CHAPTER 1

INTRODUCTION

Chapter 1 Objective: ***To define the rationale, objectives, scope, and audience for this Assessment, as well as to describe the logical progression of its primary chapters.***

Modern emission inventories have evolved to become a cornerstone of air pollution management practice. Providing consolidated information to quantify pollutant emission rates associated with specific sources and time periods, such inventories have been – and will continue to be – critical resources for air quality modeling, local and regional regulatory planning, and international cooperation. Resulting in large part from the efforts of scientists and engineers working in this field, emission inventory sophistication and complexity have increased significantly during the past several decades, to a point where it is difficult to imagine how North American pollution management strategies could operate in the absence of this important information resource.

This fundamental and critical importance provides an increasingly strong incentive to continue emission inventory improvement. In response to this need, this Assessment addresses the status of current North American emission inventories as well as projected future progress in inventory applications and research. This Assessment's primary goal is

. . . to guide the development of future inventories, as well as to facilitate the use of inventories for atmospheric process evaluation and air pollution management.

In addressing this goal this Assessment takes a critical and in-depth view of existing inventories, and suggests a number of areas for their future improvement. It does so, however, acknowledging the efforts and contributions of those who have developed the field to its present state.

The development and application of emission inventories is a particularly timely subject for several reasons. The previous NARSTO Assessments of ozone and airborne particulate matter (PM) (NARSTO, 2000; NARSTO, 2004) identify a number of desired inventory improvements that are essential for development of more efficient and reliable ozone- and PM-management strategies in the future.[1] Moreover, the recent U.S. National Research Council reports *Air Quality Management in the United States* (NRC, 2004a) and *Research Priorities for Airborne Particulate Matter* (NRC, 2004b) spotlight several areas where substantial enhancements are needed, including new emission monitoring techniques, regularly updated and field-evaluated inventories, organic PM precursor speciation, and the characterization of physiologically important PM components. The first of these NRC reports notes that, while continuous in-stack monitoring allows direct and reliable quantification of emissions from most large stationary sources, substantial future progress will be necessary to provide a corresponding level of confidence for most other source categories. These reported recommendations reflect relatively recent findings regarding health impacts of PM and other pollutants. They also recognize that emission inventories remain an essential component of air-pollution modeling and management.

Four additional features further emphasize the need for an emission inventory assessment. The first of these is the evolving recognition that traditional

[1] The emission inventory chapters of these two Assessments tabulate annually averaged national North American inventory data for primary PM emissions as well as for emissions of gaseous PM and ozone precursors. As a partial response to actions recommended in these Assessments, NARSTO hosted a technical conference in October 2003, entitled Innovative Methods for Emission Inventory Development and Evaluation (Hidy, Mobley and Cadle, 2004). Presentations from this workshop form an important technical basis for the current Assessment, and can be viewed on the NARSTO website: www.cgenv.com/narsto.

emission inventories contain substantial (and largely unspecified) levels of uncertainty, which can severely limit the reliability of associated pollution-management strategies.[2] Systematic identification and quantification of these uncertainties are essential to further progress in the field. Second, past successes in reducing emissions from many traditional sources have led to a situation wherein substantial emission fractions originate from malfunctioning and/or previously uncharacterized sources. Characterization of many of these emission categories requires new methodologies.

A third feature reflects recent scientific advances suggesting innovative techniques that are potentially applicable for future emission inventory development and verification. It is probable that application of these methods, in conjunction with the more established approaches, will be highly beneficial to the overall inventory development and verification process. There is no doubt that current emission inventory activities provide information that has been, and will continue to be, invaluable for modeling and management efforts. However, simply increasing these traditional activities is unlikely to reduce associated uncertainties in an efficient or cost-effective manner. Thus, a systematic and serious consideration of new and innovative methods to augment traditional methodologies is in order.

Fourth, inventory-related needs among Canada, the United States, and Mexico are diverse. Stemming from geographical and industrial differences as well as from varying states of inventory development, this diversity suggests that Canada, the United States, and Mexico will emphasize different priorities for immediate development efforts. At the same time, there is considerable benefit in maximizing consistency and transparency among Canadian, U.S., and Mexican inventories.

In recognition of these considerations, this Assessment takes a decidedly forward-looking perspective, which is reflected by the following sub-objectives to its primary goal:

1. **Promote Efficient and Effective Use of Current Emission Inventories and Identify Critical Uncertainty Areas in these Inventories.**

- Provide a comprehensive resource for locating and acquiring current North American inventories.
- Provide a comprehensive guide to emission inventory application tools, including emission models and emission processors.
- Assess the strengths and weaknesses associated with emission inventories in general as well as with selected specific inventories.
- Provide guidelines for efficient and appropriate application of existing inventories.

2. **Guide the Development of Future Emission Inventories.**

- Itemize advanced and potential future techniques for emission inventory development, including their potential applications, their prospects for enhancing inventory development, and their implementation requirements and timelines.
- Encourage the systematic incorporation of uncertainty analysis in inventory preparation, and promote the routine inclusion of uncertainty information in published inventories.
- Discuss possible future archival methods for emission inventory data, which will ensure greater accessibility and more reliable application.
- Encourage the further development of instrumentation, interpretive methodologies, and archival/retrieval systems.
- Encourage the development of user-friendly interfaces for emission inventory databases, to provide improved methods of data retrieval and interpretation.
- Encourage harmonization of emission inventories prepared for different and adjoining areas within national boundaries and especially across international borders.

