide support for sustainable development of the oil sands resource and environmental protection of the region.

The RSDS is being implemented in partnership with the Cumulative Environmental Management Association (CEMA), a regional not-for-profit multi-stakeholder group including industry, all levels of government, environmental organizations, aboriginal members, and others. CEMA's goal is the consensus-based development of recommendations for managing the cumulative environmental impacts of development in the Regional Municipality of Wood Buffalo (RMWB).

CEMA identified 72 areas of environmental concern in the region, grouped into 14 themes representing regional environmental issues. These were prioritized based on the urgency of the issues identified and gaps in knowledge and regulation. CEMA formed five Working Groups to address priority environmental issues. The Trace Metals and Air Contaminants Working Group (TMAC) was formed in the year 2000 to develop management frameworks to manage and control regional trace metals and air contaminants (ACs) and protect human and ecosystem health. In 2002, TMAC released the Trace Metals Management Framework (TMAC, 2002) containing recommendations intended to protect human health, wildlife, fish and vegetation from the deposition and accumulation of trace metals in the environment. Following the completion of this framework TMAC focused on development of a management framework for other AC emissions with potential health or ecosystem impacts that are not managed under existing management frameworks.

2 Regional Planning Context

The Government of Alberta (GoA) has recently released a Land-Use Framework (Government of Alberta, 2008). In the future, emissions of ACs may be addressed in the context of this framework, which sets out an approach to manage public land, private lands, and natural resources to achieve Alberta's long-term economic, environmental and social goals. The focus of the framework is land use and it also includes the effect of land use decisions on air, land, water, and biodiversity. The framework document expresses a vision for healthy ecosystems and communities.

One strategy of the Land-use Framework is to develop land-use plans based on seven new land-use regions. These plans will "integrate provincial policies at the regional level; set out regional land-use objectives and provide the context for land-use decision-making within the region; and reflect the uniqueness and priorities of each region" (Government of Alberta, Land-use Framework. December 2008; pg. 3). The RMWB falls within the Lower Athabasca Region, which also includes Lac La Biche County and the Municipal District of Bonnyville. The recommendations for management of air contaminants in the RMWB could be used by the Regional Advisory Council for the Lower Athabasca Region as they contemplate air quality management in developing their recommendations for the regional plan. The recommendations for management of air contaminants in the RMWB could be considered in the development of the regional plan for the Lower Athabasca Region or outside of the regional planning process in support of the Government of Alberta's air quality management system.

3 Background

Development of this framework was informed by an understanding of regional emissions and regional air quality and current emissions management practices and frameworks in the RMWB. Information was drawn from various sources including industry-reported emissions, Wood Buffalo Environmental Association (WBEA) monitoring reports, industry-commissioned Environmental Impact Assessments conducted as part of the approval application process, and TMAC commissioned studies. The TMAC working group commissioned the following scientific and traditional use studies to summarize, assess and interpret, or supplement the available information and help provide background for developing AC emissions management recommendations:

- a regional AC inventory and prioritization (Clearstone and Golder, 2003),
- regional AC exposure modeling (RWDI, 2003),
- a summary of monitoring information, regulatory guidelines, and health-based exposure limits for selected ACs (AENV, 2005b),
- source contributions to community ambient air quality (Golder, 2005),
- regional human health and risk assessment studies (WBK, 2005),
- human health risk communication (Jardine & Wenger, 2006),
- regional air quality monitoring results for 2000-2005 (Sonoma, 2007),
- wildlife health risk (Intrinsik, 2007), and
- traditional food consumption (Chan & Lawn, 2008).

This background information is summarized in Appendix A (section 8.1). The conclusions and recommendations of the authors of these TMAC-commissioned studies are provided in Appendix A and helped inform the development of the management framework.

4 Air Contaminants Management Framework

4.1 Scope of the Framework

The GoA manages the province's air quality for the benefit of Albertans now and in the future. AENV regulates industrial point sources and develops ambient air quality objectives for human health and environmental protection. The CEMA Air Contaminant Management Framework recommendations are intended to augment current regulatory practices for the management of industrial emissions in the RMWB. The framework recommends approaches for the management of industrial emissions to the atmosphere in the RMWB that do not have provincial air quality objectives, and/or are not managed according to other regional or provincial frameworks adopted by the GoA (see sections 8.1.9.1 and 8.1.9.2). Metal emissions, though currently managed under the Trace Metals Management Framework (see 8.1.9.2.1), should henceforth be managed under this framework.

4.2 Management Approach

Managing AC emissions in the RMWB is challenging because of the large number of AC emissions that have been identified. The following process is recommended for the selection, prioritization, and management of ACs in the RMWB.

A Multi-stakeholder Regional Advisory Panel (MRAP), appointed by the GoA, will periodically review, prioritize, and as required, develop management recommendations for regional ACs for management consideration. The terms of reference for the MRAP will be developed through consensus agreement among its members. An initial list of substances of concern in the RMWB will be identified by MRAP. A screening process will then be applied to select and rank a reasonable number of priority air contaminants (PACs) for the RMWB. Ranking criteria need not be limited to human health risk from individual ACs[2] but may, at the discretion of the MRAP, include ecological risk, odor, and cumulative effects of AC mixtures. It is recommended that this review occur at approximately 5-year intervals, supported by an update of emissions, air quality modeling, and review of monitoring results, as required.

To aid with the selection of priority ACs, a list of questions adapted from AENV's "Hot Spots" protocol (2005), will be considered. These questions consider both science-based decision making and public concerns. If the answer is "yes" to any of the following questions, a substance will be considered a priority chemical for the RMWB:

- Is there sufficient credible evidence of a real or potential adverse effect to warrant further investigation through this process (e.g., an operable pathway of exposure, industrial source for the exposure etc.)?

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[2] This includes exposures via the air, skin and through the ingestion of other environmental media as a result of deposition onto soil, plants, water, fish and wildlife.

- Is it a chemical that has been previously submitted to AENV as part of a statement of concern under EPEA or the Water Act?
- Is new information/evidence not previously considered now available?
- Has it been previously been reported in an EIA report or as part of a hearing or approval process?
- Has it been or is it currently being addressed through another program or process (e.g., AENV's Ambient Air Quality Objective's)?
- Has a priority chemical screening tool identified a priority chemical?
- Has it been identified as a chemical of concern through the regional planning process?

The MRAP will recommend to the GoA's Ambient Air Quality Objectives Stakeholder Advisory Council (AAQOSAC) that provincial objectives be developed for priority air contaminants. For priority air contaminants that are not selected for development of provincial objectives MRAP will determine whether or not to proceed with a regional cumulative risk assessment. Emissions of regional PACs with provincial air quality objectives, or existing regional management frameworks, will continue to be managed using current emissions management practices of the GoA (see sections 8.1.9.1 and 8.1.9.2). The MRAP will act as a steering committee and will, with the guidance of AENV/AHW, appoint expert/technical sub-groups, as required, to conduct the cumulative risk assessment.

If the assessment indicates negligible health risk then current emission management practices should be maintained. These may include, but are not limited to:

- continuous improvement in AC emission control through the application of the best available technology that is economically achievable (BATEA),
- compliance with facility emission control requirements or codes of practice, and
- ongoing review by the GoA of regional ambient air quality monitoring results, with emission management action as required.

