Module 4: Emission Inventory Planning, Quality Assurance and Quality Control

Emission Inventory Compilation Steps

- Planning
- Gathering information
- Estimating Emissions
- Compiling the Database
- QA/QC
- Data Augmentation
- Documentation
- Providing Access to Data
Emissions Inventory Planning

- Planning is needed to ensure that the inventory objectives are met
- Step #1 is to define the inventory uses and users
- The end uses of the inventory determine:
  - The required staffing and resource allocation
  - The structure of the inventory
  - The data quality objectives (DQOs)
  - The source types, categories, and pollutants to be included
  - Necessary level of spatial and temporal resolution

Emissions Inventory Development Process

Define Purpose of Inventory

Determine DQOs

Develop IPP/QAP

Are data/ resources adequate to achieve DQOs?

Yes

No

Can Inventory needs be satisfied with lower quality data?

Yes

No

Can IPP/QAP be modified and still achieve DQOs?

Yes

No

Renegotiate Budget, Schedule, and/or Objectives
Process (continued)

1. Prepare revised inventory (include QA/QC activities)
2. System Audits: Problems Found? (Yes/No)
3. Prepare Corrective Action Plan
4. Inventory Completed

Preliminary Planning Activities

- Define the scope of the proposed inventory
  - Base year and geographical area
  - Pollutants
  - Source types and categories
  - Spatial and temporal resolution
- Staff and resource considerations
- Interagency communication
Inventory Preparation Plan

- A concise, prescriptive document that declares how an inventory will be developed and reported
- Important sections of an IPP:
  > Introduction
  > Inventory Scope
  > Description of all steps in compiling inventory
  > Emission Estimation Methodology
  > Data Management and Reporting
  > Quality Assurance Plan
  > Documentation
  > Staffing and Resources

Inventory Preparation Plan

- Introduction
  > Define uses of inventory and acceptable data quality for uses of inventory
  > Define Data Quality Objectives (DQOs)
- Inventory Scope:
  > Identify pollutants and source categories, geographic area, and time interval to be included in inventory
Inventory Preparation Plan

- Description of all steps in compiling emissions inventory

- Emission Estimation Methodology - Define all procedures that will be used to estimate emissions
  - Data collection
  - Emission estimation methodology
    - Methods should be selected for each category
    - Selection of methods is based on several factors
      - Resources available to develop the inventory
      - Data availability
      - Time schedules
      - Priority of the category
      - DQOs and Intended uses of the inventory
    - Preferred and “Alternative” methods

Inventory Preparation Plan

- Data Management and Reporting
  - Objectives:
    - To provide a reliable and systematic procedure to record, report, and manage emissions inventory data
    - To ensure inventory results are developed in appropriate format
    - To lead to selection of a data management system that will facilitate the appropriate reporting format needed to transfer, share, and store emissions inventory data
  - Select inventory data management and reporting system
    - Facilitate data backup and revision
    - Allow tracking of changes to the inventory
    - Includes: Input, Output and Management of data
  - Summarize data reporting and documentation
    - Complete files with all data fields
    - Data summaries
    - Documentation
Inventory Preparation Plan

- Quality Assurance Plan
- Documentation
- Staffing and Resources
  > Establish resource requirements and schedule
  > Identify partners and develop communication plan
    - Industry
    - Trade Associations
    - Agencies
    - Community groups

Selection of Emission Estimation Methods

- Methods should be selected for each category
- Selection of methods is based on several factors
  > Resources available to develop the inventory
  > Data availability
  > Time schedules
  > Priority of the category
  > DQOs
  > Intended uses of the inventory
- “Preferred” and “Alternative” methods
Emissions Data Management Strategy

- Objectives:
  - To provide a reliable and systematic procedure to record, report, and manage emissions inventory data
  - To ensure inventory results are developed in appropriate format
  - To lead to selection of a data management system that will facilitate the appropriate reporting format needed to transfer, share, and store emissions inventory data
- Electronic spreadsheets and databases
  - Facilitate data backup and revision
  - Allow tracking of changes to the inventory

Emissions Data Format

- Electronic submittals of data facilitate use of inventory by various entities
  - Facility-to-agency reporting
  - Agency-to-agency reporting
- Many options for reporting data:
  - U.S. EPA’s National Emissions Inventory Format (NIF)
  - U.S. EPA’s Central Data Exchange (CDX)
  - Others available to South Africa (e.g., HEAT)
Emissions Data Elements

- Emission data elements to be collected within a database system and could include:
  - Standard Industrial Classification (SIC) codes
  - Source Classification Codes (SCCs)
  - Emission rates (tons/year, kg/day, g/second)
  - Geographic location
    - Universal Transverse Mercator (UTM)
    - Latitude/longitude
    - Country, province, city, district, grid cell

