VOLUME VI: CHAPTER 2

PLANNING AND DOCUMENTATION

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DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

CONTENTS

FIGURES

Page

TABLES

Page

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1

OVERVIEW OF QA/QC PLANNING AND DOCUMENTATION

Inventory development activities are often limited with respect to time and resources. A key to the planning process is to identify and document these limitations, prioritize inventory-development efforts, and assure that limited resources are effectively budgeted based on priorities. It is vital, therefore, that planning and documentation activities be viewed as integral, not optional. These activities will assure development of the highest quality inventory possible within resource limitations. Planning and documentation are time-consuming in the short term. However, in the long term, good planning and documentation of inventory preparation and quality assurance/quality control (QA/QC) activities will strengthen the reliability and credibility of the inventory.

Planning and documentation are complementary activities, as shown in Table 2.1-1. Documentation of all inventory and QA/QC activities is vital because it provides:

- A record of the planned activities (including QA/QC procedures);
- A statement of the level of quality sought;
- A record of the actual activities;
- Sufficient information to perform the QA/QC activities; and
- A report on the inventory and an assessment of its quality.

Thorough planning helps ensure that the inventory data quality objectives (DQOs) are identified and ultimately met. Inventory planning activities specific to estimating emissions from point, area, mobile, and biogenic sources are discussed in the appropriate volumes of this document series. Volume I of this series provides guidance on planning and documentation for the inventory as a whole. The intent of this chapter is to reinforce the benefits of good inventory QA/QC planning and documentation, while acknowledging that the QA/QC processes selected must be flexible enough to accommodate the agency's needs and goals in developing an inventory within resource limitations. The agency's inventory needs and goals define the DQOs of the inventory.

TABLE 2.1-1

INVENTORY PLANNING, PREPARATION, AND DOCUMENTATION STEPS AND ASSOCIATED QA/QC ACTIVITIES

Inventory Activity	QA/QC Activity
1. Preliminary Planning Activities: • Define purpose and scope of inventory • Define organization and staffing roles	• Define and document DQOs (see Chapter 4 of this volume) • Identify QA coordinator; assign QA/QC responsibilities to inventory staff
2. Prepare Technical Work Plan: • Identify geographical area • Delineate pollutants to inventory • Establish point/area source cutoffs • Prioritize source categories for inclusion in inventory • Prioritize data sources • Delineate emissions estimation procedures	• Prepare QA plan concurrently with or after technical work plan • Document data-gathering methods in QA plan • Choose QA/QC procedures to be used • Determine data quality indicators (DQIs) that will be used to measure quality
3. Prepare Inventory: • Data collection • Data handling • Estimate emissions • Document inventory development activities	• Follow data handling procedures as documented in QA plan • Conduct routine QC activities • Conduct independent QA audits • Document QA/QC steps coinciding with inventory development activities
4. Inventory Reporting: • Document methods, data sources, adjustments • Discuss sources excluded and explain why • Present estimated emissions	• Prepare QA audit reports • Document QC findings and resolution of problems • Discuss QA in final inventory report; prepare separate QA report

QA/QC planning and documentation should not be viewed as optional tasks in preparing inventories; however, the level of effort may vary with the inventory DQOs. In some cases, it may not be necessary to document the planning stages of the inventory in detail. The DQOs and the level of effort required to develop the inventory determine the planning and documentation steps that should be taken. For example, an inventory that is compiled entirely from published data and does not require additional data gathering could be completed with minimal documentation of QA procedures. Such an inventory may be a simple way for an agency to delineate areas for more in-depth research on emissions sources and quantities, for example.

The inventory planning process can be described in detail in a technical work plan in which the inventory preparers typically:

- Specify the geographical area covered and base year;
- Establish and document the inventory DQOs;
- Select pollutants to be included;
- Delineate point/area source cutoffs;
- Prioritize emissions source categories and data needs;
- Identify and prioritize data sources; and
- Describe the inventory methods to be implemented.

Other aspects of a technical work plan address the selection of data handling systems, growth factors that will be used if emissions projections will be needed, and other considerations specific to the inventory's intended use (e.g., modelling).

A technical work plan can be a part of a QA plan, or a separate QA plan can be prepared in addition to the technical work plan. A QA plan contains details on the QA/QC procedures to be implemented throughout the inventory development process. A QA plan also includes a discussion of how the applicability of the data obtained will be assessed and the procedures that will be used to manipulate the data and ensure that QC checks and QA audits are performed throughout the inventory development process. The QA/QC procedures to be implemented vary depending on the ultimate use of the inventory results.

For any type of inventory, documentation is needed to record the information used in data sheets, teleconferences, model inputs, and results. All calculations and spreadsheets should be clearly documented so they can be reviewed, verified, and easily updated in the future if appropriate. Documentation should be sufficient to allow reconstruction of emissions development activities. Any required reporting that accompanies the inventory should include a compilation of emissions estimates and some type of summary documentation. The inventory report should also document the QA/QC procedures used, even if only to state that the spreadsheets were reviewed by other team members for calculation errors only and to present a discussion of the findings.

1.1 INVENTORY CATEGORIES AND REQUIRED QA PLAN ELEMENTS

The intended uses of the inventory drive the documentation needs for the inventory development and QA/QC program. Ultimately, the quality and reliability of an emissions inventory and its documentation are an appraisal of how well it has supported the goals of the program. A detailed QA plan similar to the one presented in Chapter 5 of this volume is not essential for all types of inventories.

Based on their different uses, emissions inventories can be categorized into four general groups. Each of these inventory categories may have slightly different inventory planning, QA/QC, and documentation needs. A report prepared for the United Nations Task Force on Emissions Inventories (Mobley and Saeger, 1994) lists three primary uses of emissions inventories:

- Assessments of air quality problems in an area to identify emissions sources;
- Input for air quality models; and
- Input for regulatory activities associated with policy making.

The above list focuses on the state/local agency perspective. However, other groups develop and use inventories for other reasons. Industrial facilities prepare inventories as part of a permit application or to show compliance with an existing permit. They may also submit annual inventories to be used as the basis for calculating fees. Researchers may also develop inventories to identify sources of pollutants and to use as the basis for modeling or research into mitigation opportunities.

The documentation needs of a research study designed to assess air quality problems are not as stringent as those for the other inventory uses. Top-down inventory development methods are typically used to develop emissions estimates. For an emissions inventory that will serve as input to an air quality model, the methods and activities required to validate the data are more demanding and require suitable documentation. The baseline inventory data must be source-specific, with detail on the spatial and temporal variability. Emissions inventories used in regulatory activities that define policy options, assess fees, or to demonstrate

TABLE 2.1-2

DEFINITION OF INVENTORY LEVELS

Inventory Levels	Inventory Use	Requirements	Example
I	Inventories supportive of enforcement, compliance, or litigation activities.	Requires the highest degree of defensibility. Generally involves source sampling or mass balance based on site-specific data; performance audits of equipment, traditional QA plan for source sampling activities.	Monitoring for compliance
II	Inventories that provide supportive data for strategic decision making or standard setting.	Site-specific (or region-specific) data are generally required, but not necessarily direct source sampling, performance audits of equipment.	State Implementation Plan (SIP) inventory
III	Inventories developed for general assessments or research that will not be used in direct support of decision making.	May or may not include direct measurement of sources, but often involves site-specific data of some type. QA requirements must be flexible.	Evaluation of effectiveness of alternative controls or mitigation methods; bench-scale or pilot studies
IV	Inventories compiled entirely from previously published data or other inventories; no original data gathering.	Flexible and variable.	Inventory developed for informational purposes; feasibility study; trends tracking

compliance require the most significant level of documentation. These data could potentially be used in litigation and must therefore stand up to extreme scrutiny. To date, there have been few attempts to define inventory categories on the basis of quality standards. Table 2.1-2 provides a proposed formal classification of inventories. This classification was derived from the EPA's Air Pollution Prevention and Control Division (APPCD). APPCD delineated four general project categories for field projects and specifies the accompanying QA plan requirements (EPA, 1994). The key point in delineating these categories is that although good QA/QC procedures should be followed in developing any inventory, a detailed record of the planned and implemented activities is not always required. Assigning an inventory to a category level designates what is needed in terms of project staffing, a technical work plan, a QA plan, data handling and tracking, and the level of written documentation needed.

For example, data handling, tracking, and documentation requirements are least stringent for a Level IV inventory, which is usually compiled from previously published emissions data and thus involves no original data gathering. An example of a Level IV inventory is the area source hazardous air pollutant (HAP) emissions inventory that was developed for the Chicago, Illinois area by combining State Implementation Plan (SIP) activity and volatile organic compound (VOC) emissions data with HAP emission factors and speciation profiles (EPA, 1995). The goal of this type of inventory was to quantify HAP emissions in order to evaluate emission reductions from proposed area source VOC regulations. Because the goal was primarily to obtain information and did not directly support rulemaking or compliance, a Level IV inventory was acceptable. No site-specific data were gathered for this effort. In preparing a Level IV inventory, a QA Coordinator should be named, but need not be independent of the inventory staff. A technical work plan should be prepared, but it can be a separate document from the QA plan, or a QA plan may not even be prepared. All calculations should be documented for a Level IV inventory.

A Level III inventory differs from a Level IV inventory because site-specific data of some type are gathered, so more stringent QA and documentation activities are needed. Because the resulting inventory will not be used in direct support of decision making, some flexibility is still available. However, because it may be used to support decision making or to guide future research efforts, a more detailed QA plan is warranted. An example of a Level III inventory is one that is prepared as part of an air pollution control device market potential and performance evaluation. A QA plan that describes the QA/QC procedures to be implemented should be prepared, but it can be separate from the technical work plan. It is preferred that a written DQO statement be prepared, and data handling and tracking and calculational procedures should be documented in some fashion.