If the risk is found to be greater than negligible but low, then various emission management actions, which may potentially lead to emission reduction, should be considered. These may include, but are not limited to:

- identification of emission sources,
- review of monitoring and/or modeling of ambient air concentrations, and
- review and possible revision of facility emission control requirements or codes of practice.

If unacceptable health risks are identified then emission reduction management actions should be considered. These may include, but are not limited to:

- emission reduction targets and timelines for contributing sources to reduce emissions,
- additional emission controls for new facilities and emission reductions at existing emission sources, and

- management plans from contributing sources, with targets and timelines for required emission reductions.

Risk categorization (i.e. negligible, low, not acceptable) in the context of this framework is challenging to define in advance of a cumulative risk assessment. It will be the responsibility of MRAP to evaluate and approve the risk category that is recommended by the technical/expert risk assessment subgroup.

To maintain public credibility and confidence in the management process the risk assessment and management responses will be effectively communicated.

4.3 Management Recommendation

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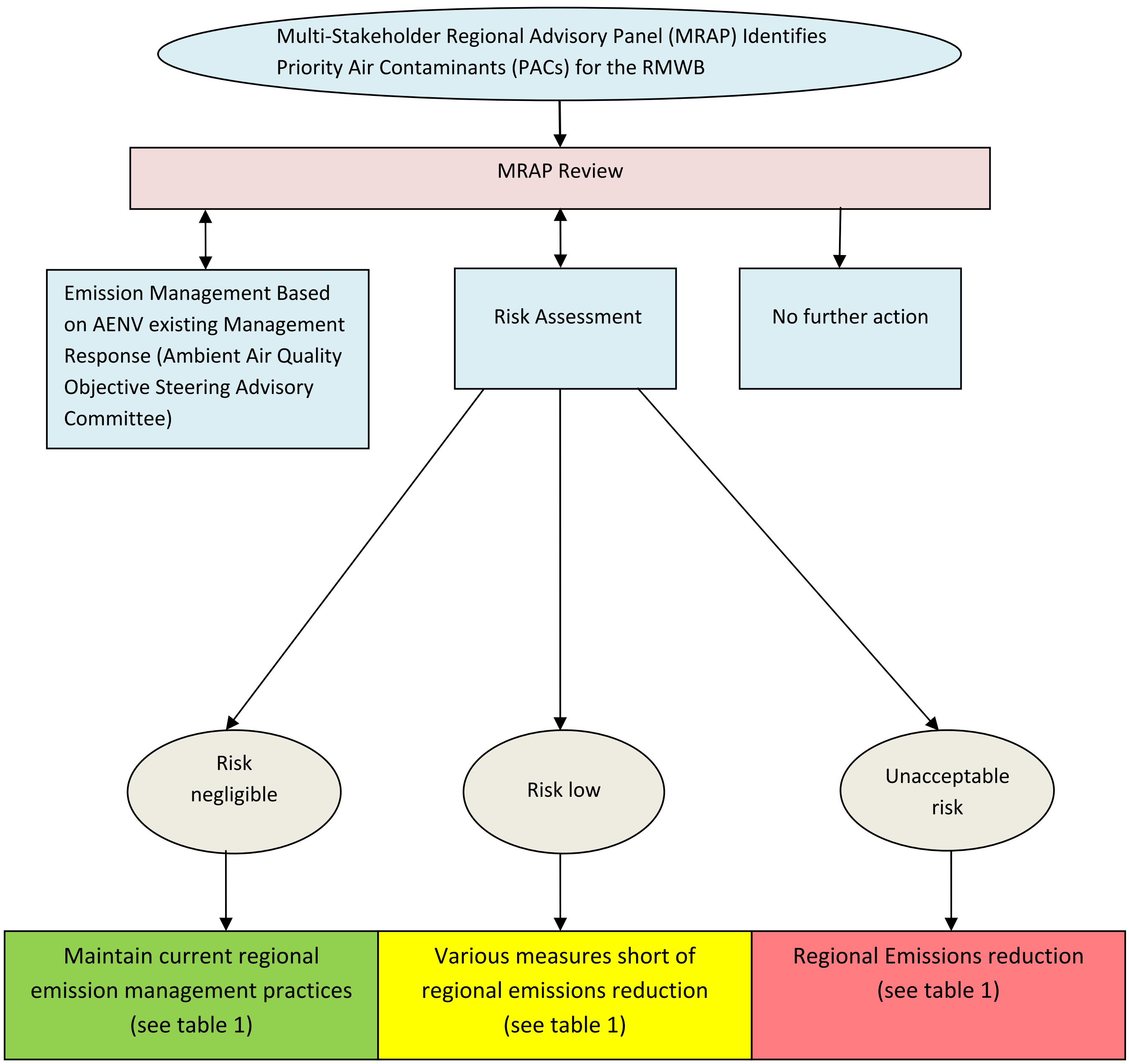
Figure 1. Flow diagram for prioritization and management of air contaminants.



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5 Stakeholder Concerns

Stakeholder groups may include aboriginal groups within the Wood Buffalo region, governmental organizations, non-governmental organizations, community organizations, industry members, and the general public. Potential issues raised by stakeholders regarding ACs will likely vary, and may include concerns specific to regulations and enforcement, nuisance issues, environmental issues, human health, or fish and wildlife health. Stakeholders can register concerns using the Alberta Environment Hotline (1-800-222-6514), and Health Link Alberta (1-866-408-5465). It is recommended that response protocols to these organizations be reviewed periodically, and revised as required, to ensure that health concerns related to ACs are identified for further consideration under the AC framework and that there is a timely and appropriate response to the originating stakeholder.

6 System Evaluation

It is recommended that the Air Contaminants Management Framework be implemented immediately and that it be reviewed approximately every five years following initial implementation to ensure on-going effectiveness and to incorporate new information and knowledge.

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8 Appendices

8.1 Appendix A: Background Information

8.1.1 Regional Emissions of ACs

The most recent comprehensive inventory of AC emissions in the RMWB is for the year 2000 (Clearstone and Golder, 2003). The regional emissions inventory examined 1900 point sources and 80 area sources. The inventory identified more than 1400 chemical compounds that were emitted to the atmosphere from these sources in 2000; of which 15 chemicals accounted for over 98% of the total mass of emissions. At the time of this inventory, the oil sands industry was largely confined to the northern portion of the RMWB (north of Fort McMurray). The oil sands industry was the source of virtually all emissions in that region due to its size and the general lack of other types of industry in the region. Dominant industries in the southern portion (south of Fort McMurray) were conventional oil and gas, forestry, and agriculture. The oil sands industry has undergone substantial expansion since 2000, including in-situ development in the southern portion of the RMWB. The emissions inventory for 2000 may not be fully representative of current emissions. However, this inventory still provides useful insight into the nature and sources of AC emissions in the region.

