

Diamonds in the Rough: Creating Optimal, Composite Inventories in the Texas Air Emissions Repository

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ABSTRACT

To support its state implementation plan and Environmental Protection Agency (EPA) reporting processes, Texas must regularly develop statewide air emissions inventories. This task requires gathering, improving, and combining emissions data from numerous sources. The Texas Commission on Environmental Quality (TCEQ) and Eastern Research Group, Inc. (ERG) have met this challenge for non-point data with the Texas Air Emissions Repository (TexAER). TexAER is a Web-based computer system that houses, reconciles, and reports non-point data.

Three TexAER tools in particular help TCEQ develop statewide inventories (or, more generally, composite inventories—inventories drawing data from multiple, variable sources).

- The **Emissions Editor** lets administrators modify emissions estimates in the TexAER repository.
- **Projected reports** permit forecasts and backcasts of emissions data.
- The **Inventory Builder** organizes and automates the assembly of source data into a composite inventory.

The first two tools prepare source data to be included in a composite inventory; the last manages the creation of the inventory itself. All three advance TCEQ's ultimate goal for inventory development: the efficient production of high-quality inventories through a process that is streamlined, transparent, repeatable, and evolutionary.

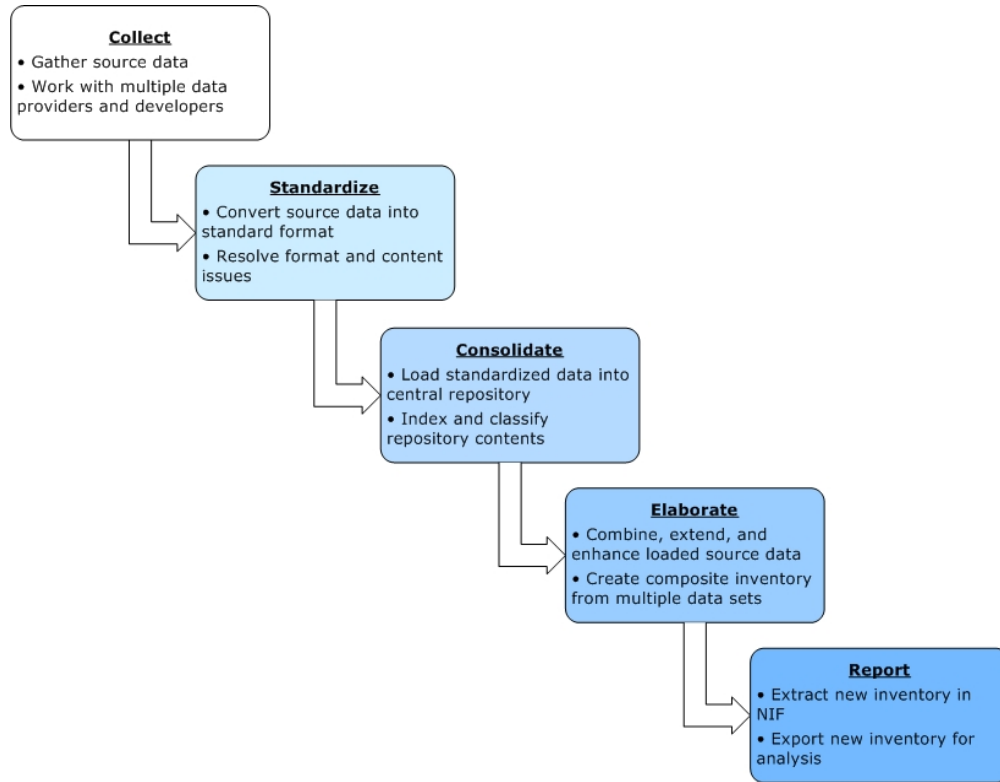
INTRODUCTION

Like every state, Texas is accountable for the quality of its air. The Texas Commission on Environmental Quality (TCEQ) meets this responsibility by tracking, regulating, and reporting on air pollution throughout the state. In the course of these duties, to satisfy Environmental Protection Agency (EPA) and state implementation plan requirements, TCEQ must periodically develop comprehensive, statewide air emissions inventories. Such inventories are the starting point for planning and control efforts.