The minimum QA plan and technical work plan requirements for Level I and II inventories are similar, but less detail is required for a Level II inventory. A SIP inventory is a good example of a Level II inventory; the results of the inventory are used to support decision making, but do not require the same level of defensibility as is needed for a Level I inventory. The primary difference in the QA/QC requirements for Level I and II inventories is that alternative methods regarding staffing and written documentation of DQOs and data quality indicators (DQIs) are acceptable for a Level II inventory but not a Level I inventory.

Level I usually applies to a specific facility or source, and is generally the result of a regulation or litigation. The elements of the QA plan are often specified in the regulation; for example, in the Code of Federal Regulations (CFR), 40 CFR 75 gives specific QA plan requirements for nitrogen oxides (NO_x) and sulfur dioxide continuous emission monitors installed in utility boilers to comply with acid rain provisions of the 1990 Clean Air Act Amendments. Precision and bias determinations are usually required for source sampling data. Other elements of the QA plan include sample custody, instrument calibration, and instrument maintenance requirements. The QA plan requirements are discussed further in Section 3 of this chapter.

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2

ORGANIZATION AND STAFFING

An important aspect of QA planning and documentation is the assignment of staff and responsibility. If staff members are clear on their roles and responsibilities, there is less chance of duplication of effort or missed inventory QA/QC steps. Clearly delineating staff roles also allows the inventory director to focus on matching staff capabilities with inventory development needs. The QA staff should have a good understanding of emissions inventory development procedures.

The QA plan identifies key inventory staff and responsibilities. The responsibilities of any outsiders involved in preparing or reviewing the inventory should also be clearly identified. For example, if a state air quality agency is preparing the inventory, consultants, industry personnel, staff from other state agencies, and EPA may be involved in the process.

The overall responsibility for developing the inventory is usually assigned to the agency director. Direct supervision of the inventory preparation process, including making decisions as to the level of effort and funds required to develop the inventory, delineating the DQOs, and evaluating the methods that will be used to create the inventory, is usually the responsibility of an inventory director.

For Level I and II inventories, QA responsibilities are usually assigned to a QA Coordinator. As shown on the example organization chart in Figure 2.2-1, it is preferable to have an independent QA Coordinator who communicates with both the agency and the inventory directors. Ideally, the QA Coordinator should not be a member of the inventory development staff (Table 2.2-1). The QA Coordinator reviews the staff training procedures and conducts QA audits throughout the inventory development process to verify that QC steps are being followed. As discussed in Chapter 1 of this volume, the role of the QA Coordinator is to provide an objective assessment of the effectiveness of the internal QC program and the quality of the inventory, to identify any bias in the inventory process, and to ensure that corrective actions are taken to reduce or eliminate bias.

Flexibility is needed in the QA/QC process so that the availability of staff and resources can be considered. For example, it may not be possible to have an independent QA Coordinator who is not involved in the development of the inventory. This is particularly true for Level III and IV inventories. In these cases, an alternative

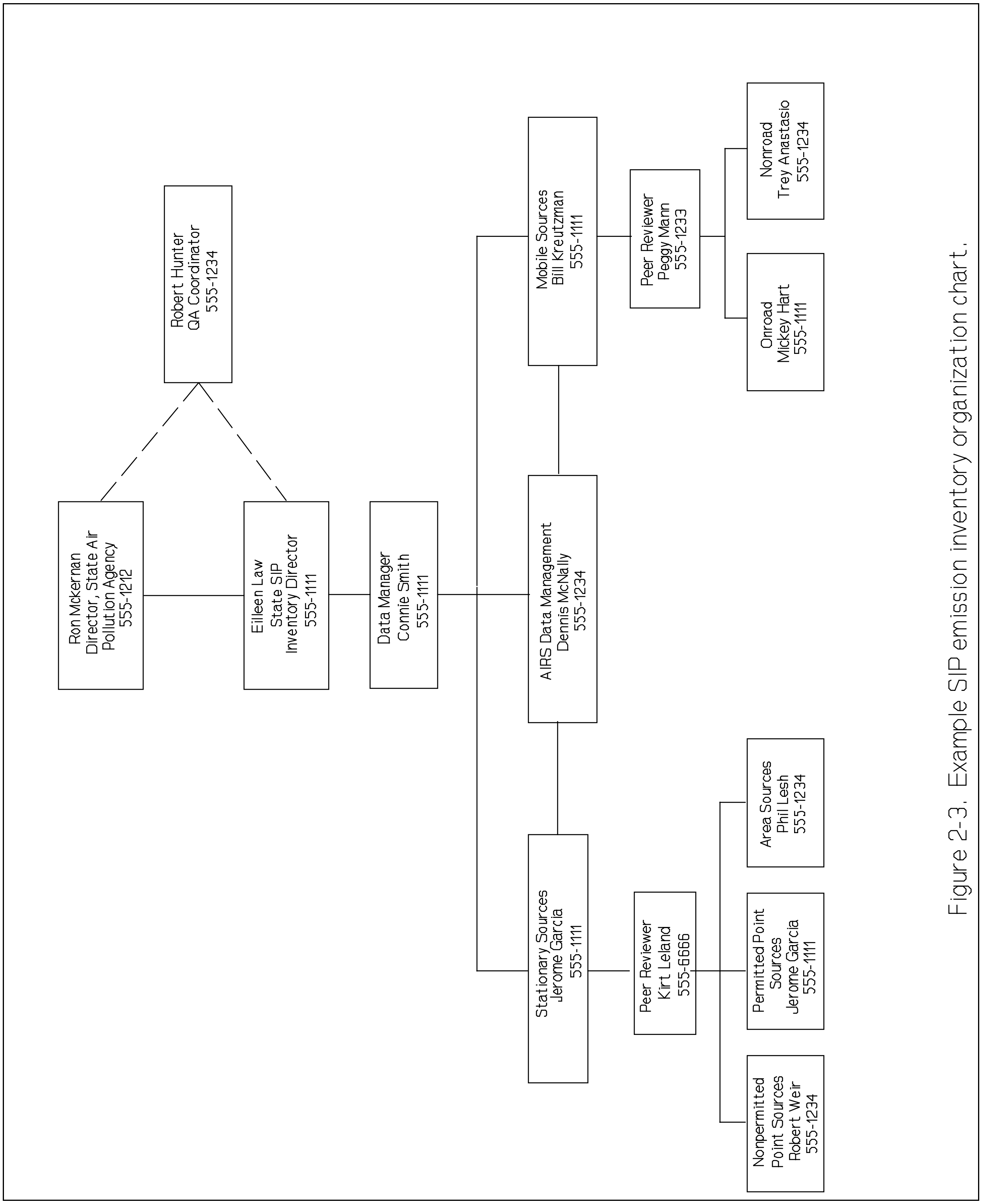

FIGURE 2.2-1. ORGANIZATION CHART FOR A SIP INVENTORY STAFF

TABLE 2.2-1
QA COORDINATOR STAFFING: PREFERRED AND ALTERNATIVE METHODS

Method	Staffing
Preferred	QA Coordinator is independent of inventory staff; conducts periodic QA audits, reviews entire inventory, and prepares QA report. Critical for Level I inventories that may be used in litigation activities. Desirable for Level II inventories.
Alternative 1	QA Coordinator is member of inventory staff; coordinates external review of entire inventory. May prepare some parts of QA report. Is acceptable for Level II, III, and IV inventories.
Alternative 2	QA Coordinator is member of inventory staff; prioritizes selected source categories for external review, coordinates review and incorporation of comments, and prepares QA report. Is acceptable for Level II, III, and IV inventories.

organization can be used. Referring again to Figure 2.2-1, the inventory director, stationary sources lead, mobile sources lead, biogenics lead, or data manager could serve as the QA Coordinator. As such, the QA Coordinator would be responsible for identifying independent peer reviewers for each general inventory category and coordinating an in-depth review. The QA Coordinator is also responsible for ensuring that all peer review comments are addressed satisfactorily.

Because of this reliance on peer review, it is important that QA staff members be chosen for their expertise in a particular area of inventory development. Expert judgement may be needed to determine the quality of the approach if no prescribed method or the required data do not exist, or certain situational factors make the preferred method inappropriate.

If inventory development resources are even more constrained, a second alternative is for the QA Coordinator to prioritize the inventory categories for external review. If this method is chosen, it is very important that the QA reviewer make clear recommendations for corrective actions and that the agency follow up on those recommendations. An external reviewer may not be able to make sure that problems are resolved. Therefore, the inventory director (or a designee) should be made accountable for following through on the recommendations of the external reviewer. A written report should be prepared to document those activities.

Regardless of the distribution of QA responsibilities, it is crucial to impress upon all inventory development and QA staff members the importance of identifying errors throughout the entire inventory development process.

2.1 EXAMPLE OF EXTERNAL REVIEW OF SELECTED SOURCES

The Virginia Department of Environmental Quality (VDEQ) hired an independent consultant to conduct a QA/QC review of portions of its 1990 ozone nonattainment SIP area source emissions inventory. The following objectives were specified for QA activities:

- Ensure that EPA guidance was correctly interpreted and implemented;
- Where EPA guidance was not followed (or was not available), assess the reasonableness of the approach used by VDEQ;
- Ensure the accuracy of input data by verifying data transcriptions from original sources (where appropriate), model inputs, and validity of any assumptions;
- Where appropriate, check the accuracy of spreadsheet calculations by replicating the calculations for at least one county's emissions; and
- If possible and where appropriate, perform some independent comparisons of emissions to other inventories.

The area source categories were selected for review based on the magnitude of the estimated emissions and/or the complexity in estimating emissions. The following area source categories were identified for external review:

- Stationary source solvent use;
- Vehicle refueling and related activities;
- Fuel combustion;
- Incineration and open burning;
- Bioprocesses;
- Waste handling facilities; and
- Leaking underground storage tanks.