The principle sources of ACs from the oil sands industry (Clearstone and Golder, 2003) were:

- Fugitive emissions from leaks and vents in process equipment and piping: Emissions include heptanes, propane, 2-methyl heptane, and octane.
- Mine fleet emissions, largely in the form of tail pipe exhaust from diesel-powered mine trucks and other mobile mine equipment: Emissions include nitrogen oxides (NO_x), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), and incomplete combustion products.
- Exposed oil sand surfaces: Emissions consist largely of gases that volatilize from exposed mine faces. These emissions vary seasonally in relation to ambient temperature. Emissions include methane and other hydrocarbons.
- Tailings ponds: Emissions occur at the point of release of liquid tailings and from the surface of tailings ponds. Emissions vary seasonally in relation to ambient temperature. Emissions include methane, various hydrocarbons, heptanes, 2-methyl heptanes and reduced sulphur compounds.
- Main stacks, secondary furnaces, and flare stacks: These are the principle sources of sulphur dioxide (SO_2), CO, NO_x[4], $PM_{2.5}$, ammonia (NH_3), and sulphuric acid in the region.
- Storage tanks holding intermediate and final products of bitumen processing. Emissions include various volatile hydrocarbons such as cis-1,1,3,5-tetramethyl and cyclohexane.

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[4] Point sources and mobile mine equipment each contribute roughly 50% of NO_x emissions

The 1400+ chemicals/chemical groups in the AC inventory will not include all chemicals released in the region. There may be hundreds of different incomplete combustion products released from flares, automobiles, heaters, and off-road equipment but emission factors to enable emission estimates were only available for 60 compounds. Also, vapours and gases released from oil and gas facilities may contain hundreds and even thousands of different compounds but emission estimates could only be made for 178 compounds (Clearstone and Golder, 2003).

8.1.2 Prioritization of ACs

Most of the air contaminants are unlikely to pose a risk to human health as they are not released in sufficient quantity to exceed an exposure threshold or represent an acceptable risk level. To understand which emissions should be given further consideration for management, AC emissions were ranked (Clearstone and Golder, 2003) according to:

- toxic potential to humans, using emission rates and toxicity weighting factors,
- odour potential, using emission rates and odour thresholds, and
- potential to bioaccumulate in biological organisms, using emission rates and octanol-water partition coefficients.

The 39 ACs that collectively comprised 99.9% of the total toxic, odour and bioaccumulation potential were designated as ‘priority pollutants’. The list includes criteria air contaminants; acid gases; volatile organic compounds (VOCs) such as benzene and other aliphatic and aromatic hydrocarbons (such as naphthalene); reduced sulphur compounds (RSCs); polycyclic aromatic hydrocarbons (PAHs); $PM_{2.5}$ and chlorinated compounds, such as chlorinated dioxins/furans, chloroform and carbon tetrachloride. The primary sources of the chlorinated compounds were forestry and urban emissions in the southern portion of the RMWB; the primary sources of the remaining compounds were oil sands industry emissions in the northern portion of the RMWB.

An interactive, computer-based screening tool (ENVIRON, 2007) has been developed. This, or a similar tool, can be used to provide both an update to the Clearstone and Golder (2003) report and an improved and more efficient approach to update prioritization of ACs with respect to human health risk. The AC ranking is derived from:

- toxicity potential, which is based on the likelihood of causing harm, either carcinogenic or non-carcinogenic, using toxicity values developed by regulatory agencies or other authoritative bodies, and on the severity of the harm,
- non-inhalation exposure potential (i.e. via water or soil), based on tendency to bioaccumulate in the environment and potential to move among environmental compartments (e.g. leaching to groundwater, migration to the food chain), and
- inhalation and deposition potential, based on emission quantity (from Environment Canada’s National Pollutant Release Inventory (Environment Canada, 2008), dispersion characteristics, and the distance from emission sources to regional population centers.

8.1.3 Regional Exposure to ACs

Public health risk from ACs is a function of personal exposure, which is determined both by outdoor and indoor air quality and by the relative amount of time individuals spend indoors and outdoors. Industrial and community emission sources are the predominant sources of ACs in outdoor air. Both outdoor air that infiltrates indoor spaces and indoor emission sources will contribute to AC concentrations in indoor air.

8.1.3.1 Outdoor AC concentrations

Ambient air quality monitoring is the most reliable source of air quality information but due to technical challenges, cost, and access, monitoring is generally limited to a few, high priority ACs at a limited number of locations. Dispersion models have been used to estimate exposure to ACs that are not monitored but are of potential health concern and also to estimate exposure between monitoring locations.

8.1.3.1.1 Monitoring Results

The Wood Buffalo Environmental Association (WBEA) operates 14 continuous monitoring stations. Substances monitored continuously are SO_2 (13 stations); nitrogen oxides (NO_x, 9 stations); total reduced sulphur (TRS, 8 stations); total hydrocarbon (THC, 13 stations); ozone (O_3, 6 stations); $PM_{2.5}$ (9 stations); NH_3 (2 stations); and hydrogen sulphide (H_2S, 4 stations). A canister sampling methodology is used at seven air monitoring stations; air samples are collected for one or two 24-hour periods per month and analyzed for 60 VOCs. A polyurethane foam (PUF) sampling methodology is used at four monitoring stations to measure 10-day average ambient concentration of selected PAHs once per month. Some of the monitoring stations are located in regional communities and, as such, provide air quality data that can be used to infer population exposure. Others are located around industrial sites to monitor compliance with air quality objectives and facilitate source identification in the event the objectives are exceeded. In addition, the WBEA conducts passive monitoring of average ambient SO_2, NO_2, NH_3, NHO_3/HNO_2, and O_3 over longer time periods, generally one month or more, at approximately 35 locations. Passive monitoring results are used in assessment of environmental impacts but are of limited value in the assessment of human health risk.

Air quality results for 2000-2005 for certain substances were summarized and assessed for compliance with Alberta Ambient Air Quality Objectives (AAAQOs) and other health-based exposure limits and also for trends over time (Sonoma, 2007). During this time, AAAQOs for CO and NO_2 were not exceeded. AAAQOs were exceeded at community sites for O_3, $PM_{2.5}$, and PM_{10} and at industrial sites for O_3, $PM_{2.5}$, and SO_2. Average concentrations of most pollutants were in the lower 25th percentile of Canadian concentrations and below Alberta's health-based exposure limits. Benzene concentrations were above cancer-based and below non-cancer exposure limits. Styrene concentrations were well below both cancer and non-cancer exposure limits. Ethylbenzene, m/p-xylene, o-xylene, and toluene were below health-based exposure limits. Trend analysis indicated that NO_x concentrations increased significantly over time at some urban and industrial sites, SO_2 concentrations increased at industrial but not urban monitoring sites, and $PM_{2.5}$ and PM_{10} did not increase significantly. A large fraction or particulate matter was not identified.

The authors concluded that oil sands operations were the likely source of benzene, trimethylbenzenes, and toluene; wind-blown dust was the likely source of PM_{10}, and regional and local wildfires and burning events were the cause of nearly all high $PM_{2.5}$ concentrations.