Developing a statewide inventory is a significant undertaking. Fundamentally, it involves collecting, selecting, and integrating emissions data from multiple sources—EPA, state and local agencies, contractors, non-governmental stakeholders, and more. Each source provides a piece of the

puzzle, and each piece has its own qualifications. Source data sets vary in reliability, geographic extent, coverage of pollutants and emissions generating processes, and numerous other ways. Some sets overlap with others; some can stand alone. Considering these complexities, preparing a statewide inventory for EPA or other users is challenging indeed. Figure 1 summarizes the exigencies of the situation.

Figure 1. Building a statewide emissions inventory.



For TCEQ, two concerns are paramount in the inventory development process: quality and efficiency. The results of the process—the final inventory—must be dependable. And the process itself must proceed quickly and economically. These concerns translate into a philosophy that suffuses all of TCEQ’s inventory work: development efforts must be streamlined, transparent, repeatable, and evolutionary.

- *Streamlined* – The inventory development process must use staff time effectively. Redundancies and bottlenecks must be minimized. Development tools should accelerate the work at hand.
- *Transparent* – The development process (including staff choices and assumptions) must be documented. Participants in the process should have an easy way to assess their role and the status of any given inventory.
- *Repeatable* – Interested parties should be able to recreate developed inventories from supporting data and historical records. The results of development must be reproducible.
- *Evolutionary* – Every developed inventory must be able to serve as a building block for future inventories. The development process should thus be continuous, allowing progressive refinement of the data.

To realize this vision for non-point inventories, TCEQ is working with Eastern Research Group, Inc. (ERG) on the Texas Air Emissions Repository (TexAER). Built on Macromedia ColdFusion and Oracle technology, TexAER is a central, Web-based computer system that stores and reports non-point emissions data and facilitates the development of non-point inventories. It manages all non-point source data for Texas: area, non-road mobile, on-road mobile, and biogenic. The general public can access TexAER at <http://www4.tceq.state.tx.us/texaer/>.

TCEQ and ERG have been collaborating on the TexAER project since 2003. In the first stage of the system’s implementation, from 2003 to 2004, work focused on establishing an infrastructure for loading, storing, and reporting emissions data. TexAER is modular, and the elements of this initial infrastructure were deployed as an integrated set of modules, or components. Table 1 lists these core components.

Table 1. TexAER’s initial components.

Component	Description
Security	Provides user authentication and session and account management services. Prevents unauthorized access to data and functions.
Table Maintenance	Allows application administrators to add, update, and delete supporting and reference data (e.g., NIF codes).
Document Catalog	Stores and retrieves background documents and files (attachments) in their native format.
Data Loader	Loads NIF formatted emissions data into TexAER. Verifies data quality and format.
Reports	Provides on-screen reports and text file exports of emissions, control, and source classification code (SCC) data.
Help	Includes online help and a stand-alone user’s guide for the system.

In a sense, this first round of components was a preparatory exercise. By itself it did not satisfy TCEQ’s inventory development goals, but it was a step in the right direction. The initial system established a single repository for emissions data, standards and tools for data storage and retrieval, a secure user interface, and a framework for accessing the application over the Web. It did not, however, substantially alter TCEQ’s inventory development process. Statewide (and other composite) inventories continued to be developed offline, manually, then loaded into the system. This approach was laborious and difficult to track and audit.

Starting in 2004, then, the implementation team turned its attention to the fourth step in Figure 1, the elaboration of composite inventories from source data resident in TexAER. The first stage of the system’s growth had addressed the other parts of the development process. Now, with the second stage, the team tackled the substance of inventory creation head-on.

This paper deals with what resulted: an innovative set of tools and procedures that allow rapid development of high quality composite inventories. The following sections describe these enhancements in detail and explain their effect on inventory development at TCEQ.

BODY

The second stage of TexAER’s implementation produced three tools that streamline the elaboration of composite emissions inventories. Two of the tools—the Emissions Editor and projected reports—allow users to work with and enhance individual source data sets, preparing them for inclusion

in a new inventory. The third, the Inventory Builder, assembles multiple source data sets into a composite inventory. All three tools support standardized, efficient procedures for inventory development.