In addition, the point source and the mobile source inventories were reviewed. The consultant delineated specific quality objectives that would be covered by the review, as shown in Table 2.2-2. This makes clear the scope of the QA activities, making it easier for subsequent inventory users to identify additional QA procedures that they might want to perform. (Note that this was not a complete QA audit; it is shown as an example of what can be done even when resources are limited.)

All issues encountered during the QA activities were communicated to VDEQ throughout the review. Upon completion of the external review, agency personnel had an idea of the overall quality of the emissions inventory, and could have chosen to have additional source categories reviewed if there had been some question about the data quality. Resolution of the issues was the responsibility of the QA Coordinator on the VDEQ staff.

Other states have used a similar approach, but called on staff from other state agencies to serve as peer reviewers. Regardless of who actually does the review, the key element is that the review be done independently of the actual inventory development.

TABLE 2.2-2

METHODS USED TO ACHIEVE QA OBJECTIVES FOR VDEQ INVENTORY REVIEW[a]

QA Objective	Point	Area	Nonroad	Onroad
1 Ensure correct implementation of EPA guidance.	Peer review of documentation.			
2 Assess reasonableness of VDEQ's approach where EPA guidance not used or unavailable.	• Peer review of documentation.	• Peer review of documentation; • Compared with results from other methods.	• Peer review of documentation.	• Peer review of documentation; • Compared with results from other methods.
3 Ensure accuracy input data	• Not possible since original data forms not provided.	• Checked spreadsheet entries against copies of originals; • Checked accuracy of conversion factors; • Assessed assumptions made to calculate input data (e.g., temperature).	• Checked spreadsheet entries against copies of originals; • Checked accuracy of conversion factors; • Assessed assumption made to calculate input data (e.g., engine matching).	• Used MIDAS software to evaluate MOBILE model input data.
4 Check accuracy of calculations by replicating a sample.	• All calculations were done by SAMS and are presumed to be correct.	• Recalculated emissions by hand.	• Recalculated emissions in a spreadsheet.	• Reran MOBILE input model for selected counties.
5 Perform independent comparisons with other inventories or data sources.	• Compared to TRI data; • Cross-checked SAMS and AIRS-AFS data.			• Modeled VMT compared to HPMS; • Emissions compared to those of four other states.

[a] Key to Acronyms:

AFS:	AIRS Facility Subsystem	MIDAS:	MOBILE Input Data Analysis System
AIRS:	Aerometric Information Retrieval System	SAMS:	SIP Air Pollution Management Inventory Subsystem
HPMS:	Highway Performance Monitoring System	TRI:	Toxic Release Inventory

3

QA PLAN

Prior to initiating work on any emissions inventory, it is imperative that inventory development procedures and QA/QC procedures be agreed upon and documented. Good documentation and involvement of QA personnel during the planning stages enhances the effectiveness of the QA/QC program and decreases the number of quality concerns found during the audits because expectations are clearly outlined in the QA plan and discussed with inventory development personnel prior to starting the work.

Some type of QA plan should be prepared for all inventories, with the level of effort depending on the DQOs of the inventory. The preferred method is to create an integrated technical work plan/QA plan. Chapter 5 contains a model of this type of QA plan for a Level II inventory, and Figure 2.3-1 outlines the key elements to be included. Table 2.3-1 shows which QA plan elements should be documented--at a minimum--for each category of inventory. The use of additional QA plan elements for Levels II, III, and IV inventories is strongly recommended. Furthermore, not all inventories will fit neatly into one of these categories. Modifications to the QA plan elements should be made with the end-use of the inventory in mind.

The purpose of the inventory and the inventory DQOs are defined in the introduction of a combined technical work plan/QA plan. The DQOs should be agreed upon by the agency director and the inventory director (setting DQOs is discussed in Section 4 of this chapter).

The program summary is an executive summary of the QA/QC procedures that will be used to ensure the quality of the inventory. The summary highlights the interaction among functional groups, explains the flow of data through the agency, identifies the points in the inventory procedures where QC is applied, and specifies the frequency of QA audits. Inventory constraints to be acknowledged include limitations on time, resources, data processing capabilities, and availability of personnel. The impacts of any constraints on DQOs should be projected if possible.

The technical work plan discusses staff assignments and responsibilities, including those of inventory development personnel and the QA Coordinator. It also establishes a commitment to the inventory development and QA/QC processes by delineating the resources required to develop the inventory and indicating how they have been (or will

POLICY STATEMENT

INTRODUCTION
- Purpose of inventory
- DQOs

PROGRAM SUMMARY
- Major program components and technical procedures
- Data flow through agency
- Points where QC procedures will be applied and frequency of QA audits
- Inventory constraints

TECHNICAL WORK PLAN
- Organization
  - Organization chart
  - Discussion of roles
- Resources required/how obtained
- Resource allocation
- Personnel training
- Project documentation requirements
  - Guidelines for those supplying data
  - Guidelines for those using data (data handling)
- Schedule

GENERAL QA/QC PROCEDURES
- Data quality ratings
- QA/QC techniques to be used
- QA/QC checkpoints
- Systems audits
- QA/QC review of entire inventory
  - Ensure no double-counting of emissions
  - Compare to other regional inventories for consistency
  - Completeness determination

FIGURE 2.3-1. COMPONENTS OF A COMPREHENSIVE QA PLAN

INVENTORY PREPARATION AND QA/QC ACTIVITIES

- Planning--technical approach
  - Role of state or local agency personnel; minimum QA/QC activities
  - Role of facility personnel; minimum QC requirements
  - Acceptable methods to estimate emissions; preferred method
- Sensitivity analysis to identify key sources and critical data
- Data collection and handling procedures for agency personnel
- Review of estimates
  - Data integrity QC checks
  - Completeness QC checks; ensure all emissions units at a source are included and that all point source facilities in inventory area are included
  - Consistency and reasonableness QC checks
- Data reporting

CORRECTIVE ACTION MECHANISMS

- Identification of problems during QC process
- Identification during QA process
- Documentation of corrective actions

REFERENCES

FIGURE 2.3-1. CONTINUED

TABLE 2.3-1

MINIMUM QA PLAN AND TECHNICAL WORK PLAN REQUIREMENTS FOR INVENTORY LEVELS

Element	I[a]	II[a]	III	IV
Description of project's purpose, scope, and end uses[b]	✓	✓	✓	✓
DQO statement	✓	✓	✓	
Staff organization and responsibilities[b]	✓	✓	✓	✓
Specification of data gathering/ sampling procedures[b]	✓	✓	✓	✓
Specification of estimation methods[b]	✓	✓	✓	✓
Description of internal QC checks	✓	✓	✓	
Specification of QC checkpoints	✓	✓		
Description of QA procedures to be implemented	✓	✓	✓	
Specification of QA checkpoints	✓	✓	✓	
Systems audits[c]	✓	✓		
Calculation or discussion of DQIs	✓	✓	✓	
Corrective action plan	✓	✓		
QA report	✓	✓		

[a] Although all data elements are recommended for both Level I and II, the amount of detail may vary.
[b] If two documents are prepared, these elements may be addressed in a separate technical work plan.
[c] Specific types of audits will vary (see Chapter 3, Section 8 of this volume); performance audits mandatory for all instruments used to collect data.

be) obtained and allocated among the functional groups. The technical work plan also establishes the agency's commitment to personnel training, project documentation, and schedule requirements.

The QA plan presents the general QA/QC procedures that will be implemented including a discussion of how the data will be quality rated, the QA/QC techniques to be used, and the QA/QC checkpoints. The QA plan also establishes when the QA Coordinator will complete the systems audits. Systems audits that evaluate the documentation and procedures associated with the inventory development activities are discussed. The QA plan describes the steps that will be taken as a QA/QC review of the entire inventory is conducted to ensure that no double-counting of emissions occurs. The QA plan explains that the inventory will be compared to other regional inventories for consistency and to verify that all sources of emissions are included. Along with the QA/QC activities, the inventory preparation steps including planning, data collection, review of estimates and reporting, are described in the QA plan. The QA plan also notes what corrective action mechanisms will be implemented throughout the inventory development process.

In addition to this volume, the EPA has published other information that may be helpful in preparing a QA plan (EPA, 1988, 1989).

One alternative to a combined technical work plan/QA plan is that the QA plan and technical work plan be separate documents. However, the use of a combined document is likely to result in a more cohesive and integrated inventory development and quality program. Table 2.3-2 summarizes the preferred and alternative methods.

TABLE 2.3-2

QA PLAN: PREFERRED AND ALTERNATIVE METHODS

Method	Description
Preferred	Prepare an integrated technical work plan/QA plan prior to initiating inventory development.
Alternative	Prepare separate technical work and QA plans prior to initiating inventory development.

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4

STATEMENT OF DQOs

The first step in planning any inventory is to define the purpose and intended use of the inventory. This information will, in turn, be used to determine the DQOs for the inventory as well as the QA/QC requirements.

DQOs are statements about the level of uncertainty a decision-maker is willing to accept. Their purpose is to ensure that the final data will be sufficient for its intended use. DQO statements must identify the end use or intended purpose of the data and the level of uncertainty anticipated in the emissions estimates.

It is very important to recognize that DQOs are method-specific; they are based on what is possible for a given methodology and the quality of the data available. The inventory preparers should look at the historical data. What problems have they had in the past that limited inventory quality? Can these problems be overcome for this effort? If this inventory is for a source or region that has never been inventoried, information and experiences from similar efforts should be studied.

DQOs must be realistic and achievable. However, recognition that the inventory quality is less than desirable should be documented in the DQO statement and discussed further in the QA plan (as a constraint). The impacts of weaknesses in methods, data, or other inventory elements should be included in any discussion of uncertainty (see Section 6 of this chapter and Chapter 4 of this volume).

DQOs should be planned in advance and written down. The DQIs that will be used to measure these objectives should also be specified. Specific methods for defining DQOs are discussed in Chapter 4. A complete DQO statement should address:

- Accuracy (or uncertainty) of emission estimates;
- Completeness;
- Representativeness; and
- Comparability.

