Final

Mexico Emissions Inventory Program Inventory Methodology Development for the Country of Mexico:

Lessons Learned from the Application of the Mexico Emissions Inventory Methodology in the City of Mexicali, Baja California

Prepared for:

Western Governors' Association
Denver, Colorado
and
Binational Advisory Committee

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MEXICO EMISSIONS INVENTORY PROGRAM

INVENTORY METHODOLOGY DEVELOPMENT FOR THE COUNTRY OF MEXICO:

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CONTENTS

ACRONYMS

ADT	average daily traffic
ARB	California Air Resources Board
BAC	Binational Advisory Committee
B.C.	Baja California
CO	carbon monoxide
COA	Cédula de Operación Anual (annual certificate of operation)
DDF	Departamento del Distrito Federal (Federal District of Mexico City)
EPA	U.S. Environmental Protection Agency
HAP	hazardous air pollutant
HC	hydrocarbons
ICAPCD	Imperial County Air Pollution Control District
ICAR	Ingeniería en Control Ambiental y Riesgo, S. de R.L.M.I.
INE	Instituto Nacional de Ecología (National Institute of Ecology)
LPG	liquefied petroleum gas
NH_3	ammonia
NO_x	nitrogen oxides
Pb	lead
PEMEX	Petróleos Mexicanos
$PM_{2.5}$	particulate matter less than 2.5 µm in diameter
PM_{10}	particulate matter less than 10 µm in diameter
PSQ	point source questionnaire

QA	quality assurance
QC	quality control
RVP	Reid Vapor Pressure
SEMARNAP	Secretaría de Medio Ambientes, Recuros Naturals, y Pesca (Secretariat of the Environment, Natural Resources, and Fisheries)
SO_2	sulfur dioxide
SO_x	sulfur oxides
U.S.	United States
TOC	total organic compounds
TOG	total organic gases
TSP	total suspended particulate
VKT	vehicle kilometers traveled
VOC	volatile organic compound
WGA	Western Governors' Association
Yr	year
μm	micrometer

PROLOGUE

This report is a final version of a draft document originally prepared in May 1999 to document the "lessons learned" during the development of the Mexicali emissions inventory. The draft document contained 19 specific "lessons" associated with the Mexicali emissions inventory. Some of these identified lessons were things that should be repeated in future inventories, while other lessons were things that should be changed or avoided.

However, the draft "lessons learned" document was developed before the final Mexicali Emissions Inventory Report had been completed. In fact, the interim reports documenting emission estimates for point sources, area sources, and natural sources had not even been finalized prior to the release of the draft document. Ideally, the final inventory report would have been completed before this document was started. However, due to scheduling requirements associated with the Tijuana emissions inventory, it was decided that this document should be developed prior to finalization of the Mexicali emissions inventory in order to assist the Tijuana inventory effort.

Although the timing of the inventory report and the "lessons learned" report development was less than ideal, one positive aspect of this timing was that many of the lessons from the draft "lessons learned" were incorporated into the final inventory report which improved the quality of the final inventory. Conversely, due to the incorporation of the "lessons learned" into the final inventory report, the draft "lessons learned" report no longer accurately represented the conditions of the final inventory report.

One option for the final "lessons learned" report would have been to revise the text to match the final inventory report rather than the draft version. This revision might have required significant effort. Instead, it was decided that considerable benefit had already been obtained by incorporating the "lessons learned" into the final inventory report and that not much more would be gained by revising this document to match the

final inventory report. As a result, the main text of the draft "lessons learned" report is contained in this document virtually unchanged, while a prologue and epilogue have been added to explain the relationship of the final "lessons learned" report to the draft version. The only changes to the main text are those needed for consistency. In general, these changes are relatively minor.

1.0 INTRODUCTION

The Mexicali emissions inventory was developed under the Mexico Emissions Inventory Development Program and represents the first time that the overall Mexico methodology was implemented. The Mexico methodology is documented in a series of manuals developed by Radian International (Radian) for the Western Governors' Association (WGA) and Mexico's Instituto Nacional de Ecología (National Institute of Ecology [INE]).

The primary purpose of this report is to document the "lessons learned" from applying the Mexico methodology in Mexicali, and identify what should be repeated and what changes should be made during subsequent inventory efforts in Mexico. This report will be useful when conducting the Tijuana, Baja California, inventory during 1999-2000. The focus of this report is more on the "procedural" issues encountered during the inventory process, and less on the "technical" issues. (A technical validation of the Mexicali inventory will be conducted under a separate task, and should be completed in mid-2000.)

This report is based on the experiences of INE, Radian, and the Mexicali inventory subcontractor (Ingeniería en Control Ambiental y Riesgo, S. de R.L.M.I. [ICAR]), during inventory development in Mexicali. The technical work conducted by ICAR is documented in three reports:

- Final Motor Vehicles Interim Report (ICAR, 1998a).
- Draft Point Sources Interim Report (ICAR, 1999a); and
- Draft Area and Natural Sources Interim Report (ICAR, 1999b).

In addition, ICAR will develop an overall Mexicali Emissions Inventory Report; however, that report is not yet available. (The Spanish version of the final Mexicali Emissions Inventory Report was completed in September 1999; an English translation will be available in February 2000).

In order to answer the question "What should be changed?" several recommendations are made. These recommendations will help INE focus their efforts as they strive to improve Mexico's emissions inventories in the future.

2.0 BACKGROUND OF THE MEXICALI EMISSIONS INVENTORY

The Mexicali emissions inventory was conducted from October 1997 to May 1999 for the metropolitan area of Mexicali, the capital of the state of Baja California. The inventory base year was 1996 and emissions from point sources, area and natural sources, and motor vehicles were included. The following pollutants were inventoried: hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and particulate matter with an aerodynamic diameter less than 10 micrometers (µm) (PM_{10}). Some emission estimates for ammonia (NH_3) and lead (Pb) were also included.