Before examining the tools themselves, a word about TexAER terminology is in order. In TexAER, an *inventory* is a published set of emissions estimates. Each inventory is for a particular year and purpose and is composed of one or more subinventories. A *subinventory* is a subset of an inventory containing emissions estimates of a single source type—area, non-road mobile, on-road mobile, or biogenic. Within an inventory, no two subinventories can share the same source type.

Emissions Editor

The Emissions Editor lets TexAER administrators modify emissions data directly. For ease of use, the Editor is an adjunct to the TexAER Report Creator, or emissions reporting system. The TexAER team has put considerable effort into the Report Creator to make it users’ main point of access for emissions data. Whenever users wish to work with emissions records—whether to display them on screen, or export them to a spreadsheet, or (as of 2006) analyze them on graphs or geographic information system (GIS) maps—they turn to the Report Creator.

The idea behind the Creator is to empower users to design their own reports and answer their own questions. Flexibility is a watchword, as Table 2, which lists Report Creator options, shows.

Table 2. TexAER Report Creator options.

Report Types	<ul style="list-style-type: none"> • Emissions Data – NIF-level emissions data or emissions summarized by county, SCC (any tier), and/or SCC class (a TCEQ grouping of SCCs) • Emissions With Controls – NIF-level emissions and controls data cross-referenced with proposed, planned, and actual control regulations • Projected Emissions – forecasted or backcasted emissions data
Filters/Selection Criteria	<ul style="list-style-type: none"> • Inventory • Subinventory • County/Location • Location Group • Pollutant • Pollutant Group • Time Period • SCC • SCC Class • NIF Control Status • Applicable Control Regulations
Display Parameters	<ul style="list-style-type: none"> • Emissions Unit of Measure • Sort Order • Report Title
Output Formats	<ul style="list-style-type: none"> • On Screen – Full Color • On Screen – Data Only • NIF 3.0 Text Export • Comma Delimited Text Export • Tab Delimited Text Export

With these options users can quickly sift through the data in the TexAER repository, identify records of interest, and retrieve them in the desired format.

The Emissions Editor fits naturally into this framework. It is activated through an administrator only control in the Report Creator, selected while administrators are defining a report. If the Editor is turned on, the report runs normally but the on-screen display allows the viewer to alter (or add to) the reported emissions quantities. In this way the Editor takes advantage of the familiarity and focusing power of the Report Creator interface. It is an overlay on displayed reports, permitting administrators to make targeted changes to a reported data set. Figures 2 and 3 show a sample on-screen report with and without the Emissions Editor overlay. As Figure 3 suggests, when the overlay is present administrators can edit data in several ways:


- 1) By selecting a hyperlinked emissions quantity—to change the quantity.
- 2) By selecting an “(Add)” hyperlink—to add a new quantity for the indicated location (county), SCC, and pollutant.
- 3) By selecting the “Add Row” button—to add a new row to the report, with a quantity for the new row’s location and SCC.
- 4) By selecting the icon to show row details ()—to change any quantity on the chosen row.

Figure 2. Sample on-screen report.

Emissions Detail Report

If you print your report, set the page orientation to "Landscape" for optimal display.

Petroleum Products Report
San Antonio
 Area Sources

Inventory: C 2002 SAN ANTONIO AREA SOURCES—2002 / AREA
Display Unit of Measure: Tons
Report Type:

Petroleum Products

	Location	SCC	SCC Short Description	CO		NOX		VOC	
				ANNUAL (YEARLY)	OZONE SEASON (DAILY)	ANNUAL (YEARLY)	OZONE SEASON (DAILY)	ANNUAL (YEARLY)	OZONE SEASON (DAILY)
	ATASCOSA COUNTY	2310000000	OIL AND GAS PRODUCTION: ALL PROCESSES	237.30	0.6503	282.60	0.7741	1,242.00	3.4030
	ATASCOSA COUNTY	2501000120	PETROLEUM PRODUCTS: ALL STORAGE TYPES: BREATHING:GASOLINE					77.31	0.2118

Logged In As: SIP_ADM Date: 05/12/06

Figure 3. Sample on-screen report with Emissions Editor overlay.