The issue of *accuracy* has plagued inventory users since the concept of emissions inventories was introduced. Where emissions are measured directly, statistical measures of bias and precision can be used to qualify data accuracy. However, this is rare in a regional inventory. Emissions are usually estimated using factors and surrogate activity data. In some cases, quantitative measures of uncertainty can be made. Also, relative quality ranking systems (such as the Data Attribute Rating System or DARS discussed in Chapter 4) may be used as a quantitative method. At the very least, a qualitative assessment can be employed. For example, a discussion of data strengths and weaknesses, uncertainties, and other qualifiers will set a level of confidence for the inventory user.

The relevance of the other terms is easily shown. *Comparability* can be defined by the intended use of the inventory. For example, emissions trading programs generally require that the emissions of the sources involved be estimated or measured using similar (or identical) methods. In this situation, comparability of the estimates may be the most important DQO.

Representativeness means that the inventory is representative of the region and sources it is meant to cover; for example, if a regional ozone precursor inventory is being prepared, the categories of sources included should represent all of the major sources of VOCs, carbon monoxide (CO), and NO_x in the region. Likewise, the methods and emission factors should be representative of local conditions. The DQOs would assess how representative a national average emission factor is for certain area source categories, and may lead to the decision to use a survey of local sources instead.

Inventory preparers have always been concerned about *completeness*. The DQOs for an inventory must first establish the reference for assessing completeness. It could be a list of businesses in the area, the list of sources from a previous inventory, or some other standard. The DQOs may state that 90 percent completeness is acceptable. Different sections and subsections could have different targets for completeness; 100 percent of the 100-ton sources but only 80 percent of the remaining sources might be required.

Despite the best intentions of inventory preparers, the development effort is often constrained by schedules, resource limitations, and lack of data. The DQOs for the inventory should be realistic and need to account for any factors that will limit inventory quality. Table 2.4-1 lists the preferred and some alternative methods for DQO statements. Other alternative methods are feasible, and can be made very specific to the needs of the inventory. The important thing is that some thought be given in advance to the desired quality of the product.

Having determined the DQOs, the next, and often more difficult, step is to identify the DQIs that will be used to measure the progress towards each DQO. Quantitative measures (such

TABLE 2.4-1

PREFERRED AND ALTERNATIVE METHODS FOR DQOS AND DQIS

Method	Description
Preferred	Written DQO statement addresses accuracy or uncertainty, completeness, representativeness, and comparability. Quantitative methods are used to document inventory quality DQIs; DQIs are specified in the DQO statement and linked directly to DQOs. Critical for Level I inventories; desirable for Levels II and III.
Alternative 1	Written DQO statement addresses specific criteria, but may include less detailed discussions of accuracy or uncertainty, completeness, representativeness, and comparability, or may exclude discussion of one or more of these elements. Qualitative methods are used for DQIs, and each DQO identified is addressed specifically. The DQO statement provides some guidance on the elements to be considered for each DQI. Acceptable for Levels II and III; desirable for Level IV.

as confidence limits, numerical ranking systems, or letter grades) are preferable. However, implementing these is also more difficult. An alternative is to use qualitative DQIs, which may simply be a critical discussion of the inventory's strengths and limitations. Specific methods and examples of DQIs are provided in Chapter 4 of this volume. Table 2.4-1 also summarizes the preferred and alternative methods for DQIs.

4.1 A HYPOTHETICAL EXAMPLE OF DQOS FOR A SIP REASONABLE FURTHER PROGRESS (RFP) INVENTORY

The four general DQO categories described above have been informally used by inventory analysts to review inventory quality. Therefore, this explicit use in a more formal DQO statement is fairly easy to envision. Table 2.4-2 presents a hypothetical summary of DQOs and the minimum DQI values that might be set for an update (or RFP inventory) to a SIP inventory.

Presumably, the inventory preparers have considered the sources to be inventoried and the methods/data available. They have chosen to use DARS to set quantitative targets for inventory quality, but also want a quantitative assessment of the variability or uncertainty.

TABLE 2.4-2

DQO TABLE FOR AN RFP INVENTORY

DQO	Inventory DQI Target Values
Accuracy/Uncertainty	• Achieve DARS score of ≥0.7 for all area sources contributing >10% of total emissions of VOC or NO_x. • Achieve DARS score ≥0.8 for all point sources ≥100 tons per year (tpy). • 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	• 100% of all point sources ≥100 tpy. • 90% of all other point sources. • Top 15 area sources listed in 1990 base year SIP inventory.
Representativeness	• Counties A, B, C, and D. • 1993 daily ozone season.
Comparability	• Results to be compared to 1990 base year inventory.

The inventory preparers have also made the determination that as long as they have included all of the ≥100 tpy point sources, they only need to include 90 percent of the remaining point sources. They are also dropping smaller area sources. Not much is made of representativeness in this case. Only the region and relevant year are specified. However, other attributes could be added such as seasonal considerations, conditions that might require adjustments to some emission factors, or other specifications.

Finally, if this inventory must be comparable to the 1990 base year inventory because it will be used to show reductions (or increases) in emissions, the use of comparable methods may be very important. Otherwise, detailed documentation will be needed to demonstrate that differences in emissions are not simply results of the different methodologies, but result from real changes in activity. Additional guidance may be needed on how to ensure comparability while achieving the other DQOs. For example, if meeting the accuracy DQO requires use of a new (and improved) method, the 1990 estimate may have to be recalculated or adjusted to ensure comparability.

A table such as the one shown in Table 2.4-2 may sufficiently describe the DQOs. However, usually some additional details are needed. These may be provided as text in the DQO statement or may be included elsewhere in the QA plan (see Section 3 of this chapter).

4.2 AN ALTERNATIVE APPROACH TO A DQO STATEMENT

The Intergovernmental Panel on Climate Change (IPCC), in collaboration with the OECD and the International Energy Agency (IEA), has led the development of a series of inventory guidance documents for the preparation of greenhouse gas inventories (IPCC/OECD, 1994a, 1994b, 1994c). The guidelines are to be used by individual countries to prepare national inventories. The guidelines must balance the need for well-documented inventories of known quality with the widely varying resources and technology available to participating countries.

The IPCC has essentially one clearly stated DQO, which is to "use comparable methodologies for inventories" because each country is free to use a range of methods at different levels of detail. The IPCC’s approach to ensuring comparability is to establish minimum requirements for reporting data that allow for comparison and identification of differences in the methods used. These reporting requirements include "Minimum Data Tables" for various categories, standardized summary and overview tables, and specific reporting elements.

The IPCC has incorporated other DQOs somewhat informally into its guidelines. In a chapter entitled "Reporting the National Inventory," specific QA/QC procedures are listed (the term "verification" is used rather than QA/QC). The last task listed (IPCC/OECD, 1994a, p. 3.5) is to "prepare a brief self-assessment of the quality of the resulting inventory" Furthermore, specific tables are provided for reporting the inventory quality, as shown in Figure 2.4-1. This table indirectly identifies the data attributes of interest without setting specific objectives or targets for quality. Quantification of uncertainties is strongly encouraged as well, and specific methods are described in the IPCC guidance (see also Chapter 4 of this volume).

Table 7A Overview Table for National Greenhouse Gas Inventories

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documen-tation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Total National Emissions and Sink									
1 All Energy (Fuel Combustion + Fugitive)									
A Fuel Combustion									
B Fugitive Fuel Emission									
2 Industrial Processes									
3 Solvent and Other Product Use									
4 Agriculture									
A Enteric Fermentation									
B Animal Wastes									
C Rice Cultivation									
D Agricultural Soils									
E Agricultural Waste Burning									
F Savannah Burning									
5 Land Use Change & Forestry									
6 Waste									

KEY							
Estimates		**Quality**		**Documentation**		**Disaggregation**	
code	*meaning*	*code*	*meaning*	*code*	*meaning*	*code*	*meaning*
PART	Partial estimate	**H**	High confidence in estimation	**H**	High (all background information included)	**1**	Total emissions estimated
ALL	Full estimate of all possible sources	**M**	Medium confidence in estimation	**M**	Medium (some background information included)	**2**	Sectoral split
NE	Not estimated	**L**	Low confidence in estimation	**L**	Low (only emission estimates included)	**3**	Sub-sectoral split
IE	Estimated but included elsewhere						
NO	Not occurring						
NA	Not applicable						

FIGURE 2.4-1. INVENTORY QUALITY TABLE USED BY IPCC/OECD (TABLE HAS BEEN ADAPTED FROM IPCC/OECD AND EDITED TO FIT PAGE)

Rather than stating detailed DQOs and specifying targets for the DQIs, the IPCC approach is to make it as easy as possible for inventory users to assess the comparability of the methods. This approach is not the best way to ensure quality, but in some circumstances it is probably a more realistic approach.

4.3 AN EXAMPLE DQO APPROACH FROM THE NAPAP EMISSION INVENTORY

Another example of documented inventory DQOs is from the EPA's 1985 National Acid Precipitation Assessment Program (NAPAP) emission inventory QA/QC plan (EPA, 1986). The objective of the NAPAP inventory was to compile a comprehensive and accurate inventory of emissions and facilities data from natural and anthropogenic sources for the 1985 base year. The EPA developed the DQOs based on the use of the inventory data. For example, one key use of the data was to support atmospheric modeling activities. This required accurate location of emissions sources both geographically and spatially. The EPA also acknowledged the constraints to the inventory because of a tight schedule, budget constraints, and limited availability of emission factors for some source categories (which will affect accuracy). To overcome the problem of scheduling the resources needed to assist with the resolution of questions raised in QA/QC checks, the EPA developed a computerized routine to check for as many of the NAPAP DQOs as possible. The EPA also prioritized sources to be included in the inventory based on pollutants and pollutant quantities emitted, stack heights, and type of industry (combustion sources, petroleum refineries, etc.).