Air quality information for 2007 is summarized in the 2007 WBEA annual report (WBEA, 2007b). This report uses the AAAQOs for evaluating the relative significance of the measured air quality values. The hourly AAAQO for SO_2 was exceeded 10 times with all exceedances occurring at industry stations except for a single exceedance at Fort McKay; there was no trend over time. Hourly and annual average NO_2 were well below AAAQOs; annual average NO_2 was higher in 2007 than in previous years. The hourly AAAQO for O_3 was exceeded once; there has been no trend over time in the annual average. There has been no trend over time in annual average $PM_{2.5}$. There were no exceedances of the AAAQO for NH_3. TRS and H_2S concentrations appear to have increased over time (statistical significance was not assessed); the increase appears more pronounced at the community monitoring stations than at industry stations. There may be an increasing trend over time in CO at the one station where it is monitored; AAAQOs were neither exceeded nor approached. Hourly average THC at the continuous monitoring stations ranged from 3.0 to 15.5 ppm; there are no AAAQOs for THC. Results of VOC analysis of canister samples and PAH analysis of PUF samples are reported. Only two compounds have AAAQOs consistent with the sample collection (i.e. averaging) time; neither of these exceeded their AAAQO. Ambient concentrations of NH_3 were well below the AAAQO. It should be noted that the AAAQOs are not always fully protective of health and therefore do not necessarily provide an absolute indication of health risk levels.

8.1.3.1.2 Modeling Results

Ambient outdoor concentrations of the 39 priority ACs (Clearstone and Golder, 2003) were estimated with the CALPUFF dispersion model, using the emissions inventory for 2000 and meteorology during 1995 (RWDI, 2003).

Estimated ambient concentrations were compared with measured concentrations of monitored ACs during the 3-year period, 1998-2000, in order to assess the level of confidence that should be placed in the model-based estimates. Estimates were compared to measurements for SO_2 (11 sites), NO_2 (six sites), H_2S (six sites), and CO (one site), $PM_{2.5}$ (four sites), and benzene (four sites). Estimated and measured concentrations of SO_2, NO_x, and benzene were reasonably consistent; estimated concentrations of H_2S and $PM_{2.5}$ were generally much lower than measured concentrations.

Factors that may have contributed to differences between measured and predicted concentrations of H_2S and $PM_{2.5}$ include:

- Model limitations: Community emission sources may have been too close to community monitoring stations for their contribution to community air quality to be reliably modeled with the regional-scale modeling approach that was used.
- Emissions variability: The hourly emissions used for modeling were an average based on estimated annual emissions during 2000. For a variety of reasons, including abnormal and plant upset conditions and seasonal variability in emissions from some sources such as tailings pond surfaces and mine faces, actual emissions during a given hour in the comparison period of 1998-2000 may have varied from this average.
- Meteorological variability: The year 1995 was considered a typical meteorological year and was used for modeling. Actual meteorology for each of the years 1998-2000 likely varied from 1995.
- Emissions not included in the inventory: The emission inventory does not include fugitive emissions, unusual emissions due to plant upset conditions, and natural emissions (e.g. particulates from forest fires, VOCs from biogenic sources), and community emissions of $PM_{2.5}$.
- ACs from emission sources outside the study area: Estimated AC concentrations are based only on AC emissions within the modeling domain.

Modeling was separately conducted with only community emissions to assess their contribution to ambient air quality in the community. Community emissions were estimated to contribute:

- very little to ambient SO_2 at community monitoring stations,
- about 50% of ambient NO_2 at Anzac and Fort McKay and 100% at Fort Chipewyan and Fort McMurray,
- more than 75% of ambient benzene at Anzac and Fort Chipewyan and more than 50% at Janvier, Fort McKay, and Fort McMurray, and
- significantly to C_5-C_8 cyclohexanes in Fort Chipewyan and Fort McMurray.

Differences between estimated and measured concentrations results suggest that model-based estimates may need to be improved prior to being used in health risk assessment. A case study of air quality in Fort McKay was undertaken to provide further insight into these differences and possible improvements to modeling (Golder, 2005). Fort McKay was chosen for this case study since it is the most exposed regional community to oil sands air emissions.

Fort McKay lies between the Syncrude UE1 (2.6 km SSW of Fort McKay) and Fort McKay monitoring stations (1.3 km NNW of Fort McKay); the major oil sands developments are in a southerly direction and approximately 16 – 34 km from both stations. Ambient concentrations at the two monitoring stations were analyzed in relation to wind direction in an attempt to assess the relative contributions of oil sands, community, and natural sources.

Ambient concentrations at the monitoring stations were attributed:

- almost entirely to oil sands developments for SO_2,
- to oil sands, community sources, and vehicle traffic on highway 63 for NO and NO_2,
- to forest fires, community and industrial sources for $PM_{2.5}$, and

- at least in part to natural sources for THC which consists largely of methane and VOCs.

The overall conclusion was that community-based sources can contribute significantly to NO_x, NO_2 and $PM_{2.5}$ ambient concentrations within the communities and natural sources may contribute significantly to $PM_{2.5}$ and THC.

Dispersion modeling approaches used by RWDI (2003) were examined to identify contributing factors to the differences between model-estimated and measured ambient concentrations. It was found that:

- an erroneous spatial location for two major mine fleet emission sources may have contributed to under-estimation of NO_x and NO_2 concentrations (this error was corrected and is not a factor in the final results reported in RWDI (2003)),
- omission of $PM_{2.5}$ community emission sources may have contributed to under-estimation of $PM_{2.5}$ concentrations,
- temporal variability in H_2S emissions from tailings ponds and mine surfaces, biogenic emissions (not included in the emissions database) and an under-estimate of emissions from some sources may have contributed to the under-estimate of H_2S concentrations, and
- local and natural emissions sources, which were not adequately accounted for in the emission data base, may have contributed to under-estimation of priority organic compound concentrations.

The study identifies several changes to modeling approaches and input parameters but does not offer an opinion as to whether model-estimates can be sufficiently improved to provide a reliable basis for health risk assessments.

8.1.3.2 Indoor AC concentrations and personal exposure

Personal exposure studies have been conducted in regional communities since 1997. These started with initial studies in Fort McMurray and Fort McKay in 1997/98 (WBK, 2005) and progressed to an ongoing, long term monitoring program conducted by the WBEA, starting in 2005 (WBEA, 2007a; WBEA, 2008). The objective of these studies has been to assess overall personal exposure to selected ACs in relation to indoor and outdoor air quality.

Pollutants are monitored over a 7-day period in a person’s breathing zone using a personal monitor carried 24-h per day, at a suitable location inside the person’s home, and at a suitable location outside a person’s home.

Personal exposure of Fort McMurray and Fort McKay residents was measured in 1997/98 for SO_2, NO_2, selected VOCs, and airborne particulate matter. Personal exposure levels were very low in comparison to human health-based exposure limits. Local indoor and outdoor sources of ACs were present and dominated personal exposure relative to oil sands sources for the limited number of compounds measured. Personal exposure was strongly related to indoor air concentrations which were not linked, or only weakly linked, with outdoor air concentrations. These studies did not provide evidence of elevated exposure to air contaminants attributable to oil sands activities. However, the authors note that it is challenging to find a link between air contaminants emitted by the oil sands plants and air quality in Fort McKay because outdoor ambient concentrations are low and because local sources are present and dominate personal exposure relative to oil sands plant emissions. Source apportionment studies were recommended to assess the contribution of oil sands emissions to community air quality.