2.1 Mexico Methodology Development Project

The Mexico Methodology Development Project was initiated by WGA in 1994 with U.S. EPA funding for the purpose of increasing emissions inventory capabilities within the country of Mexico. One of the early project tasks was to evaluate numerous emissions estimating methodologies and determine which ones were most applicable to Mexico. The recommended methodologies were presented to the Binational Advisory Committee (BAC), with the methodologies described in greater detail in emission inventory manuals.

Mexicali was selected by INE and the BAC as an appropriate test site for the validity of the recommended methodologies. Potential revisions to the recommended methodologies may be developed from the results of the Mexicali inventory.

2.2 Inventory Objectives

Several objectives were identified at the start of the Mexicali inventory development process. Some of these objectives relate directly to the Mexico Methodology Development Project; other objectives contribute to overall air quality

programs within the country of Mexico. The four main inventory objectives are described as follows:

- **Capacity Building.** The Mexicali emissions inventory effort provided government, industry, and consultants in Mexicali the opportunity to build capacity by drawing upon U.S. inventory expertise. This capacity can then be effectively used in the future to develop emissions inventories for other regions in Mexico.

- **Methodology Testing.** Mexicali was selected as the site for testing the Mexico Methodology Development Project. Through the implementation of the recommended methodologies in an actual inventory, the validity of the methodologies in Mexico can be assessed. Data availability and estimated emissions accuracy may be used as criteria for this assessment.

- **Mexicali Emissions Inventory Development.** Because Mexicali is a growing metropolitan area, its air quality will require increasing attention. Emissions inventories are one of the first elements that need to be developed for air quality management. With the exception of some large industrial facilities that are under federal or state jurisdiction, air emissions from sources in the Mexicali metropolitan area have never been inventoried. The Mexicali inventory serves as the initial emissions inventory for the Mexicali area.

- **Support of the 1999-2003 Mexicali Air Quality Improvement Program.** INE is currently developing an air quality improvement program for Mexicali. The Mexicali inventory serves a central role in this program. Without an accurate inventory, any air quality improvement strategies that may be developed are technically unfounded.

2.3 Inventory Participants

Many interested parties filled active roles in the development process of the Mexicali emissions inventory. The functions and activities of the key participants are detailed as follows:

- **INE.** As the main environmental agency in Mexico, INE provided extensive guidance for the inventory development process and identified appropriate Mexico-specific data and information. INE also ensured that the Mexicali inventory supported the Mexicali air quality improvement program and other national air quality objectives. INE was responsible for implementing the quality assurance and quality control (QA/QC) program for the inventory.

- **SEMARNAP B.C.** SEMARNAP, Baja California (B.C.) is the state-level environmental government agency in Mexicali. This agency provided data collection assistance for ICAR and coordinated local agency particpation for the inventory. Their personnel's knowledge of local environmental conditions in Baja California facilitated the inventory development process.

- **ICAR.** Ingeniería en Control Ambiental y Riesgo Industrial, S. de R.L.M.I (ICAR) was the Mexicali contractor selected to perform the majority of technical work on the Mexicali inventory. ICAR's responsibilities included data collection, emission estimation, inventory database management, and report writing.

- **Radian.** Radian International provided technical oversight and review for the Mexicali inventory. As the developer of the recommended methods being tested in Mexicali, Radian also provided technical guidance to INE and ICAR, including training on motor vehicle emissions estimating and the point source questionnaire. Radian reviewed all inventory documents produced by ICAR.

- **Mexicali Technical Group.** The Mexicali Technical Group provided overall guidance for the inventory development process. Bimonthly meetings were held to report on inventory development progress and resolve any problems that had occurred. In addition to the participants described above, representatives from the following agencies were members of the Mexicali Technical Group:
  - Baja California General Office of Ecology;
  - Mexicali City Council;
  - U.S. EPA Region IX;
  - WGA;
  - California Air Resources Board (ARB); and
  - Imperial County Air Pollution Control District (ICAPCD).

3.0 GENERAL OBSERVATIONS

Some observations and lessons learned during implementation of the Mexico emissions inventory methodology in Mexicali were general in nature and related to the success of the overall inventory, not to any specific source category. These general observations range from the successful development of an emissions inventory work plan to the absence of important inventory quality assurance/quality control (QA/QC) guidance document. Details related to these observations are discussed below.

Lesson #1:	**A work plan should be developed for every emission inventory effort and should be based on the objectives and end uses defined for the emissions inventory.**

An emissions inventory work plan was developed for the Mexicali inventory by ICAR in the early stages of the project (ICAR, 1998b). Based on the objectives and end uses defined for the Mexicali inventory, this work plan provided a guideline for identifying sources and emissions data, and establishing specific inventory attributes such as base year, emission or pollutant types, etc. Even though it was necessary to deviate from the work plan during inventory development in order to take advantage of new and evolving data sources and methods, the work plan provided a framework for successful completion of the emissions inventory. Development of a work plan should be repeated in the initial stages of other emissions inventories developed for Mexico, even if an inventory has been previously developed for a specific area, since inventory attributes will change over time.

Lesson #2:	**Methodology training sessions should be conducted at the beginning of the emissions inventory development process to familiarize inventory staff with difficult or new methodologies.**

Training was an important part of the inventory development process in Mexicali. The following training courses were offered:

- General emissions estimating methodology training was offered by INE, to SEMARNAP B.C., other agency staff, and ICAR at the beginning of the inventory to discuss the work plan and share understanding of the inventory objectives.

- Motor vehicle emissions methodology training was offered to INE, SEMARNAP B.C., other agency staff, and ICAR to teach them about the use of U.S. EPA's emission factor models and other relevant motor vehicle methodology issues.

- Point source questionnaire (PSQ) training was offered to agency staff in a "train-the-trainers" format. Subsequently, agency staff offered two one-day training sessions to representatives from many Mexicali industries on the new PSQ content and use, and data-collection procedures.

These training courses contributed to the successful completion of the emissions inventory in Mexicali. Similar training should be considered for other areas in Mexico, especially where inventories are developed for the first time.