The definition and specification of DQOs in the NAPAP QA/QC plan does not entirely coincide with the approach presented here. However, the basic concept of data accuracy is addressed. The DQOs focused more on identifying critical data elements (such as ensuring accuracy of geographical location), most of which related to representativeness of the inventory.

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5

DATA HANDLING

Data handling is an important but often overlooked element of good QA. Information (or data) can come from many different sources, requiring varying degrees of checking, processing, and storage. The key elements of data handling procedures that need to be addressed in the QA program are:

- Tracking data received from different sources in various formats;
- Documenting and managing corrected data; and
- Checking data after conversion to inventory format.

These procedures can be done manually or by use of computerized databases. The methods selected will depend on several factors including the size of the inventory, the inventory level, the number of calculations to be made, and time and budget constraints. In developing most inventories, both hard-copy and electronic data must be dealt with.

5.1 DATA GATHERING

The data handling section of a QA plan discusses how data will be gathered and how subsequent emissions calculations will be affected. The backbone of any data handling system is the project filing system. The organization of the filing system, specifically the names of files and examples of the contents of each, should be specified in the QA plan. The filing system should be set up so that a newcomer could find all relevant data in a logical order if needed. Could an independent QA auditor, for example, trace the sources of data reported in the inventory through the filing system back to the original source?

Regardless of the inventory category level, pertinent information for data obtained from all sources should be kept in a project file. If data are obtained from facility surveys or site visits, the original survey forms and site visit notes and reports should be kept in the project file. Complete copies of all pertinent source test reports should also be kept in the project file. For data obtained from other media, such as electronic bulletin boards or databases, hard-copy printouts of pertinent data should be kept in the project file (if they are not too cumbersome), along with an electronic copy of the original data. For very large databases, a hard-copy summary or description of the database (including date and contents) should be kept with the electronic copy.

Data or information used to develop assumptions or estimation methods can come from several different sources including:

- Published books, documents, reports, or articles;
- Unpublished documents or reports;
- Personal communication via letter, facsimile, or computer e-mail; and
- Personal communication (spoken).

If the data source is published (and presumably available to anyone), a complete citation of the source should be kept in the project file. If feasible, the pages containing specific data should be copied and kept in the file.

Unpublished data sources require that more information be maintained in the file. It is preferable that the entire document, letter, or facsimile be kept in the file. If this is not possible for larger documents, the relevant pages and cover/title pages should be copied and filed. Computer e-mail (or other electronically transmitted information) should be printed and filed.

Any information obtained by telephone, at a meeting, or by other unwritten means should be recorded in a contact report. Standardized forms will help remind staff to record all pertinent information. An example is shown in Figure 2.5-1.

As data are obtained from external sources, it is important to document standardized log-in procedures and verify periodically that the procedures are being followed. Similarly, anyone taking something out of the file for temporary use should sign it out. An early QA audit is a good way to evaluate data handling procedures.

Even when much of the inventory development is done by an electronic database system, some handwritten documentation is usually needed. Each staff member should be assigned a project-specific notebook for recording all calculations and assumptions. If spreadsheets are used for any part of the inventory development, the project file should contain up-to-date electronic versions. The project file should also include copies of completed data entry forms used if the data are combined into a master database. The project file should also contain a discussion of statistical data handling procedures (if relevant), with written documentation of the assumptions made and how outliers in the data were treated.

QC review by inventory team members throughout the emissions estimation process is crucial. It is at this stage in the process that all assumptions, data entry, and

CONTACT REPORT

Date 6/5/95 Originator Joan Brown

CONTACT BY: TELEPHONE X MEETING OTHER ______

NAME, TITLE, & ORGANIZATION J.P. Morgan, Ozoneville DEQ
ADDRESS & TELEPHONE NUMBER 541-5555
PURPOSE OR SUBJECT (Give project number if appropriate) XYZ Industries Title V Permit Application

SUMMARY:

J.P. Morgan (permit engineer) was called to determine if the state had any guidance on how to group emissions from a set of related emission units (see contact report for J. O'Conner).

J.P. indicated that the state will allow grouping of emission units as long as each piece of equipment is listed (such as paint booth, drying oven, touch-up). Emissions from each piece of equipment do not need to be specified individually as long as mass balance is used to estimate emissions from the group (paint used - waste = emissions) and all emissions go to one stack. (He also said if hardware controls were added later, we may have to be more specific about emissions).

ACTION: Distribute this information to the XYZ team.

FIGURE 2.5-1. EXAMPLE CONTACT REPORT

calculations are reviewed for technical merit, and transcription and/or data entry errors are also detected. The key here is to encourage all inventory and QA staff members to identify errors throughout the entire inventory development process. Specific QA and QC methods are described in Chapter 3 of this volume and some examples of documentation for specific methods are given. These completed checklists, log sheets, tables, or reports should be kept in the project file.

5.2 ELECTRONIC DATABASES

Data gathered and entered into an electronic database to develop and store emissions estimates should first be validated. A QA/QC program that deals with electronic databases should:

- Check the accuracy of the data input;
- Ensure that emissions are calculated accurately and in a manner consistent with selected methods;
- Ensure that all emissions units are reported and emissions are calculated correctly; and
- Ensure the overall integrity of the database file.

These objectives are met by technically reviewing the input data (QC review), reviewing the emissions estimation methodology, comparing the results of some emissions estimates with estimates calculated by hand, and developing a checklist of emissions sources based on site visits and data gathering efforts and comparing the list to the emissions sources in the database file. Specific methods for accomplishing these tasks are discussed in Chapter 3. Logs should be maintained to track data for each emissions unit as it is entered into the database and its accuracy is checked. Two examples of systems for tracking data entry and flow are provided below. These examples apply most directly to Level I and II inventories. For Level III and IV inventories, less stringent approaches can be used, provided data entry and manipulation are of high quality.

5.3 TRACKING DATA ENTRY

A fairly typical approach for inventory development requires some data manipulation prior to entry into an emissions calculation program or a computer-based data repository. Sometimes the data will change hands several times during this process. It is therefore very important that the person responsible for each step and the date of the activity be recorded.

In the first example system for tracking data entry presented, data to be used in estimating emissions for a military base were gathered on site. Emissions for some sources are to be estimated using the Air Quality Utility Information System (AQUIS) designed by Argonne National Laboratory for the U.S. Air Force; for others, emissions must be calculated in spreadsheets or by hand, and then entered in AQUIS. Data entry is handled by two people, one of whom is the database administrator. The data were reviewed for accuracy (using sample calculations, peer review, and reality checks as described in Chapter 3 of this volume) prior to entry into AQUIS. After AQUIS data entry, the data were reviewed again to correct any transcription errors. Each step was recorded on a logsheet that was updated electronically and distributed to staff periodically. An example of this tracking sheet is shown in Figure 2.5-2.

In addition, data entry into AQUIS was tracked in more detail. This was necessary because more than one person could enter data; also, the inventory was changing often with updates or corrections. Figure 2.5-3 gives an example of a data entry log.

This level of manual tracking is very tedious, but is necessary--especially when several people are working on the same database. More sophisticated emissions software may have tracking procedures built in that show when an element was last changed and by whom. Depending on the level of detail provided by these computerized "audit trails," some of the manual tracking may not be needed.

5.4 STANDARDIZED QA PROCEDURES FOR ELECTRONIC DATA SUBMITTALS

State agencies must assemble data from many sources, often passing them through different groups within the agency. A second example of a standardized data handling procedure is provided by the California Air Resources Board (ARB), and is depicted in Figure 2.5-4. ARB has standardized procedures to handle emissions inventory data as they are received by the air quality management districts and ARB. The data are reviewed in a hierarchical fashion, beginning with Level 0 data that are provided directly by the source facilities; the district has little direct knowledge of the data quality.

After district personnel have reviewed the facility data by checking for completeness and accuracy and screening for computational errors, the data are referred to as Level 1a data. When the Level 1a data are converted by the district to standard ARB format they termed Level 1b data. This process allows for another completeness check. After ARB inputs the Level 1b data into the electronic database system (EDS), they become

OZONEVILLE ARSENAL INVENTORY REPORTS				County name:	Ozoneville	
Source Category Progress Log				Inventory manager:	A. Griffith	
Last update:	06/06/96					
		Enter date :				
Source Category Description	Source Manager	Through Review	EDI Entry Started	EDI Entry Complete	QA/QC Complete	Write-up Complete
Emergency generators	B. Fife	x	7/20/94	7/28/94	8/04/94	x
Boilers	B. Fife	x	7/20/94	7/28/94	8/04/94	x
Degreasers	N. Bates					
Paint booths	N. Bates	x	7/20/94	7/28/94	8/01/94	
Welding	N. Bates	x	7/08/94	7/09/94		
Cutback asphalt	B. Fife	x	7/20/94	7/21/94		
Abrasive cleaners	B. Fife	x	7/05/94	7/07/94	8/01/94	x
Spills	B. Fife					
Miscellaneous paint use	B. Fife	x	8/06/94			
Wood cyclones	F. Kruger					
Fire fighter training	F. Kruger	x	7/28/94	7/31/94	8/01/94	