Air pollutants monitored in the WBEA human exposure monitoring program are NO_2, SO_2, O_3, VOCs, and $PM_{2.5}$. Communities that have participated on a rotating basis in this program to date are Fort McMurray (2005, 2007), Fort Chipewyan (2005, 2008), Janvier (2007), Fort McKay (2006, 2008), and Anzac (2006). Odours and risk perception were not included in these studies.

Results to date indicate:

- personal exposure to $PM_{2.5}$ is low and is primarily influenced by lifestyle choices (i.e. smoking) or indoor sources,
- personal O_3 exposure is very low compared to health-based exposure limits, with outdoor O_3 higher than indoor, likely due to indoor air pollutants that destroy O_3 that infiltrates from outside,
- personal exposure to NO_2 is low compared to health-based exposure limits, with indoor sources contributing significantly to personal exposure in Fort Chipewyan,
- SO_2 levels are very low compared to health-based exposure limits with personal exposure largely a function of indoor air quality, with uncertainty over the contribution of outdoor air quality to indoor air quality, and
- personal VOC exposure is low (well below AAAQOs for the three VOCs, benzene, ethylbenzene, toluene, which have objectives) and is determined primarily by personal lifestyle choices or indoor VOC sources.

8.1.4 Regional health risk studies and assessment

Thirteen human health risk assessments, completed as part of the environment impact assessments (EIAs) for proposed oil sands developments, were reviewed (WBK, 2005). Based on model-predicted exposure to ambient air concentrations, two of these EIAs concluded that the projects assessed would not pose any health risk and 11 concluded that the projects could pose some health risk. EIAs differed substantially in their choice of which ACs and which exposure pathways to evaluate, depending on the nature of the project (e.g. insitu, mine, upgrader) and the consultant preparing the EIA. Concentrations of $PM_{2.5}$, SO_2, NO_2, various air toxics (e.g. benzene, C_2 to C_8 aliphatics, metals, benzo(a)pyrene) were predicted to exceed health-based exposure limits. In all cases, based on professional judgment (described as combining experience with common sense to interpret findings) the authors of the EIAs concluded that the project would not result in significant health effects.

The EIAs do not adequately describe the nature and context of health risk posed to the general oil sands population by trace air contaminants (WBK, 2005). Worst case assumptions are embedded in both the dispersion modeling to estimate exposure and in the health risk assessment resulting from that exposure. These worst case assumptions are sequential and their effects compounded, exaggerating the final conclusion regarding risk to the average individual by an unknown amount. To improve dispersion model estimates of current and future ambient exposure to ACs, WBK (2005) recommends:

- a source apportionment study in order to understand the relative current contribution of oil sands emissions and other sources to ambient air quality in the community,
- the combined use of modeling and monitoring to better predict changes to air quality that may occur with further oil sands development, and
- improved estimates of background exposure to ACs (i.e. from community and natural sources and sources outside the modeling domains).

To improve health risk assessment WBK (2005) recommends a site-specific analysis of AC behavior in the environment (i.e. transport, partitioning, uptake, and removal) and human parameters (i.e. local food consumption, residence, time activity, etc) used in exposure rate calculations.

8.1.5 Wildlife Health Risk

A literature review was conducted of concentration levels in the environment of ACs that are associated with adverse effects to wildlife, with a focus on the 39 priority compounds, but also including other known chemicals of potential concern that are environmentally persistent and associated with oil sands operations (Intrinsik, 2007). The authors concluded that insufficient information exists to characterize the potential for adverse effects to terrestrial and aquatic mammals, birds, amphibians, and reptiles, but ecological soil screening levels (USEPA, 2007) and CCME guidelines (CCME, 2006) provide conservative guidelines for terrestrial wildlife and bird exposures to metals, metalloids and PAHs. The most comprehensive information for determining adverse effects to wildlife is available for metals and metalloids (Intrinsik, 2007).

Wildlife risk assessments in six recent EIAs associated with project approval requests were reviewed. Three of these included an assessment of chronic effects of chemicals of potential concern on selected wildlife species. The chemicals addressed varied. All three concluded that potential effects were negligible. Two of these discussed wildlife health in relation to air quality and human health risk assessments and concluded that adverse effects were unlikely. One did not address wildlife health effects due to emissions.

8.1.6 Public Perception of Health Risk

A study was commissioned on public risk communication and perception in the RMWB (Jardine & Wenger, 2006). About half of respondents to the survey indicated concerns about their health related to air quality in the region; about 75% of the people with concerns felt they did not have enough information to understand the impact of air quality on their health; 60% of people with health concerns worry more about air quality related health concerns than any other health concerns in their life. Members of First Nations and Métis communities felt that their observational evidence on changes in their environment and health were being ignored.

The authors of the study recommended improved health risk communication with the general public and with First Nations and Métis communities, including development of a communications infrastructure with adequate resourcing.

8.1.7 Traditional Food Consumption

A survey of locally harvested, traditional food consumption was completed (Chan & Lawn, 2008) as recommended in an earlier report (WBK, 2005). Some survey participants (28%) reported changes in the appearance and health of wild game, fish and birds over the past 10 years. The reported changes included decreases in number of wildlife and abundance of berries, poor condition or disease in moose, and change in color and deformities in fish, and change in taste. Concern was expressed regarding health risk related to fish and berry consumption, air quality, and water quality.

The survey involved 180 people from 119 households in the RMWB. Amounts and types of traditional foods consumed were determined and perceptions of risk associated with that consumption were assessed. Over 70 species of locally harvested plants and animals were consumed; the most commonly consumed species were moose, blueberries, whitefish, pickerel, and rabbit. Almost all (98%) survey participants reported eating traditional food with a mean daily intake of 99 g. About 4% of calories, 15% of protein, 14% of iron, 17% of zinc, 12% of niacin, and 37% of vitamin B12 was obtained from traditional food with the remainder from market food, indicating that the relatively small amount of traditional food consumed contributed significantly to consumption of some important nutrients.

There was no correlation between traditional food intake and self-reported health status or body mass index.

8.1.8 Key Learnings and Conclusions

This section summarizes the learnings and conclusions of the Working Group regarding air contaminants and potential health risk in the region, based both on the aforementioned studies and on the professional judgment of the members of the Working Group.

Average concentrations of most pollutants have been in the lower 25th percentile of Canadian concentrations and below health-based exposure limits. There have been some exceedances of AAAQOs at community monitoring sites for O_3, $PM_{2.5}$, and PM and at industrial sites for O_3, $PM_{2.5}$, and SO_2.

There is widespread concern regarding health risk in relation to air quality among residents in the region in spite of studies that show low levels of exposure to monitored ACs. Concern is likely related to the large scale of industrial development, odours, and the paucity of information regarding human health hazards associated with most of the 1400+ chemicals emitted in the region. The significance of these emissions with respect to their human health risk remains uncertain in the public's perception. The anticipated ongoing expansion of the oil sands industry, the evolving nature of health-based exposure limits, and continued public health concern indicate the need for ongoing monitoring of exposure and periodic reassessment of risk.