The screenshot displays the 'Emissions Detail Report' interface for 'Petroleum Products Report' in San Antonio. The report is titled 'Petroleum Products Report' and 'San Antonio Area Sources'. The inventory is 'C 2002 SAN ANTONIO AREA SOURCES—2002 / AREA' and the display unit is 'Tons'. The report type is set to 'Detail'. A 'Show Row Details' button is visible. Below the report title, there are several action buttons: 'Edit Filter', 'Edit Formatting', 'Return to Report Index', 'Save Report As', 'Export', 'HTML Only', 'Add Row', and 'Go To Bottom'. The main data is presented in a table with columns for 'Location', 'SCC', 'SCC Short Description', and grouped columns for 'CO', 'NOX', and 'VOC' emissions, each with 'ANNUAL (YEARLY)' and 'OZONE SEASON (DAILY)' sub-columns. The table contains two rows of data for ATASCOSA COUNTY. The first row is for SCC 2310000000 (Oil and Gas Production) with values: CO Annual 237.30, CO Ozone 0.6503, NOX Annual 282.60, NOX Ozone 0.7741, VOC Annual 1,242.00, VOC Ozone 3.4030. The second row is for SCC 2501000120 (Petroleum Products Storage/Breathing) with values: CO Annual (Add), CO Ozone (Add), NOX Annual (Add), NOX Ozone (Add), VOC Annual 77.31, VOC Ozone 0.2118. Below the table, there are more action buttons: 'Edit Filter', 'Edit Formatting', 'Return to Report Index', 'Save Report As', 'Export', 'HTML Only', 'Add Row', and 'Go to Top'. The footer shows 'Logged In As: SIP_ADM' and 'Date: 05/12/06'.

Location	SCC	SCC Short Description	CO		NOX		VOC	
			ANNUAL (YEARLY)	OZONE SEASON (DAILY)	ANNUAL (YEARLY)	OZONE SEASON (DAILY)	ANNUAL (YEARLY)	OZONE SEASON (DAILY)
ATASCOSA COUNTY	2310000000	OIL AND GAS PRODUCTION: ALL PROCESSES	237.30	0.6503	282.60	0.7741	1,242.00	3.4030
ATASCOSA COUNTY	2501000120	PETROLEUM PRODUCTS: ALL STORAGE TYPES: BREATHING:GASOLINE	(Add)	(Add)	(Add)	(Add)	77.31	0.2118

Any time an administrator adds or modifies data with the Emissions Editor, TexAER documents the change in a log. The log captures several fields (user name, original and new emissions values, change reason, date), providing an audit trail for all edits.

The Emissions Editor is a key contributor to the creation of composite inventories because it supports direct revisions to source data in the TexAER database. It obviates exporting and reimporting source data sets when changes are necessary, instead enabling administrators to focus on the repository of record. This feature facilitates the preparation of source data; and the Editor's history tracking ensures that preparation activities are transparent.

Projected Reports

Projected reports allow forecasts and backcasts of emissions data. Like the Emissions Editor, projected reports are an extension to the Report Creator. This situation lets them build on the Report Creator's infrastructure, including filtering and display options (Table 2).

To define a projected report, users take a regular report—a selection of source data—and apply to it economic growth factors and optional control information. The starting report is a baseline; its year is the base year for the projection. The growth factors determine the expected change in emissions from the base year to a specified target year. The controls adjust the expected emissions according to various regulatory scenarios.

TexAER models both growth factors and control scenarios, or *strategies*, with a fair degree of specificity. Key fields for growth factors include SCC, location (county), base time period, target time period, and factor quantity. Control strategies define rule penetration, rule effectiveness, and total capture control efficiency (capture efficiency x net control efficiency) quantities for combinations of effective dates, locations, SCCs, and pollutants. Taken together, these attributes permit the system to align factors and strategies with individual emissions estimates.

When TexAER generates a projection, it performs this mapping and applies relevant growth and control factors to each base year emissions estimate. It then outputs a report containing projected emissions modified by all pertinent control strategies. (Note: If a report includes multiple control strategies, users can choose whether to apply overlapping strategies incrementally or by supplanting lower priority values with higher priority values.)