Emissions Inventory Documentation

- A comprehensive document that provides adequate detail on data, methods, and calculations to duplicate the inventory results
  - Clear, concise text
  - Tables and graphs to illustrate results
  - Appropriate level of commentary related to conclusions and recommendations
- Include an outline of the inventory report within the IPP/QAP to facilitate early-feedback on content
Emissions Inventory Report Outline

- Executive Summary
  - Overview of scope, uses
  - Inventory summaries
- Introduction
  - Background, objectives, uses
  - Scope, inventory characteristics
  - Data management approach
- Point Source Inventory
  - Categories
  - Methods, data, assumptions
  - QA/QC steps, corrective actions
  - Results by source category
- Area Source Inventory
- Motor Vehicle Inventory
- Nonroad Inventory
- Natural Source Inventory
- Results by Pollutant
- References
- Appendices
  - Sample calculations
  - Additional tables, graphs

Summary: Emission Inventory Planning

- Inventory characteristics (e.g., year, pollutants, sources) are determined by the uses of the inventory
- Inventory Preparation Plan describes how and why the inventory is being developed
- Data management strategies address the elements needed to record and manage the inventory data and results
- Estimation methods are determined by the DQOs, resources, and data available
  - Least resource/data intensive methods yield most uncertain results (extrapolation)
  - Most resource/data intensive methods yield least uncertain results (source sampling)
- Proper inventory documentation allows reproduction of the emissions estimates
Questions or Comments?

Quality Assurance/Quality Control (QA/QC)

- QA versus QC
- QA Plan
- QA/QC Activities
- QA/QC Tools
- Uncertainty Analysis
<table>
<thead>
<tr>
<th>QA</th>
<th>vs.</th>
<th>QC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• External review and audit process</td>
<td>• Routine technical activities to measure and control the quality of the inventory as it is being compiled</td>
<td></td>
</tr>
<tr>
<td>• Independent review by a third party to assess</td>
<td>• Accuracy checks</td>
<td></td>
</tr>
<tr>
<td>&gt; Effectiveness of QC program</td>
<td>• Uses standardized procedures</td>
<td></td>
</tr>
<tr>
<td>&gt; Overall quality, completeness, accuracy, representativeness of the inventory</td>
<td>• Includes use of good documentation</td>
<td></td>
</tr>
<tr>
<td>• Conducted by person not involved in inventory development</td>
<td>• Carried out by members of the inventory team</td>
<td></td>
</tr>
</tbody>
</table>

**Quality Assurance (QA)**

• Quality assurance is the system of procedures used to ensure that inventory meets a specified level of quality

• Purpose is to ensure development of a complete, accurate and consistent inventory that meets the defined need
Quality Control (QC)

- Quality control is the system of routine technical activities designed to measure and control quality
- Example QC activities
  > Comparing emissions to previous inventories
  > Using checklists to ensure that all inventory development requirements are met
  > Determining outliers by using computer-aided, graphical, or other reviews

Quality Assurance Coordinator

- Individual responsible for all QA activities
- One person for entire inventory for each major section
- Individual not involved in actual inventory work
Data Quality Objectives (DQOs)

- Qualitative and quantitative descriptors to interpret the degree of acceptability of data
  - Accuracy
  - Comparability
  - Completeness
  - Representativeness
- Ensures that the final inventory meets intended uses
- DQOs must be realistic and achievable to be useful

Example DQOs Table

<table>
<thead>
<tr>
<th>DQO</th>
<th>Inventory Target Values</th>
</tr>
</thead>
</table>
| Accuracy/Uncertainty | • Achieve Data Attribute Rating System (DARS) score of ≥ 0.7 for all area sources contributing >10% of total emissions of VOC or NOx  
  • Achieve DARS score of ≥ 0.8 for all point sources ≥ 100 metric tons/yr  
  • Quantify variability of all emissions based on source test data or surveys  
  • Use expert judgement method to estimate uncertainty for all sources >5% of emissions of any pollutant |
| Completeness         | • Include 100% of all point sources equal to or greater than 100 metric tons/yr  
  • Include 90% of all other point sources  
  • Include top 20 emitting area source categories from the 1999 inventory |
| Representativeness   | • Provinces A, B, C, and D  
  • 2004 daily ozone season |
| Comparability        | • Results to be compared with the 1999 base year inventory |
Quality Assurance Plan (QAP)

- A description of specific QA and QC procedures and responsibilities
- Generally accompanies an IPP
- Initial QA/QC planning
  - Identify a Quality Assurance Coordinator
  - Restate the DQOs
  - Determine resources needed to implement the QA plan
  - Determine authority and responsibility for QA/QC plan implementation

Components of a Comprehensive QAP

- Policy Statement
  - Declares agency commitment
- Introduction
- QA Program Summary
  - Data flow
  - Points where QC procedures will be applied
- Technical Work Plan
  - Resources, documentation, schedule
- QA/QC Procedures
  - Techniques, checkpoints
- Inventory Preparation and QA/QC Activities
  - Roles and responsibilities of agencies, personnel
  - Reality checks, peer review, sensitivity checks, audits, etc.
- Corrective Action Mechanisms
- References
Primary QA/QC Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Reasonableness of Emissions, Data</th>
<th>Validity of Methods, Assumptions</th>
<th>Mathematical Correctness</th>
<th>Validity of Data</th>
<th>Accuracy of Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reality checks</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Peer review</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Sample calculations</td>
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<td>✓</td>
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<tr>
<td>Computerized checks</td>
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<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Sensitivity analysis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Statistical checks</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Independent audits</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Emissions validation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