Some of the priority chemicals are monitored in the region. Reliance upon model-based estimates for the remainder is problematic; monitored concentrations can in some instances differ substantially from model-based estimates for some ACs (e.g. $PM_{2.5}$ and H_2S) casting doubt on the reliability of model-based ambient exposure estimates for those ACs that are not monitored. While model-based predictions of ambient AC concentrations provide useful estimates of possible exposure and health risk, they should not be used as the sole basis for management decisions regarding emissions control and should be used with caution for human health risk assessment.

Health risk assessment completed for EIAs is one tool used by stakeholders to better understand potential health impacts from industrial development. It has proven useful in the setting of policy, in particular, for standard setting and regulation of hazardous chemicals or practices. However, it is only one tool amongst many other tools (e.g., health surveillance) that are being used to assess potential health effects from industrial and other emission sources.

TMAC considered commissioning an independent health risk assessment but concluded that this would not contribute significantly to current understanding regarding health risk until studies are completed to address some key uncertainties. These studies may include:

- site-specific analysis of AC behavior in the environment (i.e. transport, partitioning, uptake, and removal),
- further refinement of human parameters used in exposure rate calculations (i.e. local food consumption of traditional foods, time activity, etc),
- better characterization of community emissions for some ACs,
- source contribution studies that include community, natural emission, and industrial emission sources, and
- assessment of background air quality from emission sources outside of the modeling domain.

8.1.9 Regulation of AC emissions in the RMWB

Environmental protection is a shared responsibility between federal and provincial governments. The federal government establishes regulations to control the emission performance of a wide range of on-road and off-road vehicles, industrial boilers, steam generators, heaters, and stationary combustion turbines. The federal government also develops National Ambient Air Quality Objectives in cooperation with provincial governments. Decisions regarding implementation of these objectives are made by each province (Environmental Law Centre, 2003). The federal government also has legislative power to set regulated limits on industrial emissions and to require companies to prepare and implement pollution-prevention plans. The intent to set national and industrial-sector (including oil sands facilities) specific emissions caps for various pollutants was announced in 2007.

The Government of Alberta has the right to legislate and set policy for air and water pollution and soil contamination within provincial borders (Environmental Law Centre, 2003). ACs with ambient objectives include:

- Criteria pollutants: SO_2, CO, O_3, NO_2, and total suspended particulates. Alberta has established AAAQOs for criteria pollutants. These are used to assess air quality, set emission standards, design stacks at industrial facilities, guide and evaluate monitoring, and initiate control action at industrial facilities (AENV, 2008a).
- Air Toxics: These include metals and metalloids, respirable mineral fibers, inorganic gases, non-halogenated and halogenated organic compounds. Alberta has established AAAQOs for some air toxics, including H_2S and NH_3. For a substance without an Alberta objective, acceptable ambient concentration has been determined using Texas “Effects Screening Levels” (Texas Commission on Environmental Quality, 2008), Ontario’s “Point-of-Impingement Standards” (Ontario, 2005), or other health-based exposure limits (AENV, 1998).

Multi-stakeholder organizations such as airshed associations, CEMA, and CASA are an important part of Alberta’s governance structure for air management. CASA developed the Clean Air Strategy for Alberta in 1991, a set of recommendations for managing air quality in Alberta. CASA is currently updating this strategy, which will serve as the foundation for the government of Alberta’s long term strategy for clean air.

Stakeholders are involved in the development of new ambient air quality objectives by the GoA. Periodically CASA organizes stakeholder workshops to nominate and prioritize substances for the development of provincial air quality objectives. The Ambient Air Quality Objectives Stakeholder Advisory Committee (AAQOSAC), led by AENV, develops objectives for the selected substances. In the setting of objectives, human health, environment, and odor thresholds are considered and the most conservative value is selected. Objectives may be adopted from other jurisdictions, generally using the most conservative of recognized objectives used in other jurisdictions.

8.1.9.1 The Regulatory Approval System

Regulatory approvals are a key implementation tool in the Alberta’s air quality management system. Each oil sands development requires an operating approval, which must be obtained before construction can begin and which must be renewed every 10 years thereafter, or earlier at the discretion of the Director of AENV. The application for approval may include an Environmental Impact Assessment (EIA) of the project and cumulative impacts of regional emissions on air quality and human health risk. Approvals include requirements for:

- fugitive emission detection, repair, and monitoring (AENV, 2008b),
- emissions control equipment/technologies,
- maximum emission limits from specified sources and/or the whole project,
- operational procedures to minimize emissions,
- stack design to ensure prescribed ambient air levels are met, and
- source emissions and ambient air quality monitoring and reporting (AENV, 2008b).

Emission limits or standards are based firstly on the application of best available demonstrated or best available technology. Then, in order to determine if emission limits beyond those achievable with best available demonstrated or best available technology are required (AENV, 2000) there is an assessment of additional factors such as:

- existing air quality,
- ambient air quality guidelines or prescribed ambient levels,
- nature of the contaminant,
- nature of the process,
- results of air dispersion modeling,
- national or international agreements on emission limits, and
- Canadian Council of Ministers of the Environment (CCME) or Canadian Environmental Protection Act (CEPA) emission limits (dioxins/furans, polychlorinated biphenyls, vinyl chloride).

Required emissions control equipment/technologies to minimize emissions from fugitive sources include:

- treatment of tailings waste streams with solvent recovery and sour water stripping units,
- use of solvents that contain lower levels of benzene and that facilitate efficient collection by solvent recovery units,
- tailings technology that reduces the area and duration of tailings ponds,
- submerged tailings outfalls, and
- storage tanks designed to manage pressure, temperature, roof seal, vapor recovery.

Required emissions control equipment/technologies to minimize emissions from point sources include:

- burner and heater design to achieve near complete combustion of fuels and low NO_x formation,
- bag houses and scrubbers,
- appropriate flare stack burner temperature, and
- vehicles that meet US EPA standards.

Source emission monitoring includes stack emission monitoring, either periodic manual or continuous, and fugitive emission monitoring to detect leaks in process equipment and piping. Ambient monitoring may take the form of discrete sampling at specified locations and periods or continuous monitoring at one or more permanent stations. Emissions and air quality monitoring results are reported to Alberta Environment, generally monthly and annually for oil sands plants. Immediate reporting is required for certain releases, including releases in exceedance of approval maximums, and for exceedances of AAAQOs.

Approvals specify ambient air quality monitoring requirements. Ambient air quality monitoring in the RMWB is coordinated through the WBEA, which receives funding from the oil sands industry and operates air quality monitoring stations.

All ambient air quality exceedances are investigated by the facilities potentially contributing to the exceedance to determine cause and mitigative action. These are reviewed by AENV.

AENV will take corrective action if emission limits or AAAQOs are exceeded on a repeated and ongoing basis.

8.1.9.2 Existing Air Quality Management Frameworks

Provincial and regional air quality management frameworks have been developed for some ACs. These specify the conditions under which further investigation and analysis of air quality concerns and/or emission reduction initiatives may be required. Recommendations of these frameworks are generally implemented by the GoA through project approvals.