The report interface supports two views of projected data. The default view parallels regular reports and simply shows the projected, controlled emissions. A second view, the delta report, is more advanced and provides four values:

- 1) Base: The original, base year quantity.
- 2) Projected (Base Controls): The projected quantity unmodified by the user's control strategy selections (i.e., the quantity as it would be if the base year's controls were unchanged in the target year).
- 3) Projected (New Controls): The projected quantity adjusted by the user's control strategy selections.
- 4) Delta of Projected: The difference between 2) and 3).

Figure 4. Sample projected report (delta view).

Projected Delta Summary Report

If you print your report, set the page orientation to "Landscape" for optimal display.

Projected Report
East Texas 5-County Area
 Area Sources

Base Inventory: C 2002 EAST TEXAS 5-COUNTY AREA SOURCES—2002 / AREA
Display Unit of Measure: Tons
Grown Inventory Target Year: [2002](#)
Includes alternative control strategy information?: [Yes](#)
Report Type: Delta Summary

[Edit Filter](#) [Edit Formatting](#) [Save Report As](#) [HTML Only](#) [Go To Bottom](#)

Location ▲	Pollutant	Time Period	Base	Projected (Base Controls)	Projected (New Controls)	Delta of Projected
GREGG COUNTY	CO	Annual (Yearly)	1,845.20	1,845.20	1,845.20	0
GREGG COUNTY	CO	Ozone Season (Daily)	3.7969	3.7969	3.7969	0
GREGG COUNTY	NOX	Annual (Yearly)	4,605.83	4,605.83	4,605.83	0
GREGG COUNTY	NOX	Ozone Season (Daily)	13.2262	13.2262	13.2262	0
GREGG COUNTY	VOC	Annual (Yearly)	7,363.63	7,363.63	7,282.47	81.16
GREGG COUNTY	VOC	Ozone Season (Daily)	19.9137	19.9137	19.6625	0.2512
Total			13,851.60	13,851.60	13,770.19	81.41

[Edit Filter](#) [Edit Formatting](#) [Save Report As](#) [HTML Only](#) [Go to Top](#)

Logged In As: [jason.veysey@erg.com](#) Date: 05/12/06

Users can create projections for detail/NIF-level or summarized emissions data. The target year for a projection can be in the future (a forecast) or past (a backcast), or it can be the same as the base year. This latter feature allows users to check the impact of control scenarios on base year data (for example, to see what would happen if a new rule went into effect immediately).

After viewing a projected report, users can request that it be converted into a new, independent inventory. The system routes requests for conversion to administrators, who may fulfill them or decline them with comments. If an administrator performs a conversion, the resulting inventory comprises the projected, controlled emissions and is a separate data set in its own right. For traceability purposes, however, the inventory does retain metadata that link it to the projected report.

The option to instantiate a projected report as an inventory has real benefits for composite inventory development. It gives users a way to “play” with source data, subjecting them to potential control and growth scenarios, and to save the outcome as a new data set. The saved data set can then be a building block for a composite inventory.

Inventory Builder

The Inventory Builder is TexAER's main tool for assembling composite inventories. In reality, it is both a tool and a set of procedures, since the software assumes and enforces a certain work flow. It is most instructive to consider the procedures first.

When TCEQ develops a composite inventory, such as a statewide inventory, one team member is designated to lead the effort. This inventory manager is in charge of dividing the source data into reasonably sized *blocks* and assigning the blocks to auditors and peer reviewers (one auditor and reviewer per block). Each block contains related data—for common locations (counties), SCCs, pollutants, and time periods—from several source data sets. The auditor compares the sets side-by-side and selects the best available emissions estimate for each combination of location, SCC, pollutant, and time period.

The peer reviewer then checks the auditor's work. If the reviewer and auditor disagree about a choice, they attempt to reconcile their differences. If they cannot, the inventory manager intervenes and makes a final decision.

After ensuring that all applicable source data have been reviewed, the inventory manager gathers the team's final selections, from all source data sets, and compiles them into a new, unified inventory. This inventory is the product of the development effort and synthesizes the team's collective analysis of the data.