Lesson #3:	**A technical group should be established for the inventory project and a communication protocol should be defined.**

A Mexicali Technical Group was established early in the inventory process (see Section 2.3 of this report for details). An important feature of the group was the cross section of interests represented (e.g., Mexico and United States federal, state, and local governments, and contractors). The group represented diverse interests, and participated at different levels to ensure that the inventory objectives were met and capacity building was accomplished. The group met bimonthly and served as the main forum for communicating progress, problems, methodology changes, and other technical issues that arose during inventory development.

The importance of following a "communication protocol" became apparent during the report-approval process. For example, it was necessary to establish and follow a set procedure for review of the interim reports that involved translation into English, distribution for review, collection of comments, and submittal of consolidated comments to ICAR. If not planned for in advance during future inventory efforts, a

communication delay or breakdown can adversely impact the project's budget and schedule.

Lesson #4:	**A quality assurance/quality control (QA/QC) plan should be available to all inventory staff at the beginning of the emissions inventory development.**

One significant challenge presented to the inventory developers was the absence of an official QA/QC plan. A QA/QC plan is important for all parts of an emissions inventory, but particularly for those components that contain large quantities of data, such as point sources. If a QA/QC plan is implemented, then questionable data or "outliers" can be identified for future research. Without a QA/QC plan in place, all data within an inventory are incorrectly assumed to be equally valid.

Also, a QA/QC plan is important to ensure the quality of the area and natural sources portion of an emissions inventory, where the many area source categories require many different emissions calculations. Although the calculations themselves may be relatively simple, errors may be made due to the large number of calculations and variety of data sources. f a QA/QC plan is implemented, then higher quality area and natural source emission estimates will be generated. Without a QA/QC plan, some crucial errors in the inventory are likely to be made, thereby invalidating portions of the findings.

A QA/QC plan should be in place prior to commencement of any data collection activities. Training should also be provided, if needed. This was particularly true for development of motor vehicle emissions in Mexicali since inventory staff were relatively unfamiliar with the estimation methodology (e.g., motor vehicle emission factor models). In this case, great effort was required simply to understand and implement the estimation methodology, and less time than necessary may have been spent performing important QA/QC activities, which may have been exacerbated by the lack of official guidance. The QA/QC plan should address both emission factor model input data and output results.

Similar to the work plan, the QA/QC plan needs to be flexible and evolve as the emissions inventory is developed in order to address the QA/QC needs of specific source categories with the data available for the inventory region. QA/QC resources should be allocated based on the relative significance of each source category to the overall emissions inventory.

Lesson #5:	**The existing Mexico Emissions Inventory Program Manuals should be updated to incorporate new methodology information identified during the Mexicali inventory effort. Development of additional manuals would help support the overall emissions inventory process.**

The primary reference materials used in development of the Mexicali emissions inventory were the Mexico Emissions Inventory Program Manuals. Specifically, Volumes II through VI provided recommended methods and guidance on a range of topics including emissions inventory fundamentals, emissions estimating techniques, and methods for estimating emissions from point sources, area sources, and motor vehicles. After each inventory effort, these manuals should be updated to incorporate any new methodology information identified for the benefit of future inventory efforts.

Having additional manuals would be helpful. Development of Volume IX (Emissions Inventory Program Evaluation) is underway; however, funding for development of the inventory manual providing specific guidance on estimating emissions from natural sources (i.e., biogenic VOC and soil NO_x) has not been secured. The absence of a methodology document addressing natural sources (planned as Volume VII of the Mexico Emissions Inventory Program Manuals) was an obstacle noted by the inventory developers during development of the Mexicali emissions inventory.

4.0 POINT SOURCES

A large number of industrial facilities in Mexicali exert considerable influence on the local economy. The emissions from these sources cannot be overlooked in the context of air quality in the Mexicali metropolitan area. This section briefly summarizes the methods used to estimate emissions from industrial (i.e., point) sources in Mexicali, and identifies several lessons learned during the emissions inventory development.

4.1 Summary of Methodology

Approximately 1,076 industrial facilities (including large, medium, small, and micro industries) are located in the Mexicali metropolitan area. The point source portion of the inventory included only the 112 facilities (primarily large and medium-sized industries) that applied for an annual certificate of operation (i.e., Cédula de Operación Anual [COA]) in 1996. Of these 112 facilities, 36 facilities were under federal environmental jurisdiction due to their economic sector (e.g., electricity generation, metal production, mineral production, etc.), and the remaining 76 facilities were under state environmental jurisdiction. Over half of the facilities (60) were maquiladora facilities (i.e., foreign-owned "twin plants") and the remainder (52) were Mexican-owned facilities. Point source emissions were primarily derived from existing federal and state records. For federal sources, data were collected from the COA itself or COA applications. For state sources, data were mainly collected from the Air Emissions Sources State Register.

In addition, a point source questionnaire (PSQ), specially designed to improve the quantity and quality of point source inventory data collected in Mexico, was implemented for the Mexicali inventory. Mexico's current COA application process facilitates data collection on a facility level and focuses primarily on combustion sources. In order to improve emissions inventory quality, the PSQ facilitates data collection on a process-specific basis (e.g., boilers, degreasers, paint spray booths,

etc.). The PSQ was used along with Volume IV of the Mexico Emissions Inventory Program Manuals (Point Source Inventory Development) (Radian, 1996) to estimate emissions from some point source categories.

Because the PSQ was significantly different from the COA, INE and ICAR offered two one-day PSQ training sessions for Mexicali industry staff. Also, ICAR provided assistance to industry staff by answering questions that arose during PSQ preparations. It was emphasized that industries would benefit from additional environmental training for their staffs and improved data quality for their official data submittals. Although PSQ results were not used as the primary data source for the point source inventory, they provided valuable insight regarding potential implementation of the PSQ on a larger scale within Mexico.