8.1.9.2.1 Recommendations on Trace Metals Management

This framework (CEMA, 2002), developed by CEMA in 2002 and adopted by AENV was designed to protect human health, wildlife, fish and vegetation from the deposition and accumulation of trace metals in the environment. The framework document concludes that “At current and projected metal emission rates, trace metals appear unlikely to pose risks to human health and ecosystems now or in the future, provided best management practices continue”, with the caveat that regional metal particulate emissions from mine fleet activity and wind-borne dust had not been assessed. The management objective of the framework was that there should be no significant increase in exposure risk with respect to metals in regional air emissions. Framework recommendations include:

- Metal emission controls be maintained and/or improved.
- Periodic emission inventories be conducted of indicator metals () released from fixed and mobile combustion sources.
- Monitoring of air and water and sentinel receptors (e.g. lichens and mosses, sediments)
- Studies with follow-up on observations on elevated aluminum in ratroot and elevated aluminum concentrations in wildlife.
- A review and system evaluation in 2005.

8.1.9.2.2 Emission Management Framework for the Alberta Electricity Sector

The framework (CASA, 2003a) was designed to lead to significant reduction over time in emissions of mercury, SO_2, NO_x, and PM. The mechanisms for reduction (AENV, 2005a) include:

- new source emission standards, based on best available technology economically achievable (BATEA) applied to new units effective 2006, and to existing units at the end of their design life,
- mercury emission controls on new coal-fired units and a significant reduction in mercury emissions from existing units by the end of 2009,
- formation of a multi-stakeholder team to address any potentially emerging “hotspot”, defined as an area where electricity generation emissions contribute to, or are projected to contribute to, adverse health or environmental outcomes, and

- continuous improvement through regular review and updating of technology performance standards.

Since electrical generation is a significant source for many of the ACs emitted from oil sands operations, the hotspot provision could trigger management action based on health risk.

8.1.9.2.3 Provincial Ozone and Particulate Management Framework

This framework (CASA, 2003b) is Alberta's implementation of the Canada Wide Standards (CWSs) for $PM_{2.5}$ and O_3. Compliance assessment is based on ambient air quality monitoring. While the federal CWSs apply to monitoring stations that fall within population areas of 100,000 or more, the Alberta framework applies to all monitoring locations in the province.

The framework has four action levels defined by threshold levels for ambient $PM_{2.5}$ and O_3 concentrations. These are:

- *baseline monitoring* if $PM_{2.5}$ < 15µg/m^3 (CWS metric) or, at the discretion of AENV, at any level of O_3 < 58 ppb (i.e. level can be set at either baseline or surveillance),
- *surveillance* if $PM_{2.5}$ is between 15 and 20 µg/m^3 (CWS metric) or, at the discretion of Alberta Environment, at any level of O_3 < 58 ppb, with AENV taking steps to ensure that the source(s) of elevated ambient concentrations are determined and that trends in ambient concentrations are analyzed and monitored,
- *management* if $PM_{2.5}$ is between 20 and 30 µg/m^3 (CWS metric) or, if O_3 is between 58 and 65 ppb (CWS metric), including development of a management plan with the objective of preventing exceedance of the CWS and maintaining and, wherever possible, improving air quality, and
- *exceedance* if $PM_{2.5}$ > 30 µg/m^3 (CWS metric) or if O_3 > 65 ppb (CWS metric), with AENV developing and implementing an action plan with measures to reduce ambient concentrations to below the threshold level.

The CWS metric for $PM_{2.5}$ is based on a 24-h average and achievement is based on the 98th percentile ambient measurement annually, averaged over three consecutive years. The CWS metric for O_3 is based on an 8-h average, and achievement is based on the 4th highest measurement annually, averaged over three consecutive years. Episodes that are primarily caused by natural events, high background, or transboundary transport are removed from the calculation of the 3-year metric.

Annual analyses of $PM_{2.5}$ and O_3 monitoring results determine the appropriate action level for each area of the province. The most recent analysis (2002-2004) found that ozone concentrations at monitoring stations in the RMWB were below levels that trigger the "surveillance" level (with the caveat that the analysis was based on an incomplete data set for one of the monitoring stations).

8.1.9.2.4 Ozone Management Framework for the Oilsands Region

This framework (CEMA, 2006), developed by CEMA in 2006, and adopted by AENV has threshold levels and action plans for the protection of human health consistent with the provincial $PM_{2.5}$ and O_3

management framework (see previous section). Additional metrics have been recommended for protection of vegetation. Based on the most recent analysis, regional O_3 concentrations fall within the range where AENV can use discretion to prescribe either a baseline or surveillance management level; the framework recommends application of the surveillance level.

8.1.9.2.5 Acidifying Emissions Management Framework for the Regional Municipality of Wood Buffalo

This framework (CEMA, 2004) recommends management actions for acidifying emissions (largely SO_2, NOx, and NH_3) to prevent acidification of soils or water bodies due to multi-year deposition. Recommendations for management action are not based on human health risk criteria.

8.1.9.2.6 Interim Nitrogen (Eutrophication) Management Recommendations and Work Plan for the Regional Municipality of Wood Buffalo.

This focus of this framework (CEMA, 2008) is multi-year emission and deposition of nitrogen compounds which could cause ecosystem eutrophication (excessive fertilization). Emissions control actions are not based on human health risk from exposure to these substances.

8.2 Appendix B: Studies Commissioned by TMAC

A priority ranking of air emissions in the oil sands region. (Clearstone and Golder, 2003)

Purpose: Develop an inventory of emissions and emission sources in the RMWB and identify a manageable number of priority ACs for dispersion modeling and health risk assessment.

Results: An inventory of emissions and emission sources was prepared. More than 1400 chemicals/chemical groups are emitted in the RMWB. Thirty-nine chemicals/chemical groups were identified as priority chemicals.

Further work resulting from this study: This study provided the necessary data for dispersion modeling to estimate ambient concentrations of priority chemicals.

Predicted ambient concentrations and deposition of priority substances released to the air in the oil sands region, final report. (RWDI, 2003)

Purpose: Estimate ambient concentrations of the 39 priority chemicals using dispersion modeling and assess the level of confidence that should be placed in these estimates.

Results: Ambient concentrations of priority chemicals were estimated in communities and other locations within the region. Dispersion model estimates of ambient concentrations were compared with measurements for monitored chemicals to provide insight into the level of confidence that should be placed in these estimates. While estimates for some substances were relatively close to monitored values, others were substantially under-estimated. Insufficient information on emissions within the community, inability of the regional-scale model to adequately model near field emissions, natural background concentrations, and background due to emissions outside of the modeling domain were considered contributing causes to the discrepancy between model predictions and monitoring results.

Further work resulting from this study: A study was commissioned to analyze reasons for the differences between measured and estimated concentrations, recommend approaches to improve model estimates, and to assess the contributions of industrial, community, and background emission sources to air quality in the community of Fort McKay.

Report on estimating contributions to ambient concentrations in Fort McKay. (Golder, 2005)

Purpose: To analyze reasons for the differences between measured and estimated concentrations of ACs, recommend approaches to improve model estimates, and to assess the contributions of industrial, community, and background emission sources to air quality in the community of Fort McKay.

Results: The spatial configuration of the industrial sources (south and distant from Fort McKay), the Syncrude UE-1 monitoring station (south and near Fort McKay), and the Fort McKay monitoring station (north and near Fort McKay) enabled the analysis of ambient air concentrations in relation to wind direction to assess relative source contributions. Community-based sources significantly contribute to NO_x, NO_2 and $PM_{2.5}$ concentrations and natural sources contribute significantly to $PM_{2.5}$ and THC.