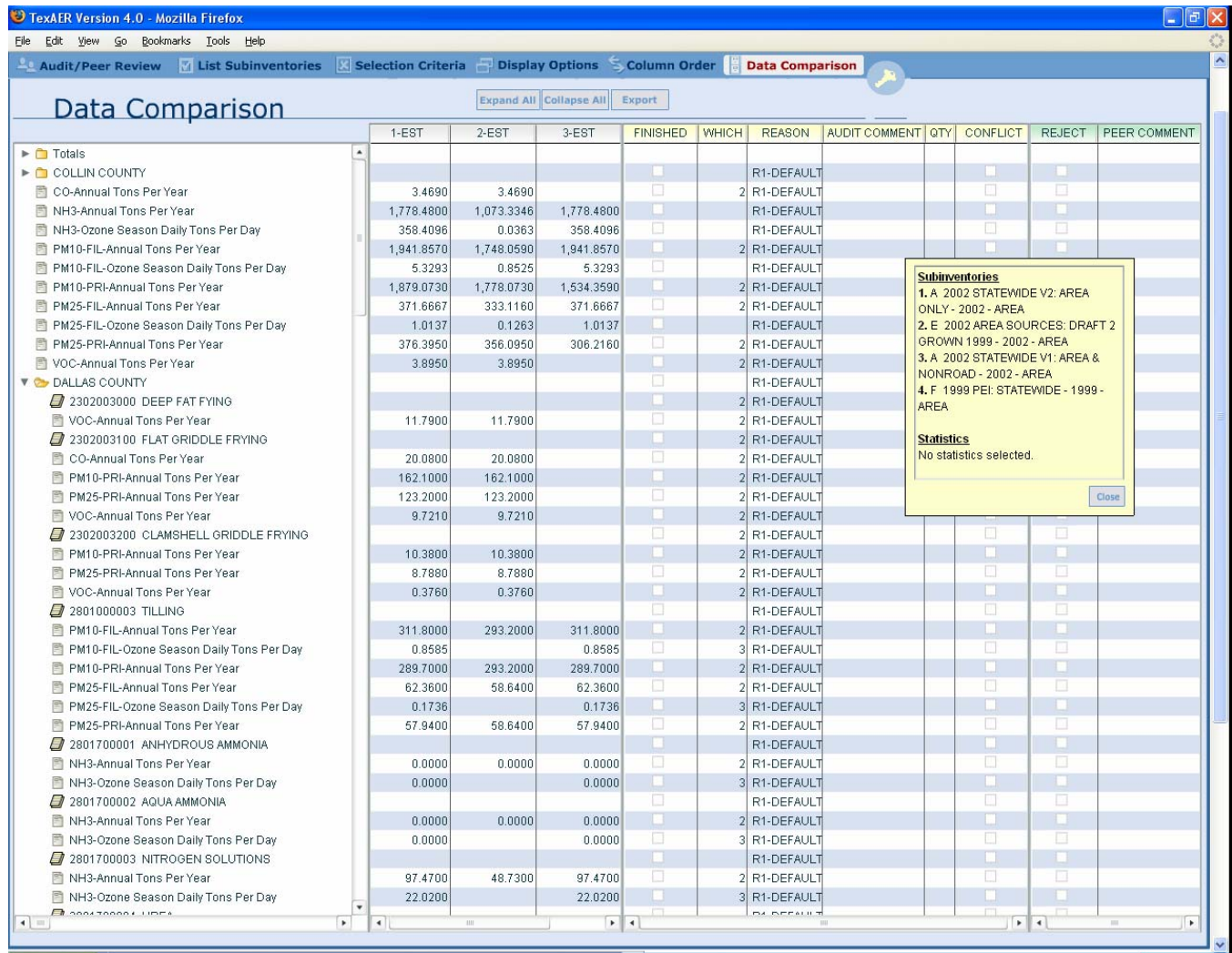
Within TexAER, this development process unfolds through the mediation of the Inventory Builder. The Builder includes utilities for the inventory manager, auditors, and peer reviewers. To start a development cycle, the inventory manager employs the Builder's administrative interface. There he/she creates an *inventory build*, or composite inventory in progress, and chooses the source data sets/subinventories from which the build will draw data. The manager then separates the source data into blocks and designates auditors and peer reviewers (providing both with due dates for their work).