FIGURE 2.5-2. EXAMPLE INVENTORY DEVELOPMENT TRACKING SHEET

	EDI Data Entry Log for:						
		Last Update:	06/06/96				
Date	EDI ID	Source Category	Name of data entry person	Date QC'd	QC Name	Problem? (Y/N)	Describe Problem
7/8/94	24000	IFRTS	B. Fife	8/1/94	A. Griffith		
7/8/94	24001	IFRTS	B. Fife	8/1/94	A. Griffith		
7/8/94	24002	IFRTS	B. Fife	8/1/94	A. Griffith		
7/8/94	24003	IFRTS	B. Fife	8/1/94	A. Griffith	Y	Check throughput next visit
7/19/94	16000	Fuel Loading	G. Pyle	7/26/94	H. Crump		
7/19/94	16001	Fuel Loading	G. Pyle	7/26/94	H. Crump		
7/19/94	16002	Fuel Loading	G. Pyle	7/26/94	H. Crump	Y	EDI not speciating emissions
7/19/94	16003	Fuel Loading	G. Pyle	7/26/94	H. Crump		
7/19/94	16004	Fuel Loading	G. Pyle	7/26/94	H. Crump		
7/19/94	16005	Fuel Loading	G. Pyle	7/26/94	H. Crump		
7/20/94	13000	Cutback Asphalt	H. Crump	7/25/96	B. Fife		
7/20/94	14010	Boilers	H. Crump	7/25/96	O. Taylor	Y	EDI calcs different from hand calcs
7/20/94	14020	Boilers	H. Crump	7/25/96	O. Taylor		
7/20/94	14030	Boilers	H. Crump	7/25/96	O. Taylor		
7/27/94	14040	Boilers	H. Crump	7/25/96	O. Taylor		
7/27/94	14050	Boilers	H. Crump	7/25/96	O. Taylor		
7/27/94	20000	Degreasers	J. Beasley	8/19/96	B. Taylor	Y	Check values entered for fuel usage
7/27/94	20001	Degreasers	J. Beasley	8/19/96	B. Taylor		
7/27/94	20002	Degreasers	J. Beasley	8/19/96	B. Taylor		

FIGURE 2.5-3. EXAMPLE DATA ENTRY LOG

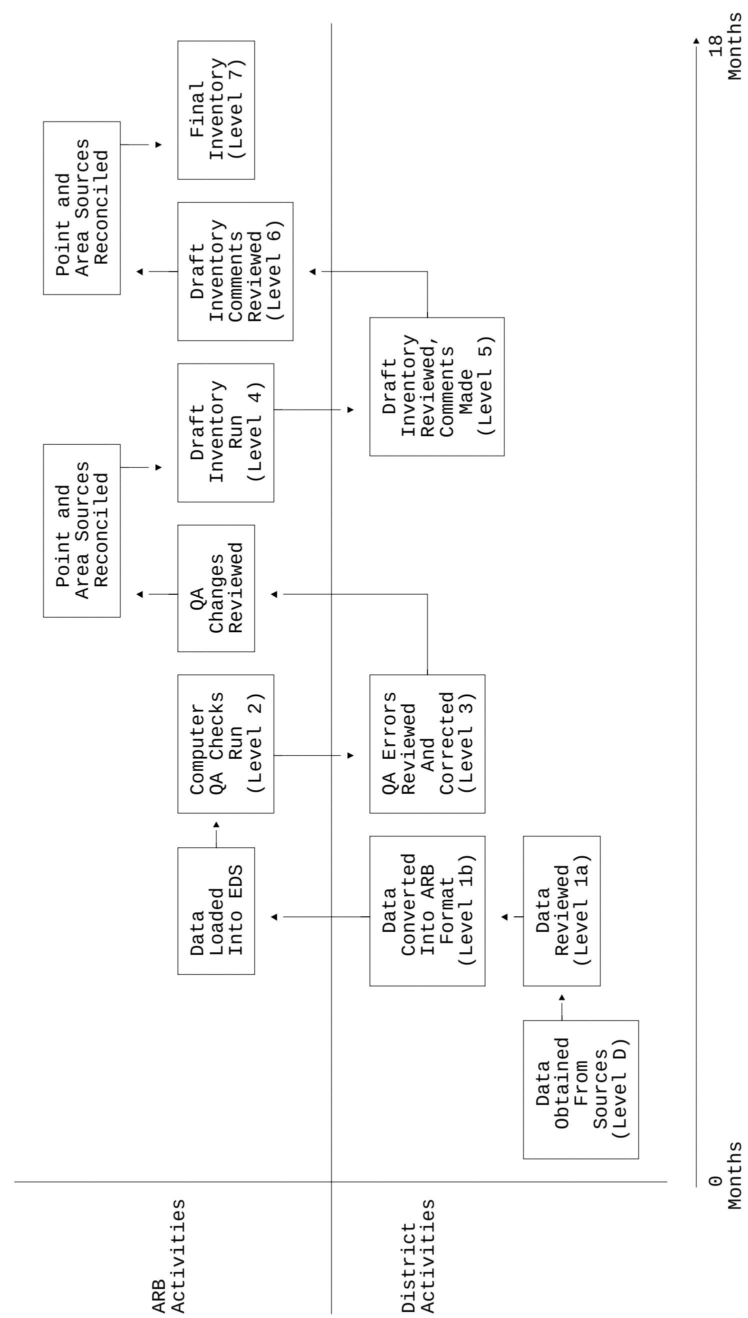

FIGURE 2.5-4. EXAMPLE STANDARDIZED DATA HANDLING PROCEDURE

Level 2 data. Then data are subjected to a variety of computerized QA checks by an independent staff.

Level 2 data are transmitted back to the districts along with a summary of potential errors. There are numerous transmittals to and from ARB (Levels 3-6) as the districts make the necessary corrections and return the data to ARB with recommended changes to the data in EDS. Final inventory data are referred to as Level 7 data.

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6

DOCUMENTATION OF INVENTORY COMPONENTS

Previous sections of this chapter have stressed the importance of planning and described the appropriate documentation for each specific procedure. However, written documentation of calculations, assumptions, and all other activities associated with developing the emissions estimates is also a key element of the QA program. Preferred and alternative methods for documenting the planning procedures (technical work plan/ QA plan) and DQOs (DQO statement) are described in Sections 2, 3, and 4 of this chapter.

This section covers documentation of the work that is actually performed during inventory development. The following topics are addressed:

- Documentation of calculations (hand calculations, spreadsheets, databases);
- Documentation of the QA program implementation; and
- Documentation of the results (the inventory report).

As with other elements of inventory preparation, the level of documentation detail required for a specific inventory will vary. The definitions of the Levels I through IV inventory categories given in Section 3 may be used as a guide to the amount of documentation required.

Documenting inventory preparation activities allows the QA Coordinator and others to ensure that the inventory report accurately reflects the data. Examples of topics requiring good documentation in the inventory development process include:

- Point/area source cutoffs to demonstrate that double-counting of emissions does not occur;
- Point source information on survey mailout procedures, tracking and logging of returned surveys, and verification procedures for source test data;
- Adjustments made to source test data to represent longer periods of time, seasonal influences, etc;

- Data obtained from permit and compliance files;
- Adjustments made for applicable rules: control efficiency (CE), rule penetration, and rule effectiveness;
- For area sources in particular, information obtained on emission factors and activity data;
- Data references;
- Adjustments made for local conditions, and assumptions made to adjust for scaling up emissions to account for "nonreported" sources; and
- Mobile source documentation: vehicle miles traveled (VMT), traffic speeds, miles of roadway for each roadway class, hot- and cold-start percentages, vehicle age distribution, etc.

6.1 DOCUMENTATION OF CALCULATIONS

Emissions calculations are generally accomplished using one or a combination of the following methods:

- Handwritten calculations;
- Spreadsheets; and
- Emissions models or databases.

The electronic methods can be very simple or quite complex. However, even when a sophisticated emissions database or estimation program is used, some calculations on the input data may still be needed. At the very least, any assumptions or caveats about the data should be documented. Documentation of calculations should be performed for all inventories, Levels I through IV.

6.1.1 DOCUMENTATION OF HAND CALCULATIONS

All calculation sheets should provide the following information:

- The preparer’s name;
- Date created (and modified, if applicable);

- Signature of reviewer;
- Date reviewed;
- Citations for all data used;
- List of assumptions; and
- Page number (showing total pages as well).

Calculations should be done in ink (not pencil); any errors should be corrected by drawing one line through the number and writing the correct value above (or nearby). Standardized calculation sheets can be used to prompt staff to remember to provide all of the above information. In addition, written procedures for documentation requirements should be provided, preferably as part of the technical work plan. However, if the agency already has standard guidance or standard operating procedures (SOPs) for documentation, these can be referenced in the technical work plan.

6.1.2 DOCUMENTATION OF SPREADSHEET CALCULATIONS

Documentation is also important on spreadsheets used to calculate emissions, whether they are part of a formal inventory report or an informal report. The spreadsheet contains all pertinent information used to estimate emissions. The information that should be included on the spreadsheet is similar to that required for handwritten calculations. Because spreadsheet calculations are hidden on the hard copy, additional documentation is needed. The minimum information required is:

- The preparer's name (author);
- Date created (and modified, if applicable);
- Spreadsheet version number;
- Name of spreadsheet reviewer (QC check);
- Date reviewed;
- Citations of all references from which data were obtained (the project file will contain copies of all reference materials);
- All constants, factors, or other data (i.e., no hidden data);

- All calculation documentation (as footnotes or in some other manner); and

- Page number.

A number of alternative spreadsheet designs will fulfill the above requirements. The simplest approach is to show all values used in a calculation as columns (or rows). However, if there are a large number of repetitive values, more concise layouts are better. Figure 2.6-1 gives an example of selected pages from a spreadsheet used to develop area source emissions from gasoline distribution (the entire spreadsheet is not shown). The information at the top serves to document assumptions and values used in the equations; they are also referenced by the appropriate equation in the main table of the spreadsheet. The footnotes at the bottom of the last page also document assumptions and equations used.

6.1.3 DOCUMENTATION OF EMISSIONS DATABASES OR MODELS

Increasingly, emissions inventories are being developed and/or compiled using computerized emissions databases or models. Presumably, the methods, assumptions, and any data included with the software are documented in a user's manual or a technical manual. If not, the user should conduct extensive and careful QA of the model (see Chapter 3, Section 4, "Calculation Checks") or find a better documented system.