To improve model estimates it was recommended that community emissions of ACs and seasonal changes in fugitive emissions should be adequately accounted. A combined modeling and monitor approach is recommended for predicting the change to community air quality from future increases in AC emissions.

Further work resulting from this study: The WBEA is conducting a source attribution study.

Health risk literature review: Current approaches and data used to assess health risks associated with emission in the oil sands region. (WBK, 2005)

Purpose: To determine whether EIA health risk assessments and personal exposure monitoring studies provide an adequate understanding of potential health risk from AC emissions in the region, with recommendations for further health risk assessment.

Findings: Thirteen recent health risk assessments and two personal exposure monitoring studies were reviewed. Eleven of the health risk assessments found that dispersion model estimated future exposure to ACs would exceed health reference standards. However, based on professional judgment of the EIA authors, health risks were deemed negligible in all cases. Health risk assessments do not provide an adequate understanding of regional health risk. Health risk is exaggerated by the use of a sequence of compounded worst case assumptions both in ambient exposure estimates and in the health risk assessment process. The authors provide recommendations to enable better characterization of health risk in the future, including a regional case study of the dispersion modeling and risk assessment parameters that determine estimated exposure rates and further source attribution studies. Indoor and outdoor air quality and personal exposure studies, conducted in Fort McMurray and Fort McKay, were reviewed. These studies did not provide evidence of elevated personal exposure to air contaminants attributable to oil sands activities. The authors note that it is challenging to find a link between air contaminants emitted by the oil sands plants and air and air quality in Fort McKay because concentrations are low and because local sources are present and dominate personal exposure relative oil sands plant emissions.

Other work resulting from this study: A study of consumption of locally harvested food by individuals and households in aboriginal communities was commissioned by TMAC and is nearly complete. Studies by the WBEA on source attribution with respect to air quality are underway. Also, the Working Group concluded that a TMAC-commissioned risk assessment would not substantially improve the current understanding of health risk without first completing studies to address uncertainties with respect to exposure and assessment of risk.

Summary of State of the Issue Sheets for Trace Metals and Air Comtaminants Priority Pollutants. (AENV, 2005b)

Purpose: To summarize available information pertaining to health risk on ACs.

Findings: Available information was summarized for the top 18 ACs, with respect to toxicity, of the 39 priority chemicals. The focus was on inhalation effects rather than ingestion and dermal contact exposure pathways. The information summarized includes: emission sources, exposure pathways, AAAQOs, objectives in other jurisdictions, health reference concentrations, and results of ambient air quality monitoring in Alberta.

Risk communication plan for the issues surrounding the risk assessment of trace metal and air contaminants in the Athabasca oil sands region, final report. (Jardine & Wenger, 2006)

Purpose: To assess health risk perception in the region and provide recommendations on effective health risk communication.

Findings: About half of respondents to a health risk perception survey indicated concerns about their health related to air quality in the region; about 75% of the people with concerns felt they did not have enough information to understand the impact of air quality on their health; 60% of people with health concerns worry more about air quality related health concerns than any other health concerns in their life. Members of First Nations and Métis communities felt that their observational evidence on changes in their environment and health were being ignored.

Further work resulting from this study: An analysis of changes over time in air quality and air quality in relation of AAAQOs and other health-based exposure limits was commissioned.

Characterization of ambient air quality in the oil sands region of northern Alberta. (Sonoma, 2007)

Purpose: To assess air quality and air quality trends over time in the RMWB

Findings: Air quality results for 2000-2005 were summarized and assessed for compliance with Alberta Ambient Air Quality Objectives (AAAQOs) and health-based exposure limits and also for trends over time. During this time AAAQOs for CO and NO_2 were not exceeded. AAAQOs were exceeded at community sites for O_3, $PM_{2.5}$, and PM and at industrial sites for O_3, $PM_{2.5}$, and SO_2. Average concentrations of most pollutants were in the lower 25^{th} percentile of Canadian concentrations and below health-based exposure limits. Benzene concentrations were above cancer exposure limit and below non-cancer exposure limits. Styrene concentrations were well below both cancer and non-cancer exposure limits. Ethylbenzene, m/p-xylene, o-xylene, and toluene were below health-based exposure limits. Trend analysis indicated that NO_x concentrations increased significantly at some urban and industrial sites, SO_2 concentrations increased at industrial but not urban monitoring sites, and $PM_{2.5}$ and PM_{10} did not increase significantly. Oil sands operations were the likely source of benzene, trimethylbenzenes, and toluene; wind-blown dust was the likely source of PM_{10}, and regional and local wildfires and burning events were the cause of nearly all high $PM_{2.5}$ concentrations.

Wildlife health literature review with specific reference to wildlife species and chemicals of concern in the oil sands region, final report. (Intrinsik, 2007)

Purpose: To summarize and assess available health-based exposure limits of regional wildlife species.

Findings: A literature review was conducted of concentration levels in the environment of AC emissions that are associated with adverse effects to wildlife, with a focus on the 39 priority compounds but also including other known chemicals of potential concern that are environmentally persistent and associated with oil sands operations (Intrinsik, 2007). Insufficient information exists to characterize the potential for adverse effects to terrestrial and aquatic mammals and birds, amphibians, and reptiles. Ecological soil screening levels (USEPA, 2007) and CCME guidelines (CCME, 2006) provide conservative guidelines for terrestrial, but not aquatic, wildlife and bird exposures to metals, metalloids and PAHs. The most comprehensive information for determining adverse effects to wildlife is available for metals and metalloids. The report also reviewed six recent EIAs with respect to wildlife health risk. Three of these conducted an assessment of chronic effects of chemicals of potential concern on selected wildlife species. The chemicals addressed varied among EIAs. All concluded that potential effects were negligible. Two EIAs discussed wildlife health in relation to air quality and human health risk assessments and concluded that adverse effects were unlikely. One did not discuss wildlife health effects due to emissions.

Traditional food consumption and risk communication project in the Regional Municipality of Wood Buffalo (Phase 1) (Chan & Lawn, 2008)

Purpose: To quantify consumption of locally harvest foods in aboriginal communities in support of future health risk assessment and assess health risk perceptions associated with consumption of traditional foods.

Findings: A survey of local/traditional food consumption and health risk perception by 180 in 119 households was completed. Over 70 species of locally harvested plants and animals were consumed; the most commonly consumed species were moose, blueberries, whitefish, pickerel, and rabbit. Almost all (98%) of participants reported eating traditional food with a mean daily intake of 99 g. About 4% of calories, 15% of protein, 14% or iron, 17% of zinc, 12% of niacin, and 37% of vitamin B12 was derived from traditional food with the remainder from market food, indicating that the relatively small amount of traditional food consumed contributed significantly to consumption of some important nutrients. There was no correlation between traditional food intake and self-reported health status or body mass index. Some survey participants (28%) reported noticing changes in the appearance and health of wild game, fish and birds over the past 10 years. The changes included decreases in number of wildlife and abundance of berries, poor condition or disease in moose and change in color and deformities in fish, and change in taste. Concern was expressed about the safety of fish and berries.