The auditors and peer reviewers take up their blocks in a rich client comparison tool. Programmed in Macromedia Flash, this tool allows spreadsheet-like analysis of a block's data. It offers the following features among others:

- Side-by-side comparison of up to five subinventories' data
- Filtering of emissions data by location, location group, SCC, SCC class, pollutant, pollutant group, time period, audit status
- Variable, hierarchical aggregation of emissions data; hierarchies based on locations, SCCs, SCC classes
- Calculation of comparative statistics
- Conversion of emissions quantities to any of several units of measure
- Multi-level sorting
- Hiding, freezing (in position), and rearranging of data columns

Figure 5 depicts the comparison tool’s interface. The tool has several tabs on which users can set comparison options—including Selection Criteria, Display Options, and Column Order—and a single tab, Data Comparison, for viewing emissions data and making audit and peer review choices.

Figure 5. Inventory Builder comparison interface.



A block’s auditor is the first to work with its data. Using the comparison tool’s analytic options, the auditor traverses the block, considers each source data set, and chooses values from one or another (in the “WHICH” column, shown in Figure 5; alternatively, the auditor can hand-enter quantities in the “QTY” column). The auditor must select a reason for each choice (in the “REASON” column) and set a flag when the choice is final (in the “FINISHED”) column. Comments can also be entered (in the “AUDIT COMMENT” column).

Once the auditor finishes making selections, he/she marks the entire block as complete. This step makes the block available to the peer reviewer and sends a notification to both the reviewer and the inventory manager. The reviewer then accesses the block, in the same interface presented in Figure 5, and reprises the auditor’s work. He/she notes disagreements with the auditor (in the “REJECT” column) and provides comments as necessary (in the “PEER COMMENT” column). When the reviewer is satisfied, he/she checks another flag, triggering additional notifications and sending the block back to the auditor.

The auditor then conducts a final survey of the block and evaluates any rows that the peer reviewer rejected. If the auditor accepts the reviewer's position on a disputed row, he/she makes the necessary change to the selected value; otherwise he/she indicates a conflict (by checking the box in the "CONFLICT" column). Upon finishing this last review, the auditor updates the block's overall status, further notifications are sent, and control passes to the inventory manager.

The inventory manager receives all completed blocks, examines and rules on any conflicts, and uses the Builder's administrative interface to merge prepared blocks into the composite inventory. The merge process takes each vetted, documented emissions selection and adds it to the new inventory. In the event that the build contains overlapping blocks that disagree on an emissions estimate—the quantity for a particular location, SCC, pollutant, and time period—the Builder prompts the manager and requires a resolution before proceeding.

The new inventory is a self-sufficient data set but is traceable to its originating build. Users viewing the inventory in reports, for example, can follow the history of any estimate back to the build and see the basis for the emissions value.

The Inventory Builder is the cornerstone of TexAER's support for composite inventory development. It addresses the needs of all development contributors, focusing their work and helping reconcile their opinions and analysis. Its enforcement of step-by-step processing (first by dividing source data into blocks, then by defining a clear lifecycle for each block) provides valuable structure for development efforts. Its implementation within TexAER supports an iterative, progressive approach to development: the result of one inventory build can become a source data set for another build, which can become a source data set for another build, and so on.

CONCLUSIONS

TexAER's tools for the elaboration of composite inventories help TCEQ deliver on the promise of streamlined, transparent, repeatable, and evolutionary inventory development. The Emissions Editor and projected reports give users an intuitive way to enhance source data sets before combining them into a composite inventory. The Inventory Builder enables the combination, bringing together people, source data, and analysis in a controlled and productive process.

The advent of these tools has significantly advanced TCEQ's development of statewide non-point inventories. It has allowed TCEQ to create these inventories in a central, visible location, the TexAER database, to maintain consistent development history, and to effect continuous, incremental improvement of the data. These advantages help TCEQ find inventory "diamonds in the rough" and fulfill its responsibilities to EPA, state and local governments, the public, and the environment.

REFERENCES

<http://www4.tceq.state.tx.us/texaer>

KEY WORDS

CEER

Composite Inventory

Eastern Research Group

EDMS

Emissions

Emissions Inventory

Emissions Report

Emissions Data Management System

ERG

Forecast

Inventory

Inventory Development

Non-Point

Projection

Rapid Inventory Development

SIP

SIP EDMS

State Implementation Plan

Statewide Inventory

Subinventory

TCEQ

TexAER

Texas Commission on Environmental Quality