4.2 Lessons Learned

Lessons learned during development of the point source emissions inventory in Mexicali include the need to adequately define point sources (vs. area sources) and reasons for limited success of the PSQ. Also, a QA/QC plan is essential for a thorough assessment of inventory accuracy, as well as more complete documentation of inventory procedures.

Lesson #6: The size and type of sources to be included in the point source inventory should be defined at the beginning of the inventory development process. This would clearly distinguish point sources from area sources and ensure that no emissions sources are omitted or double-counted.

As noted above, point sources were defined as those 112 facilities that applied for COAs in 1996. However, the distinction between point sources and area sources as presented in the Draft Point Source Interim Report was not clear. The distinction between point and area (i.e., small, dispersed point sources) was based

upon a definition (i.e., facilities that did or did not apply for an annual operating license) rather than a numerical cutoff (e.g., emissions greater than a predetermined threshold amount). It is possible that a facility that did not apply for an annual COA might have emissions greater than a facility that did apply for a COA. This may result in a large point source either being overlooked or inventoried as an area source without important point source characteristics or location information. This could lead, in turn, to erroneous modeling or implementation of "wrong" control measures.

Because of this potentially confusing situation, it is not clear if emissions from 964 industrial facilities (1,076 facilities present in Mexicali, minus the 112 facilities with COAs or applications for COAs) have been properly accounted for in the area source portion of the inventory. The only evidence of point source and area source reconciliation (see Section 5.0, Lesson #12 for more details) documented in the Draft Point Source Interim Report is that point source liquified petroleum gas (LPG) consumption was subtracted from the overall LPG consumption in order to determine commercial, residential, and service sector LPG consumption.

Lesson #7: Certain aspects associated with training and implementation of the PSQ should be repeated during future inventory efforts, while others should be changed to achieve a higher rate of return and more complete forms.

The final return rate for the PSQ was approximately 20%. Although this return rate is low compared to the required federal COA (80%), it is similar to other voluntary surveys both in Mexico and the United States. The rate of return of the PSQ in Mexicali was influenced by several factors described as follows:

- Completion of the PSQ was voluntary and was requested only a few weeks after submittal of the (required) COA. Industry resources were adversely impacted by the "closeness" of the COA and PSQ submittals.

- Environmental consultants were hired by several companies to assist with completing the PSQ and conducting other environmental compliance activities. However, return rates and data quality did not significantly increase for those companies that retained a consultant.

- Efforts by the local agency (i.e., SEMARNAP B.C. and INE) to contact each facility via letters, and by ICAR to make followup phone calls, contributed to the high attendance rates at the training sessions (i.e., 43 industries). However, the number of one-day training sessions or the scope of the material covered may have been insufficient for some facilities; most of the submitted PSQs were from facilities that did not attend the training sessions. It should be noted that one-day sessions are easier for facility staff to attend because this format has less of an impact on work schedules than multiple-day sessions.

- There was only about one month between the industry training course and the deadline for the PSQ to be completed.

- Detailed operational records required to complete the PSQ often were not available for Mexicali industries.

- Industry was usually familiar only with monitoring or material balance emission estimating techniques; therefore, data collection favors these methods.

- Industry often was unable to provide any information beyond that required by the official COAs; many returned PSQs had data only for combustion sources.

In order to increase the PSQ return rate, several actions could be taken. One significant step would be to make the PSQ submittal mandatory. However, in the short term, this appears unlikely because legislative approval would be required. Also, a longer survey period would reduce the pressure of time constraints on facility staff, encouraging participation and more complete responses.

The two one-day training sessions were reasonably well-attended (43 facilities were represented), but additional classes likely would increase participation. ICAR received 48 calls from facility staff requesting advice regarding the PSQ;

participation rates could be improved further by proactive followup calls to industry. Overall, it appears that the PSQ may have been too complex relative to the technical abilities of the Mexicali industry workforce, as evidenced by the actual returned PSQ data collection forms and comments collected by ICAR. Additional training classes and workshops are possible tools that could be offered to facility staff to raise their level of familiarity with the PSQ and sense of value in the inventory process, thus increasing the rate of return of completed PSQs and quality of emissions data reported.

Lesson #8: The quality of the point source inventory was limited by a lack of an official QA/QC plan and guidance document.

For the Mexicali inventory, the lack of a QA/QC plan was evident by some of the technical issues discovered during the review of the draft Point Sources Interim Report (ICAR, 1999a), including:

- Incorrect totals of subsector facilities.
- Potential under-reporting of maquiladora facilities relative to other metropolitan areas and statistics stated in the Mexicali Emissions Inventory Work Plan (ICAR, 1998b).
- Potential over-reporting of CO (i.e., 95% of the point source CO was from two metallic mineral facilities).
- Potential over-reporting of SO_x (i.e., large quantities of SO_x [652 tons/yr] from four vegetable and animal product facilities).
- Virtually no HC emissions were reported from the two chemical facilities.

Lesson #9: Insufficient documentation prevented thorough review of the point source inventory. There should be enough inventory documentation in a final report to allow readers to understand the inventory methodology and the significance of the results.

Inventory documentation is an important part of every emissions inventory. Documentation should clearly describe the entire inventory methodology. Without sufficient documentation, the final inventory results may be known but the quality and meaning of those results cannot be assessed.

Although the draft Point Sources Interim Report contained several pages devoted to emission totals, there were only a few tables containing emission factor information and very little discussion regarding activity data. Because much of the point source data used in the Mexicali inventory came from existing federal and state records (many that contain confidential information), it is likely that ICAR was unable to provide this information in the draft Point Sources Interim Report. Regardless, additional explanation would be helpful regarding the following:

- How were data from official records and the completed PSQs integrated together within the inventory?
- How were existing control measures incorporated into the inventory?
- Is the inventory limited to primarily combustion emissions? Have process and fugitive emissions been included?
- What emissions were estimated with emission factors? With actual monitoring data? With material balances? With other methods?
- Do the inventory developers have other recommendations for improving the point source inventory in the future?