- **Reality checks**
  - Is this number reasonable? Does it make sense?
  - You should never use the reality check as the sole criterion of quality

- **Peer review**
  - An independent review of calculations, assumptions, and/or documentation by person with a moderate to high level of technical experience

- **Sample calculations – Replication of Calculations**
  - Most reliable way to detect computational errors
  - General rule, a minimum of 10% of calculations is checked depending on:
    - Complexity of calculations
    - Inventory DQOs
    - Rate of errors encountered
Primary QA/QC Methods

- Computerized checks
  - Automated data checks can be built-in functions of databases, models, or spreadsheets or can be designed as stand-alone programs
  - Automate to
    - Check for data format errors
    - Conduct range checks to ensure data falls within specified min/max
    - Provide look-up tables to define permissible entries

- Sensitivity analysis

- Emission estimation validation

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Primary QA/QC Methods

- Statistical checks
  - Descriptive statistics
  - Statistical procedure to identify outliers
  - Statistical tests

- Independent Audit
  - Identify staffing issues
  - Evaluate the effectiveness of the technical and quality procedures
  - Provide confidence in the accuracy and completeness of the emission data
  - Determine if DQOs are being met
  - Identify the need for additional QC measures
### What QC Procedures Should I Follow?

- Best implemented through standardized checklists
- Use checklist to monitor
  - Data collection
  - Data calculations
  - Evaluation of data reasonableness
  - Evaluation of data completeness
  - Data coding and recording
  - Data tracking

### What Types of Errors Are Typically Found During QC?

- Missing facilities
- Duplicate facilities
- Closed facilities
- Improper facility locations
- Missing operating or technical data
- Erroneous technical data
- Inconsistent point and nonpoint source size designation
- Double counting
- Errors in calculations
- Data entry and transposition errors; data coding errors
QA/QC Tools

  (http://www.epa.gov/ttn/chief/eiip/techreport/volume06/index.html)
- QA/QC Checklists
- Computer software
  > Automated QC tools available
    - Format
    - Emissions

See Appendix A, B, and C included in your student handbook.

- Appendix A – Sample QA/QC Corrective Action Form
- Appendix B – Sample QA/QC Checklists
- Appendix C – Sample QA Audit Checklist
QA/QC Documentation

- QA/QC documentation should include records of QA/QC activities, especially changes made as a result of these activities
  - Any calculation sheets and QA/QC checklists
  - Responses to QA/QC audits

QA/QC Documentation: How Do I Document QA/QC Procedures?

- QA/QC must be documented and reported
- Report should include
  - Procedures used
  - Technical approach used to implement QA plan
  - Dates of each audit, and the names of the reviewers
  - Results of QA activities, including problems found, correction actions and recommendations
  - Discussion of the inventory quality
Uncertainty in Emissions Inventories

- Two types of errors cause uncertainty in emissions inventories:
  - Bias = Systematic difference between a measurement and its true value
  - Imprecision = Random fluctuations between a measurement and its true value
- Factors introducing uncertainty in emissions data
  - Variability (spatial and temporal uncertainty)
  - Parameter uncertainty
  - Model uncertainty

When Should Uncertainty in Emissions Inventories be Estimated?

- Overall objective of an uncertainty analysis is to develop confidence limits (e.g., 90-95%), about the mean of emission estimates from each source type analyzed.
- A needs analysis can help determine:
  - Degree of acceptable uncertainty
  - Appropriate statistical approach
  - Resources needed to implement the approach
### Methods and Relative Time to Estimate Emissions Uncertainty

<table>
<thead>
<tr>
<th>Time (Hours)</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>Qualitative discussion, Subjective Data Quality Ratings</td>
</tr>
<tr>
<td>&gt;500</td>
<td>Data Attribute Rating System (DARS), Expert Estimation, Propagation of Errors</td>
</tr>
<tr>
<td>&gt;1,000</td>
<td>Direct Simulation, Direct or indirect measurement, Receptor modeling (source apportionment), Inverse air quality modeling</td>
</tr>
</tbody>
</table>

### Summary: Quality Assurance and Quality Control

- QA/QC is conducted external/internal to the emissions inventory development process
- A QA Plan implements QA/QC procedures and establishes DQOs for: Accuracy, Comparability, Completeness, Representativeness
- EIIP, Volume VI is a good reference
- Uncertainty analysis can help establish level of quality of an inventory, can be resource intensive
Questions or Comments?

END

Module 4: Emission Inventory Planning, Quality Assurance and Quality Control