Even if the system is well documented, the user will need to provide information about the input data. Comment fields, if available and sufficiently large, can be used to record assumptions, data references, and any other pertinent information. Alternatively, this information can be recorded in a separate document, electronically or otherwise. If at all possible, the electronic database should record a cross-reference to that document. This cross-reference could be a file name (and directory or disk number), a notebook identification number or code, or other document.

	Project number:	123-456-78-99			Special Inputs						
	Project name:	ODE Emissions inventory			1. Dist. of OZ Gasoline (Reference 1)						
	Date Created:	08/06/88			County	VMT	Percentage				
	Last modified:	06/06/96			A	8852	17.20%				
	Author(s):	Joseph Smith			B	12804	24.89%				
	File Name:	OZ Gas Distribution			C	7954	15.46%				
	Checked:	Maryanne Jones			D	17471	33.96%				
	Version Number:	4.00			E	4371	8.50%				
	Purpose:	To calculate the VOC emissions for the			OZ Total	51452	100.00%				
		distribution of gasoline in Ozone State.									
			2. Base Emission Factors (Reference 2)								
			2.1 Transit losses (loaded w/ product)				0.005	lb VOC/1000 gal of gas			
			2.2 Transit losses (return w/ vapor)				0.055	lb VOC/1000 gal of gas			
			2.3 Splash underground tank filling				12.18	lb VOC/1000 gal of gas			
			2.4 Submerged underground tank filling				5.04	lb VOC/1000 gal of gas			
			2.5 Vapor balance underground tank filling				0.3	lb VOC/1000 gal of gas			
			2.6 Underground tank breathing				1.0	lb VOC/1000 gal of gas			
Ozoneville Metropolitan AQMA O3 Season: Summary of Emissions From Automobile Gasoline Distribution, SCC 25-01-060- , and Transit Losses, SCC 25-05-030-120											
	(b) OZ State County	(c) 1990 County Gasoline Use (Reference 3) (1000 gal/yr)	(d) Transit Loss (loaded tank truck) (tons/yr)	(e) Transit Loss (empty tank truck) (tons/yr)	(f) Total Transit Losses (tons/yr)	(g) Total Transit Losses (lb/day)	(h) Station Loading Losses (tons/yr)	(i) Station Loading Losses (lb/day)	(j) Station Breathing Losses (tons/yr)	(k) Station Breathing Losses (lb/day)	(Ref 6) (l) Vehicle Refueling (tons/yr)
1. Non-Attainment Areas Within OZ State											
1.1 Ozoneville Metropolitan Area											
	County1	213,097	0.7	7.3	8.0	51.2	149.1	956.0	106.5	585.4	286.6
	County2	308,235	1.0	10.6	11.6	74.1	215.7	1,382.8	154.1	846.8	414.5
	County3	630,114	2.0	21.7	23.6	151.5	405.1	2,597.0	315.1	1,731.1	805.7
	County4	191,479	0.6	6.6	7.2	46.0	134.0	859.0	95.7	526.0	257.5
	County5	39,208	0.1	1.3	1.5	9.4	112.8	723.1	19.6	107.7	169.4
	County6	420,585	1.3	14.5	15.8	101.1	294.3	1,886.8	210.3	1,155.5	565.6

FIGURE 2.6-1. DOCUMENTATION OF A SPREADSHEET USED TO DEVELOP AREA SOURCE EMISSIONS

	(b) OZ State County	(c) 1990 County Gasoline Use (Reference 3) (1000 gal/yr)	(d) Transit Loss (loaded tank truck) (tons/yr)	(e) Transit Loss (empty tank truck) (tons/yr)	(f) Total Transit Losses (tons/yr)	(g) Total Transit Losses (lb/day)	(h) Station Loading Losses (tons/yr)	(i) Station Loading Losses (lb/day)	(j) Station Breathing Losses (tons/yr)	(k) Station Breathing Losses (lb/day)	(Ref 6) (l) Vehicle Refueling (tons/yr)
	County7	105,224	0.3	3.6	3.9	25.3	73.6	472.1	52.6	289.1	141.5
	County8	50,619	0.2	1.7	1.9	12.2	33.5	214.8	25.3	139.1	65.3
	County9	641,903	2.0	22.1	24.1	154.3	412.7	2,645.6	321.0	1,763.5	820.8
	County10	234,536	0.7	8.1	8.8	56.4	155.2	995.2	117.3	644.3	302.5
	Subtotal	2,835,000	8.9	97.5	106.3	681.5	1,986.2	12,732.3	1,417.5	7,788.5	3829.4

2. Spreadsheet Calculation Reference and Examples

(d) Transit Losses, (loaded tank truck) (tons/yr)

=1990 County Gasoline Use (1000 gal/yr) x Transit losses (loaded w/ product, 0.005 lb VOC/1000 gal of gas), D43 =$C43*$H$12/2000

(e) Transit Losses, (empty tank truck) (tons/yr)

=1990 County Gasoline Use (1000 gal/yr) x Transit losses (return w/ vapor, 0.055 lb VOC/1000 gal of gas), E43 =$C43*$H$13/2000

(f) Total Transit Losses, (tons/yr)

= Sum of Transit Losses, (loaded tank truck) and Transit Losses, (empty tank truck), F43 = D43 + E43.

(g) Total Transit Losses, (lb/day)

= [Total Annual Emissions (tons/yr) x 2000 (lb/ton) x ozone seasonal adj.]/[52 (wk/yr) x activity level (days/wk)], G43 = [F43 x 2000 x 1]/[52 x 6].

(h) Station Loading Losses (tons/yr)

Counties where Stage 1 Controls Required

= {[1990 County Gasoline Use (1000 gal/yr) x submerged tank filling (5.2 lb VOC/1000 gal of gas) x

[1-(rule effectiveness, 80%) x (rule penetration for submerged filling)x(control efficiency for vapor balance and submerged fill)]}/2000

H43=(($C43*$H$15)*(1-($T$5*$P12*(($H$15-$H$16)/$H$15))))/2000

Counties where Stage 1 Controls Not Required

= {[1990 County Gasoline Use (1000 gal/yr) x submerged tank filling (5.2 lb VOC/1000 gal of gas)] x [1-(effectiveness of submerged filling, 90%) x (control efficiency)]}/2000

H57=((($C57*$H$14)*(1-($T$7*(($H$14-$H$15)/$H$14))))/2000

(i) Total Loading Losses, (lb/day)

= [Total Annual Emissions (tons/yr) x 2000 (lb/ton) x ozone seasonal adj.]/[52 (wk/yr) x activity level (days/wk)], I43 = [H43 x 2000 x 1]/[52 x 6].

(j) Station Breathing Losses, (tons/yr)

= 1990 County Gasoline Use (1000 gal/yr) x Station Breathing Losses (1.0 lb VOC/1000 gal of gas), J43 =($C43*$H$18)/2000.

(k) Total Breathing Losses, (lb/day)

= [Total Annual Emissions (tons/yr) x 2000 (lb/ton) x ozone seasonal adj.]/[52 (wk/yr) x activity level (days/wk)], K43 = [J43 x 2000 x 1]/[52 x 6].

FIGURE 2.6-1. CONTINUED

(l) Vehicle Refueling, (tons/yr)
= 1990 County Gasoline Use (1000 gal/yr) x Refueling emission factors from Mike Keenan, NYSDEC, [L43 = C43 * Emission factor from M. Keenan].
(m) Vehicle Refueling, (lb/day)
= [Total Annual Emissions (tons/yr) x 2000 (lb/ton) x ozone seasonal adj.]/[52 (wk/yr) x activity level (days/wk)] [M43 = (L43 x 2,000 x 1.0)/(52 x 7)]
(n) TOTAL VOC Annual Emissions (tons/yr)
= Sum of annual transportation emissions + annual station loading emissions + annual tank breathing emissions + annual refueling emissions, N43 = $F43 + $H43 + $J43 + $L43.
(o) TOTAL DAILY VOC Emissions (lbs/yr)
= Sum of daily transportation emissions + daily station loading emissions + daily tank breathing emissions + daily refueling emissions, O43 = $G43 + $I43 + $K43 + $M43.
3. References
1. Fax. OZ State Dept. of Transportation, Coffee, G., to Environment Corporation, Pacino, A. July 27, 1992. Distribution of Ozone City gasoline use is based on motor vehicle miles traveled within county, p. 18.
2. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fourth Edition, EPA AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1985 (AP-42), Section 4.4 Transportation and Marketing of Petroleum Liquids, Table 4.4-7, Evaporative Emissions from Gasoline Service Station Operations.

FIGURE 2.6-1. CONTINUED

6.2 DOCUMENTATION OF QA/QC PROCEDURES

QA/QC activities and results should also be documented, either as a part of the inventory report or as a stand-alone QA report. The procedures used to meet the QA/QC objectives, the technical approach used to implement the QA plan, and the results of the QA audits should be documented.

The QA report should summarize the results of all QA activities including key problems found, corrective actions, and any further recommendations. The QA report should also discuss the inventory quality, preferably including quantitative DQIs. If no quantitative measures of quality were planned, then a qualitative assessment of the inventory's strengths, weaknesses, and uncertainties should be provided. More than one report or document may be generated as the result of QA/QC activities. In particular, a report should be prepared for each QA audit. Also, any peer review reports, checklists, forms, or QA/QC tables (or electronic database reports) constitute part of the written records of QA/QC program implementation.

For Level III and IV inventories that may not include a QA report, QA/QC activities should be documented informally (i.e., handwritten notes, comments) and kept as part of the project file. It is important that some written documentation be kept in the event that data quality is questioned.

6.2.1 EXTERNAL QA REVIEW REPORT OF VDEQ INVENTORY

As described in previous sections, an outside consultant was used by VDEQ to review specific elements of the 1990 base year SIP inventory for Virginia.