5.0 AREA AND NATURAL SOURCES

Area sources are a broad category that includes all emission sources that are too small and/or dispersed to be counted as point sources; it does not include on-road motor vehicles. Area source emissions are typically a significant portion of the overall inventory of emissions. In Mexicali, area sources are important contributors of HC and CO emissions, and are the predominant source of particulate emissions. Because area sources include a large number of diverse source categories, activity data must be collected from a wide variety of sources.

Unlike point source, area source, and motor vehicle emissions that all result from human activities, natural source emissions represent emissions occurring regardless of human presence. Natural emissions should be estimated in order to provide an accurate assessment of background conditions for a particular area, to understand the relative significance of each source category contributing to the total emissions, and to develop appropriate air quality control strategies.

This section briefly summarizes the methods used to estimate emissions from area and natural sources in Mexicali, and identifies several lessons learned during emissions inventory development.

5.1 Summary of Methodology

Area and natural sources comprise seven major source category "groups" within the Mexicali inventory:

- Combustion sources (e.g., natural gas combustion, non-road mobile sources, etc.);
- Evaporative sources (e.g., architectural surface coating, degreasing, etc.);
- Commercial/light industrial sources (e.g., bakeries, charbroiling, etc.);

- Agricultural sources (e.g., pesticide application, agricultural burning, etc.);
- Waste management sources (e.g., open burning, wastewater treatment, etc.);
- Other sources (e.g., structural fires, paved and unpaved road dust, etc.); and
- Natural sources (i.e., wind erosion and biogenic emissions).

Area and natural source activity data were provided by a variety of sources. In general, emission factors were applied to activity data in order to estimate emissions. For most source categories, these emission factors were provided in Volume V of the Mexico Emissions Inventory Program Manuals (Area Source Inventory Development) (Radian, 1997b). In some cases, however, INE provided new emission factors that were thought to be more appropriate for use in Mexicali than the emission factors in the Area Source Manual.

5.2 Lessons Learned

Lessons learned during development of the area and natural source emissions inventory in Mexicali include the need to explicitly define inventory pollutants and distinquish between point sources and area sources. Flexibility and innovation must be used to address unique or previously uninventoried source categories. Caution should be exercised when per-capita or per-employee emission factors are used, and priority should always be given to the use of locally measured data over average and/or default values. Finally, QA/QC guidelines are essential in producing quality area and natural source emission estimates.

Lesson #10:	**It is important to define the specific pollutants to be estimated early in the inventory development process. For a pollutant such as "hydrocarbons," where the term is ambiguous (e.g., VOC, TOC, TOG, etc.), the definition and emissions estimation methods should be documented to ensure accurate and consistent use of the definition.**

Every emissions inventory has several basic characteristics, or attributes, that must be identified early in the inventory development process in order to provide a framework for consistent and meaningful results. One of these basic attributes is the pollutants to be inventoried. For some pollutants, their definitions are explicit (e.g., CO or SO_2). Other pollutants, however, must be more clearly defined. For example, type or size of particulate matter should be designated (i.e., total suspended particulate [TSP], PM_{10}, particulate matter with an aerodynamic diameter less than 2.5 µm [$PM_{2.5}$]). Likewise, if hydrocarbons (HC) are to be inventoried, the exact HC definition should be specified (e.g., total organic gases [TOG] or volatile organic compounds [VOC]). These pollutant definitions should then be used consistently throughout the inventory.

The Mexicali Emissions Inventory Work Plan (ICAR, 1998b) indicates that total organic compounds (TOC) or TOG will be inventoried. However, reference to HC, VOC, and TOG were all made in the draft Area and Natural Sources Interim Report (ICAR, 1999b). It is possible that these three definitions were used interchangeably to represent the same group of hydrocarbons, but this is not clear. It is possible, too, that some emission factors were incorrectly applied. Also, if these three pollutants were estimated for different source categories, then the total sum of "hydrocarbons" as shown in the interim report would not necessarily be accurate.

Lesson #11:	**Because this was an initial inventory, there were several new source categories that were not addressed in the Mexico Area Source Inventory Development Manual, and other categories for which data could not be identified or deviations from the Mexico methodology were warranted. Flexibility and innovation were used to address these situations.**

Every emissions inventory is unique. Some new, location-specific source categories may be discovered for which existing emissions estimating methods do not exist, or deviations from existing methods may be necessary to accommodate alternative data types. For the Mexicali inventory, three new area source categories were identified; however, emissions from these categories were not included due to the

absence of available methodologies and data.

These categories include:

- Vehicle fires;
- Hazardous waste disposal in landfills; and
- Public latrines.

Possible sources of applicable emissions estimating methodologies for these source categories would be other emissions inventories; references containing methodologies for similar categories that could be adapted for use; and use of engineering judgment, extrapolation, or ratioing techniques based on emission totals from other similar types of sources.

Even if emissions cannot be estimated, it is still important to document the existence of the source category, type of emissions (e.g., TOG, PM_{10}, etc.), possible emissions magnitude, and relevant activity data. For example, ICAR identified brick manufacturing as a source category in the Mexicali inventory, with an estimated 10 brick manufacturing facilities located in the south part of Mexicali. Unfortunately, they were unable to identify any brick production statistics or fuel usage information. As a result, emissions were not estimated for this category. However, because ICAR documented this information in the Area Source Interim Report, it will support inventory revisions in the future.

Lesson #12:	**The distinction between point sources and area sources should be adequately defined at the beginning of the inventory development process to ensure accurate point/area source reconciliation.**

As mentioned in Section 4.2, Lesson #6, the distinction between point sources and area sources must be clear at the beginning of the inventory development process. For example, the draft Point Sources Interim Report (ICAR, 1999a) indicates that 112 facilities (those that applied for their annual operating license in 1996) out of

the 1,076 industrial facilities located in Mexicali are included in the point source inventory; therefore, it is reasonable to assume that the remaining 964 industrial facilities are included in the area source inventory. However, area source LPG consumption (i.e., commercial, residential, and service sectors) was the only source category adjusted to exclude potential point source emissions. Area source solvent and surface coating emissions were not adjusted for potential point source emissions. Furthermore, the accuracy of this adjustment for LPG combustion is questionable, because it is not clear whether or not the remaining 964 industrial facilities are actually included in the commercial, residential, and service sectors (e.g., hotels, restaurants, schools, hospitals, government buildings, tortilla factories, housing, bakeries, etc.).