[2] Although several relatively recent developments can be cited, the Texas 2000 field study's discovery of major underestimates in volatile organic compounds (VOCs) in Houston's emission inventory provides a key example to illustrate this point (see Section 7.3).

3. **Establish Inventory Development Guidelines for the Future.**

- Recommend actions to enhance the timeliness, quality, and cost-effectiveness of current emission inventory approaches.
- Recommend action items for development and deployment of the advanced methods discussed in this document.

1.1 AUDIENCE AND SCOPE

To fulfill the above objectives, this Assessment is directed to a diverse audience. In particular, it focuses on a variety of decision analysts, scientists, and stakeholders, including

- **Decision makers responsible for funding and setting the priorities for emission inventory development and for research needed to improve the procedures and technologies used to produce these inventories.**
- **Users of emission inventories**
  - Policy analysts, planners, and regulators
  - Air quality modelers
  - Field campaign designers and practitioners
  - Community interest groups
  - Negotiators and implementers of international agreements.
- **Developers of emission inventories**
  - Developers in organizations at all levels in Canada, the United States, and Mexico
  - Developers of tools to derive emissions from process information
  - Developers of tools to measure emissions.

In addressing its audience, this Assessment confines its scope mainly to North American emissions and to criteria pollutants and their precursors, although some discussion of non-criteria pollutants such as greenhouse gases and toxic air pollutants is naturally included owing to commonality of measurement, characterization, and data-archiving technologies.

This Assessment does not duplicate currently available documents in the emission inventory field. It is not a methods manual and, although it provides a valuable user's guide to locating current emission inventory data, it is not a compendium of these data. Rather, this Assessment provides an examination of uncertainties in current emission inventories, identifies critically important aspects of these uncertainties, and indicates future pathways for improvement. Important aspects of this improvement process include the application of evolving and anticipated future technology, as well as measurement and database quality.

1.2 REPORT STRUCTURE

The chapters of this Assessment follow a progression that closely reflects the objectives and scope noted above. Chapter 2 responds to sub-objectives 2 and 3 by providing a summary vision statement which, from the authors' viewpoint, sets forth a desired yet technologically feasible state of future North American emission inventories and emission inventory research. Chapters 3 and 4 address sub-objective 1 by presenting an overview of current North American emission inventories, emission processors, and emission models, including techniques for their development. This is followed by Chapter 5, which examines strengths and weaknesses of the current inventories and their associated uncertainties. These chapters are intended to set a basis for subsequent discussion and to serve as a location resource for those seeking current inventory information. As noted above, this Assessment is not intended to be a data compendium but rather to serve as a convenient "signpost" for information.

Chapter 6 takes a more forward-looking perspective, addressing sub-objectives 2 and 3 by providing an overview of future and evolving emission measurement technology, interpretive techniques, and data management practices. Individual methods described here are accompanied by discussions of potential feasibility and projected future applications. Chapter 7 discusses several "reality checks" of specific emission inventories using a variety of independent

measurements and back-checking techniques, and provides further indications of inventory reliability and uncertainty levels.

Uncertainty is a particularly challenging issue owing to the multitude of potential uncertainty sources, the lack of quantitative treatment in most past efforts, and the technical difficulty of grounding the multifaceted uncertainty issue on a sound mathematical basis. Chapter 8, which is rooted in basic statistical theory, addresses the issue of setting a consistent framework for interpreting inventory uncertainties. It presents an ambitious objective of providing quantitative uncertainty analysis in future inventory studies.

Chapter 9 synthesizes the previous seven chapters to construct a series of findings and recommendations for moving from the present state of emission inventory science to the advanced state anticipated in Chapter 2. Because Canada, the United States, and Mexico have different development issues and priorities, this chapter lists individual action plans for the three countries, which include specific items for primary focus in achieving the noted recommendations. While establishing specific blueprints for action is beyond the scope of this document, these action plans are intended to assist the individual countries in their subsequent, more definitive planning processes. Because the anticipated cost of improving emission inventories is an element of the planning process, the action plans address anticipated costs in general terms; refer to sections 3.5 and 9.2.1, 9.2.2, and 9.2.3.

Despite this document's chapter sequence and logical flow, it need not be read cover-to-cover. Rather, each chapter is designed as a stand-alone unit and is intended for direct reader access without necessarily studying the preceding material: for example, readers seeking information on emission inventory sources can go directly to Chapter 3, while those interested in basic statistical methods for analyzing uncertainty can proceed immediately to Chapter 8. In this manner, the document can treat its variety of subjects in sufficient detail to convey salient information without unduly burdening the reader pursuing a specific subject area.

With its stated objectives, its audience, and its presentation, this Assessment is intended to stimulate creative thinking and future activity by instrument and methodology developers, decision makers, policy analysts, and inventory developers and users. As is noted in Chapters 2 and 9, significant advancements in emission inventory science are anticipated during the coming decade as a consequence of combined efforts of members of these communities. This Assessment is intended to serve as a first step in that direction.

REFERENCES FOR CHAPTER 1

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