The VDEQ corrective action form shown in Table 2.6-1 facilitates documentation of QA comments and resolution of issues. This summary of major technical issues found during QA review would also include the name of the VDEQ staff member responsible for resolving each issue, his/her action plan, and proposed date of resolution should be recorded on the form. When the corrective action plan has been completed, the appropriate sections of the inventory should be reviewed again to verify that the emissions estimates are correct. The name of the QA reviewer and the date of the review should be recorded on the form.

6.2.2 QA REVIEW OF A STATE OZONE PRECURSOR INVENTORY

The results of QA checks of North Carolina's ozone precursor inventories were described in a paper presented at a meeting of the Air and Waste Management Association in June 1994 (Boothe and Chandler, 1994). For onroad mobile sources, QA checks of VMT applications and projections included consistency checks of VMT data, evaluation of linear regression

TABLE 2.6-1

VDEQ CORRECTIVE ACTION FORM

Source Category	Issue	VDEQ Person Responsible	Proposed Date of Resolution	Action Plan	Revised Inventory Reviewed and Approved (signature, date)
AREA SOURCES					
Surface Cleaning	• Use adjusted employment (total-point) to calculate area emissions.				
	• Apply effects of regulations or state clearly that there are none.				
Asphalt Paving	• Use 42 gal/bbl for conversion.				
	• Recalculate emissions without CE.				
Gasoline Tank Truck Unloading (Stage 1)	• Do not apply in counties outside VOC control areas.				
	• Recalculate controlled emissions.				
Wood Consumption	Residential: • Use correct heating value; • Use general wood stove factor rather than catalytic.				
	Commercial/Institutional: • Use correct heating value.				
	Industrial: • Use correct heating value; • Use SAF of 1 (or justify if less).				
Prescribed/Slash Burning	• Recalculate emissions after correcting error in input data.				
Municipal Solid Waste Landfills	• Use emission factor consistent with EPA landfill model.				
Pesticides/Commercial-Consumer Solvent Use	• Correct for double-counting.				

analysis determining total rural and urban VMT for all counties in the domain, and review of the disaggregation process of projected rural and urban VMT. QA checks applied to nonroad mobile source spreadsheets verified that the correct EPA-supplied spreadsheet was used, the correct county populations were used, and that the projected NO_x emission factors were adjusted to reflect future NO_x standards.

For area source spreadsheets, QA checks determined if point source adjustments were correctly made and evaluated formulas used to estimate emissions. QA checklists were developed to track and ensure that all sources were reviewed and to document any errors that were found. To QA point source emissions estimates, the EPA SIP Air Pollutant Inventory Management Systems (SAMS) internal QA utilities were used to verify that required fields had proper parameter data entries. When the point source data were in EPA batch transaction format, additional QA checks were performed.

Based on the results of the QA checks implemented by the NC Department of Environmental, Health and Natural Resources (DEHNR) and described briefly above, the authors concluded that although the QA process can take significant time and effort, implementation of a rigorous QA system throughout the entire inventory development process ultimately saves time by reducing the processing of invalid emissions files. A thorough QA system that is well documented will also ensure greater confidence in the modeling results (Boothe and Chandler, 1994).

6.2.3 QA REVIEW OF AN INVENTORY FOR A SPECIFIC INDUSTRY

Another example of documentation of QA/QC activities is shown in Table 2.6-2. The completeness and reasonableness checks listed in Table 2.6-2 were delineated in a project undertaken to assess air quality impacts associated with the development of outer continental shelf (OCS) petroleum reserves using photochemical modeling (Steiner et al., 1994). Emissions were estimated by soliciting activity and operating data with survey forms. The survey data were entered into Paradox® database tables and input into an inventory system designed in the format required by the EPA's Urban Airshed Model (UAM) Emissions Preprocessor System (EPS). Emissions were calculated using EPA emission factors.

To ensure that the quality of the inventory was technically acceptable, a series of automated checks were developed to review the platform data for completeness and reasonableness. For example, reported latitude and longitude were verified, and data were plotted to identify sources outside the inventory domain. Equipment ratings, annual fuel usage, and annual equipment usage were verified by calculating theoretical

TABLE 2.6-2
SUMMARY OF THE SURVEY DATA REVIEWED FOR COMPLETENESS AND REASONABLENESS IN THE OCS PRODUCTION-RELATED INVENTORY[a]

Field	Completeness Check	Reasonableness Check
Platform		
Longitude & latitude	•	•
Crude/condensate & gas throughput	N/A	•
Percent of production in summer of crude/condensate and gas	•	•
Flare and vent stack height	•	•
Vent stack velocity	•	•
Vent diameter	•	•
Number of liquid fuel oil storage tanks per platform & total liquid fuel oil storage capacity per platform	•	•
Equipment		
Equipment type	•	•
Engine type	•	•
Fuel type	•	•
Annual usage	•	•
Annual fuel usage	•	•
Equipment stack velocity	N/A	•
Equipment stack height	N/A	•
Equipment stack diameter	N/A	•
Annual average load = (annual fuel use * fuel consumption rate)/(annual use)	N/A	•

TABLE 2.6-2

CONTINUED

Field	Completeness Check	Reasonableness Check
Crude Tanks		
Capacity	•	•
Average daily throughput	•	•
Dimensions	•	•
Tank color	•	N/A
Crew/Supply Helicopters		
Longitude & latitude of home airport	•	•
Average number of landings & takeoffs per month	•	•
Average cruising speeds	•	•
Geographical area served	•	•
Monthly hours of operation	•	•
Rated capacity	•	N/A
Fuel usage at rated capacity	•	•
Annual hours in operation	•	•
Crew/Supply Vessels		
Monthly hours of operation	•	•
Time at idle at platforms during hours of operation	•	•
Monthly fuel usage	•	•
Fuel type	•	N/A
Geographic area served	•	•
Annual hours of operation	•	•

[a] • = data checked; N/A = not applicable or necessary.
Source: Steiner et al., 1994.

annual average loads, and flagging any equipment ratings greater than 200 percent or less than 20 percent of the calculated annual average loads.

Tables were generated of data that failed the completeness and reasonableness checks. Data in the tables were then checked against the original survey form data, and any changes made to the data were documented in the project file. Data corrections were entered into a data correction module within the inventory system. Corrections made typically consisted of unit conversions, which significantly affected the emissions estimates.

This example shows how QA procedures should be tailored to fit the inventory. The list of data reviewed is very specific to the industry. The level of detail gives the user some confidence in the quality of the QA program itself. (This paper also provides a good qualitative summary of uncertainty, which is discussed in Chapter 4 of this volume.)

The QA/QC efforts applied to this inventory resulted in corrections being made to 6,000 records, identification of three omitted platforms, and a decrease of more than two orders of magnitude in total estimated emissions.

6.3 REPORTING THE INVENTORY ESTIMATES

Some sort of final report is required, if only to convey the results to interested parties. The simplest report might be a table (or set of tables). This may be all that some end-users want or need.

In most cases, however, detailed inventory and QA/QC reports are crucial. An example of a formal inventory report is one prepared as a SIP submission. This type of report includes summary tables, raw listings of equipment, activity levels and emissions from individual sources, and a QA report. A detailed inventory report allows comparison of baseline inventories from one area to another, the evaluation of the impact of control strategies, and facilitates updates to the inventory and development of projection inventories.

The 1992 EPA report *Example Documentation Report for 1990 Base Year Ozone and Carbon Monoxide State Implementation Plan Emission Inventories* provides examples of formal inventory reporting (EPA, 1992). This document provides guidance for presenting and documenting SIP emissions inventories, and contains examples of how state and local agencies should present and verify inventory development efforts. Example inventory documentation is presented for point, area, mobile, and biogenic sources. The QA documentation section of a formal emissions inventory report should provide enough information to enable comparison of the QA/QC steps completed with those described in the QA plan. Examples are also presented that illustrate how the procedures used to implement the QA plan should be documented, as well as the results of the QA procedures.

Another example of very specific reporting requirements can be found in the first volume of the *IPCC Draft Guidelines for National Greenhouse Gas Inventories* (IPCC/OECD, 1994a) that specifies the following four documentation standards:

1. "National inventory reports should provide minimum information to enable the results to be reconstructed, and to justify the choice of methodology and data used. This means, for example, that to the extent possible, activity data should be provided at the level of detail at which the emissions are estimated.

2. Documentation should contain enough information to explain differences between national methods and data, and the IPCC default methods and assumptions. Reasons for the differences should be explained and sources of emission factors and other national data should also be clearly cited. Minimum requirements include: emission factors, activity data, and a list of references documenting any differences from IPCC recommendations.

3. Measurement studies containing new values should be referenced, and made available upon request. It is preferable that new emission factor data be contained in published sources.

4. Documentation should be kept for future years (by the country and by the IPCC) and countries are encouraged to publish the documentation of their inventories. This extensive record keeping will facilitate the recalculation of historical inventory estimates when changes in national methods or assumptions occur."

The IPCC reporting guidelines (OECD, 1994a) provide more than 30 tables to be completed and submitted as part of the inventory report. An example inventory quality table was shown in Figure 2.4-1. Another example with one of the data tables is shown in Figure 2.6-2.

FIGURE 2.6-2. EXAMPLE DATA REPORTING TABLE FOR IPCC INVENTORIES

5 D I Managed Forests: Annual Growth Increment

SOURCE AND SINK CATEGORIES			ACTIVITY DATA	EMISSIONS/REMOVALS ESTIMATES	AGGREGATE REMOVALS FACTORS
Forest Type			A Area of Managed Forest (k ha)	B Carbon Removal (Gg C)	C Carbon Removal Factor (Mg C)
					C=B/A
Tropical	Plantations (specify type)				
	Logged	Closed Broadleaf			
		Closed Coniferous			
		Open			
	Other				
Temperate	Plantations (specify type)				
	Commercial	Evergreen			
		Deciduous			
	Other				
Boreal					
			Number of Trees 1000	Carbon Removal (Gg C)	Carbon Removal Factor (Mg C)
					C=B/A
Afforestation Programs					
Village & Farm Trees					

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7

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