In order to ensure that emissions are properly allocated to point sources and area sources, the following point source/area source reconciliation steps should be implemented:

- Examine point source records to identify all facilities that could generate emissions that might overlap with emissions from area source categories (e.g., fuel combustion, solvent use, surface coating, etc.).
- For those facilities that should have emissions but have not reported any, estimate emissions using ratios (i.e., on a per-employee, per-unit-of-fuel-combustion, or per-unit-of-production basis) or similar engineering bases.
- For each source category, subtract point source emission estimates from total emissions to obtain area source emission estimates. (See Section 2.3.1 of Volume V of the Mexico Emissions Inventory Program Manuals for more information.)

Lesson #13:	**The appropriateness of certain area source emission factors based on per-capita or default data should be assessed, and the emission factors should be modified to include location-specific data, or avoided as necessary.**

Emissions from many area source categories with very disperse emissions (e.g., surface coating or degreasing sources) often are estimated using per-capita or per-employee emission factors. Use of these emission factors assumes that generalized large-scale usage patterns are applicable. These emission factors may be appropriate for national or regional inventories, but they may not be appropriate for smaller-scale inventories. Local usage patterns may significantly affect the accuracy of emissions estimated with per-capita or per-employee emission factors. It is important that the appropriateness of these emission factors be established prior to estimating emissions.

For Mexicali, the recommended methodology for several area source categories included using per-capita emission factors derived from data developed for the Federal District of Mexico City (Departamento del Distrito Federal [DDF]). INE, however, recommended that per-capita emission factors from AP-42, which are based on U.S. data, be used to estimate emissions. Mexicali's close proximity to the U.S. might warrant use of the AP-42 emission factors; however, DDF emission factors might more appropriately represent conditions within Mexico. Currently, it is not clear which emission factors would be better to use in Mexicali. Further research into these per-capita emission factors is needed.

Every emissions inventory should ideally use measured data that accurately represent local conditions within the inventory domain. In actuality, the unavailability of local data sometimes forces the use of nonlocal data or default values. Use of nonlocal data may be appropriate in an inventory if the location from where it derived is similar to the inventory domain. The use of default values, however, will invariably introduce uncertainty into the inventory.

The use of default values occurred throughout the Mexicali inventory. Given the amount of available data in Mexicali, this was to be expected. However, care should be given when using default values. This is illustrated particularly well with the

paved and unpaved road dust categories that constitute over 60% of the estimated PM_{10} emissions for Mexicali. For paved road dust emissions, Mexicali-specific silt loading data were unavailable. Instead, the 50^{th} percentile value for low-ADT (average daily traffic) roads from AP-42 was used. The best alternative would be to collect local silt loading data. The measurement of silt loading is relatively simple and inexpensive. A less-suitable alternative, but better than using AP-42 default values, would be to use silt loading data from nearby, similar areas (i.e., Imperial County or other areas in Southern California). The default values from AP-42 should be used only as a last resort.

For unpaved road dust emissions, no silt content or soil moisture data were available, so rough estimates were made using engineering judgment. Silt content estimates were on the low end of the valid data range and lower than the average default value, and the soil moisture estimates were on the high end of the valid data range and higher than the average default value. As a result, the estimated emissions are likely to be underestimated. This is shown by the estimated unpaved road dust emission factor for Mexicali being a factor of 10 lower than that used by the ARB for their state inventory. Actual measured data are preferable to undocumented engineering judgment.

Another example of an area source methodology that was used in the Mexicali inventory and that may not accurately represent local conditions is the wind erosion methodology. Taken from AP-42, this method uses several adjustment factors. One of these adjustment factors is a climatic factor ("C") which represents a range of different wind speeds and soil surface moistures. INE and ICAR believe that the "C" factor may not be entirely applicable for an extremely arid region such as Mexicali, because the emissions estimates resulting from use of this method seem excessively high. Investigation into the "C" factor, its origin, and the range of values under which it produces the best results is needed.

Lesson #14:	**The lack of a QA/QC document and procedure prevented consistent and thorough quality review of the area and natural source inventory. Having an official QA/QC guideline would have improved the quality of the area and natural source inventory.**

For the Mexicali inventory, some of the possible QA/QC issues discovered during review of the draft Area and Natural Sources Interim Report (ICAR, 1999b) include the following:

- Fuel combustion emissions only estimated for LPG.
- Incorrect use of the recommended methodology for the asphalt application category (i.e., evaporation loss percentage applied to the entire weight of asphalt, rather than the diluent weight; unreasonable evaporation loss percentage for medium-cure asphalt).
- Potential underestimating of PM_{10} emissions from paved and unpaved road dust due to the use of default values and engineering judgment estimates.
- Potential low population of non-road mobile equipment relative to the large-scale agricultural and industrial operations of Mexicali.
- No identified area source industrial surface coating.
- Incorrect application of gasoline distribution emission factors to diesel distribution (i.e., gasoline distribution emission factors are based on typical gasoline volatility, which is much higher than diesel volatility).
- Use of some incorrect domestic ammonia emission factors (i.e., due to typographical errors).

6.0 MOTOR VEHICLE SOURCES

Like most metropolitan areas, motor vehicles are significant contributors of air pollution in Mexicali. Consequently, considerable attention was given to the motor vehicle portion of the Mexicali inventory. This section briefly summarizes the methods used to estimate emissions from motor vehicles in Mexicali, and identifies several lessons learned during the emissions inventory development.

6.1 Summary of Methodology

Vehicle travel statistics (measured in vehicle kilometers traveled [VKT]) were combined with emission factors to calculate HC, CO, NO_x, and PM_{10} emissions. Fuel consumption data and fuel characteristics were used to estimate SO_2 and lead emissions.

Motor vehicle data were collected from four primary sources:

- Comprehensive Study of Urban Transit and Transportation for Mexicali, Baja California (UABC, 1994) (VKT statistics, vehicle speeds);
- Departamento de Control de Vehículos, Secretaria de Planeación y Finanzas, Gobierno del Estado de Baja California;
- Departamento de Transporte Federal (truck statistics); and
- Petróleos Mexicanos (PEMEX) (fuel sales and fuel characteristics).

Monthly emission factors for HC, CO, and NO_x emissions were estimated using MOBILE-Juárez (a motor vehicle emission factor model modified using U.S.-Mexico border region motor vehicle data). Particulate matter emissions factors used in other Mexico inventories were provided by INE for use in Mexicali.

Because the inventory methodology for motor vehicles used emission factor models and activity data that were unfamiliar to some inventory staff, a two-day motor vehicle inventory training session was conducted at the beginning of inventory

activities. This training session included motor vehicle inventory fundamentals, data collection, and hands-on use of the pertinent emission factor computer models. The primary reference used for the training and development of motor vehicle emissions in Mexicali was Volume VI of the Mexico Emissions Inventory Program Manuals (Motor Vehicle Inventory Development) (Radian, 1997a).

6.2 Lessons Learned

Lessons learned during development of the motor vehicle emissions inventory in Mexicali include recognition of the importance of timeliness and a method of identifying emissions data, training, and a quality assurance/quality control (QA/QC) policy and plan.

Lesson #15: Sources of emissions data should be identified as early as possible in the inventory development process. Otherwise, data sources that change, or are identified late, may negatively impact the inventory development schedule and/or available resources.

To the greatest extent possible, data sources to be used in the inventory should be identified early. Also region-specific or Mexico-specific data should be used, rather than default or U.S.-specific data. Likewise, the most accurate activity data available should be used. Other circumstances also may require that new data sources be incorporated into the inventory midway through the inventory development process.

One significant data source that was quickly identified was the Comprehensive Study of Urban Transit and Transportation for Mexicali, Baja California (UABC, 1994). This study was valuable in determining the overall fleet VKT and vehicle speed. It should be noted, however, that this study may be atypical, and similar studies may not exist in other metropolitan areas within Mexico.

In contrast, there were two data sources that were identified after considerable time and resources had been expended in collecting alternative data. First, fuel characteristic data collected by the ARB were going to be used in the inventory. Several months after this decision was made, however, it was suggested that Mexicali PEMEX data would provide more accurate Reid vapor pressure (RVP) values. Another example of emissions data discovered late in the process was the Mexico-specific PM_{10} emission factors for gasoline- and diesel-fueled vehicles. While it was recognized that these factors were more appropriate for Mexicali than the recommended methodology of U.S. EPA's PART5 emission factor model, this was not disclosed until after the submittal of the first interim report for motor vehicles. In both cases, emissions had to be recalculated due to the newly identified data. Additional time and resources were spent for these recalculations. In particular, the new PEMEX RVP data made it necessary for the MOBILE-Juárez emission factor model to be rerun.

Time and effort can be saved during future Mexico inventory efforts, such as in Tijuana, since the Tijuana PEMEX data and Mexico-specific diesel PM_{10} emission factors can be used from the beginning of the inventory development process.

Lesson #16: Motor vehicle data from Ciudad Juárez and/or countrywide data were used when local data were not available in order to avoid using default U.S. data.

In general, considerable amounts of Mexicali-specific data were used to estimate emissions from motor vehicles. Also, during the Mexicali inventory, new important Mexico-specific data were made available (see Lesson #15, page 6-2). For some of the data, however, Mexicali-specific data were not sufficiently disaggregated. In these cases, Baja California (i.e., state-level) statistics or engineering judgment were used to disaggregate the data. Also, several input parameters to the MOBILE-Juárez model were set to Ciudad Juárez default values (e.g., mileage accumulation rates and model year distributions) or U.S. default values (e.g., tampering rates). Although these

approaches were not ideal, they were the appropriate choice given the lack of Mexicali-specific information, which can be attributed to the early state of motor vehicle emissions data development in Mexico.

Lesson #17: The motor vehicle training conducted at the beginning of the inventory process was successful and improved the quality of the Mexicali motor vehicle emissions inventory.

Compared to point and area sources, the methodology for motor vehicles is considerably more complex. As a result, a hands-on motor vehicle training session, including topics such as motor vehicle inventory fundamentals and operation of motor vehicle emission factor models, was conducted for ICAR and other local emissions inventory participants. Based upon ICAR's work on the motor vehicle portion of the Mexicali inventory, it is clear they learned the basic concepts of estimating motor vehicle emissions and became proficient in using motor vehicle-related inventory data and tools. This training had a direct effect on the successful completion of the motor vehicle emissions inventory, and should be repeated in areas where inventory developers are unfamiliar with the motor vehicle emissions methods. One topic that should be added to the motor vehicle training is QA/QC.

Lesson #18: The lack of a QA/QC document and procedure prevented consistent and thorough quality review. Having an official QA/QC guideline would have helped facilitate the implementation of the emissions inventory methodology (e.g., assist with planning, data collection, data management, and reporting writing) and improve the overall quality of the inventory.

Some QA/QC activities were performed at the end of the emissions inventory (e.g., fuel economies were calculated from VKT, and fuel consumption statistics for "reasonableness" and overall emission comparisons were made with other

metropolitan areas such as Guadalajara, Monterrey, and Ciudad Juárez); however, QA/QC was not widely applied to the inventory data used to calculate emissions. For instance, "reality" checks of daily VKT by different vehicle types and average vehicle speeds were not performed prior to submittal of the draft interim report.

Lesson #19: Assistance by local authorities helps to expedite collection of emissions data.

Emissions inventory development is often a time-critical exercise; therefore, it is crucial that the effort required for collection of data for all sources be identified as soon as possible. Official requests to obtain nonpublic data should be made promptly by the inventory's sponsoring agency. Staff from the sponsoring agency can also facilitate data collection in situations where there is resistance or delays from other agencies that normally do not participate in air quality-related activities.

The effort needed to collect inventory data varies depending upon the data source. Some inventory data are normally available for public use and, therefore, are relatively easy to collect during the inventory development process. Vehicle speeds and VKT data (UABC, 1994) and vehicle fleet statistics from the Federal Transportation Department and the Secretariat of Planning and Finance are included in this category. Other necessary inventory data, however, are sometimes confidential, proprietary, and/or not normally available to the public. Proper permission and authorization is typically required to access these types of restricted data (e.g., PEMEX fuel sales data and fuel characteristics).

As part of the Mexicali inventory, the PEMEX data were identified as being essential for the development of motor vehicle emissions. Initial efforts by ICAR to collect this data from the local PEMEX offices in Mexicali were unsuccessful. After ICAR reported on the difficulties of collecting PEMEX data at a meeting of the Mexicali Technical Group, INE and SEMARNAP, B.C. made an official request to PEMEX for this restricted data. This official request enabled ICAR to receive the PEMEX data with adequate time to complete their emissions calculations.

7.0 RECOMMENDATIONS

This section summarizes recommendations for future inventory efforts in Mexico. These recommendations are based on the lessons learned (procedures that went well and procedures that could be improved) from the Mexicali emissions inventory effort.

General Recommendations

- A work plan should be developed in the initial stages of every emissions inventory, regardless of whether it is a first-time inventory or a revision. The work plan provides direction for the overall inventory effort and should be based on the objectives and end uses defined for the emissions inventory.

- Methodology training sessions should be conducted at the beginning of the inventory development process in order to familiarize inventory staff with difficult or new methodologies (e.g., new point source questionnaire or motor vehicle emission factor models). Potential problems and solutions can be discussed during these sessions.

- A technical group should be established for the inventory project. This group should meet periodically to review project progress and resolve any problems encountered.

- A communication protocol should be established at the beginning of the inventory development process to facilitate the collection and dissemination of information.

- A QA/QC plan should be available to all inventory staff in order to improve overall inventory quality.

- The existing manuals should be updated to incorporate new methodology information identified during the Mexicali inventory effort (e.g., point source questionnaire, new unpaved road emission factors from AP-42, new Mexico-specific particulate emission factors for motor vehicles, etc.). Development of additional manuals would help support the overall emissions inventory process.

Point Source Recommendations

- Point sources should be clearly defined at the beginning of the inventory development process in order to eliminate double-counting and missed emissions between point sources and area sources.

- Proactive promotion of the PSQ from the beginning of the inventory effort by the sponsoring agencies (i.e., INE and SEMARNAP, B.C.) would be beneficial. It seems that some industries were unprepared to participate in this voluntary survey. Additional promotion would allow INE and SEMARNAP the opportunity to more fully explain the PSQ to industry and convince them of its benefits.

- The PSQ should be distributed so that it does not conflict with other required submittals. It was indicated that some industries were unable to fill out the PSQ because it immediately followed the federally administered Cédula.

- Because of the unfamiliarity and complexity of the new PSQ, it is recommended that a longer survey period, as well as additional training classes or "help sessions," be provided.

- In order to improve the technical capabilities of industry, additional inventory- or air quality-related training classes and workshops should be developed for industry. For example, class topics might include learning how to use AP-42, U.S. EPA's TANKS model, or monitoring data to estimate emission rates.

- Point source documentation should be developed to the extent that people uninvolved with the actual inventory development process can understand the methodology used and the associated results.

Area and Natural Source Recommendations

- Specific inventory pollutants should be defined at the beginning of the inventory development process with emission estimates made consistently following these pollutant definitions. Ambiguous use of pollutant definitions may introduce potential errors.

- Technical flexibility and innovation should be used during inventory development, when necessary. Methodologies may not exist or be appropriate for some source categories. Expected inventory data may be unavailable. Local conditions may require modifications to the existing methodology.

- Location-specific inventory data should always be preferred over default or per capita data. If location-specific data are unavailable, then default or per-capita data can be used, but only after their appropriateness for the inventory domain has been evaluated.

Motor Vehicle Recommendations

- The recommended priority of motor vehicle data, in descending preferential order, is local data, other border region data, other Mexico data, and finally, U.S. default data. Local data or other border region data are preferable over U.S. default data and should be used wherever possible.

- Motor vehicle training should be conducted at the beginning of the inventory development process. As part of this training, motor vehicle QA/QC techniques should be explained and ways to recognize potential motor vehicle data problems should be emphasized.

- Local authorities should be used to collect emissions inventory data in the most effective manner possible. This will allow inventory resources to be utilized effectively.

8.0 REFERENCES

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EPILOGUE

In conclusion, the Mexicali emissions inventory was successful in satisfying the four main inventory objectives described in Section 2.2: capacity building, methodology testing, Mexicali emissions inventory development, and support of the 1999-2003 Mexicali Air Quality Improvement Program. It is the first comprehensive inventory developed for the Mexicali metropolitan region; subsequent inventories are sure to follow as efforts to improve the air quality in Mexicali continue.

In reviewing the process used to develop the Mexicali emissions inventory, a total of 19 specific "lessons" were identified. Some of these lessons have applicability to this inventory only, while other lessons have more general applicability to many types of inventories. Although all of the lessons identified within the main text of this report are important, several of these lessons deserve some extra emphasis. These include the importance of a work plan (Lesson #1), necessity of a QA/QC plan at the beginning of inventory development (Lessons #4, #8, #14, and #18), and adequate definition of point and area sources (Lesson #6 and #12). The most important aspect of all of these lessons is that they are "lessons learned" that can be used to improve future inventories conducted in Mexico. If these lessons are reviewed both before and during subsequent emission inventory development efforts, then some of the successes of the Mexicali inventory can be repeated and some of the difficulties encountered can be avoided in the future.