The Area Source Assessment Tool - A Software Application for Compiling Area Source Emission Inventories

Steven Boone
E. H. Pechan and Associates, Inc.
3622 Lyckan Parkway, Suite 2002
Durham, North Carolina 27707
steve.boone@pechan.com

Stephen P. Anderson
Texas Natural Resource Conservation Commission
P.O. Box 13087, MC 164
Austin, Texas 78711-3087
sanderso@tnrcc.state.tx.us

Till Stoeckenius
Environ Corporation
Golden Gate Plaza, 101 Rowland Way
Novato, CA 94945
tstoeckenius@environcorp.com

ABSTRACT

The Area Source Assessment Tool allows users to perform area source emissions assessments with county-level activity data to temporarily and/or permanently change the activity data and related input parameters; to run different control strategy assessment scenarios and to maintain documentation for each case (in order to be able to easily replicate the run). Activity data are defined as data that represent one or more variables that are multiplied by an emission factor to calculate the emission rate for area sources.

Concurrently, state and local agencies are making numerous improvements to their area source inventory to support regional modeling efforts. A user requirements analysis was performed that prioritized state and local agency needs relating to developing an Area Source Module. The analysis task referenced findings from an Area Source Inventory Preparation Plan to determine what area source categories to consider during the design for the Area Source Assessment Tool. The analysis also considered criteria and hazardous air pollutants that are emitted by the area source categories from the Area Source Inventory Preparation Plan. The pollutant list includes: the criteria pollutants, hazardous air pollutants (HAPs), toxics, greenhouse gases and speciates of volatile organic compounds. Also, as potential clean air regulatory options were considered, emission estimates are generated based on what if scenarios which require using non-default activity data via the Area Source Assessment Tool. As state and local agency staff complete multiple Area Source Assessment Tool cases, there is a need to uniquely identify what activity data have been used for each case and the ability to replicate each case. This addresses the question of where did the emissions estimate come from, what activity/control scenarios were assessed and what assumptions were made.

INTRODUCTION

Historically, emissions estimates for area sources have been developed using several analysis methods and various estimation tools. Many of the area source categories have methodologies that are specific to calculating emissions for that category. With the recent emphasis on area source inventories, improvements to and the streamlining of area source emission estimation processes to prepare consistent, high-quality, county-level emissions have taken place. The design and development of an area source emission inventory tool to accurately assess area source emissions for all categories was needed to facilitate the development of a modern era area source emission inventory.

State and Local Air Pollution Control Agencies, Tribes, Regional Planning Organizations and the U. S. Environmental Protection Agency (EPA) are all required to develop, analyze and quality assure area source emission inventory data. While EPA has developed the National Emission Inventory Input Format (NIF), a data format for reporting emissions information, the format is not conducive to the initial development of an area source emission inventory involving multiple activity factors for specific source categories. A tool for developing area source emission inventories capable of handling specific inputs for calculating each category's emissions would eliminate the morass of spreadsheets currently used to calculate area source emissions. Area source data in spreadsheets does not easily translate into the NIF, whereas the use of a database tool would greatly facilitate the data transfer processes.

When spreadsheets are used to amass area source emission inventory data, typically, several spreadsheet formats are used so that all of the existing methodologies can be implemented. Once the emissions are derived in the separate spreadsheets, it becomes a manual process to piece the data together for a complete inventory. The task of recalculating a particular category's emissions, with new activity data and merging it back into the overall inventory, quickly becomes a resource intensive exercise. The use of spreadsheets also leads to a dissociated application of methodologies between multiple personnel, especially personnel at different physical locations. A tool that can manage data in one database for the multiple methodologies required by an area source emission inventory would greatly facilitate inventory development as well; all personnel involved in developing the area would be able to apply the same methodologies to the same categories.

A WORKING PROTOTYPE

The Area Source Assessment Tool (ASAT) is a working prototype area source emission inventory tool. It was modeled after two pre-existing tools – an Ammonia emissions tool developed for the Texas Natural Resource Conservation Commission (TNRCC) by the University of Texas and the Area Source Emissions Model (ASEM) developed for the EPA by E. H. Pechan and Associates, Inc. The TNRCC Ammonia tool provided insight on the user-documentation of the input data elements and an equation builder. ASEM provided a model for developing area source emission inventories but was limited to specific methodologies for selected miscellaneous area source categories; and at the time the ASAT was developed, only the Ammonia (NH_3), Particulate Matter greater than 10 microns (PM-10) and Particulate Matter greater than 2.5 microns (PM-2.5) pollutants were managed by ASEM (ASEM has since been expanded to manage an unlimited number of pollutants). ASAT combined the desirable functionalities from both of the model tools as well as some of its own functionality to provide a cutting-edge area source emission inventory tool.

As with all "tools," ASAT is an application that provides the functionality and look up data such as pollutants and tier categories and the user(s) must provide the data specific to their location in order for the ASAT model to work. Due to time and budget constraints, it was not pre-populated with factors, efficiencies and activity data for area sources.

System Requirements

An Area Source Inventory Preparation Plan (ASIPP) was developed for TNRCC that provided a guide on what area source categories needed to have new methodologies applied for calculation of emissions. The ASIPP also provided the methodologies to be used for each category. Starting with the ASIPP, a user requirements analysis was performed to determine the requirements for the resulting tool. The user requirements analysis included the constraints of the system development life cycle for the project. Some of the constraints included the development (Microsoft Access 2000) and run-time environments (Windows 95/98), the project duration (nine weeks) and simultaneous development of area source emission inventory base data under a separate work order.

Business rules identified during the user requirements analysis stemmed from clean air regulations, reporting requirements and multi-state, regional-based modeling inventory requirements. The business rules dictated many of the functional and data requirements for the system. Business rules included the periodic estimation of area source emissions, reporting of the resulting inventories nationally and regionally, and application of approved methodologies for specific area source categories.

The analysis resulted in multiple area source emission inventory specific functionalities that were required in the resultant tool. The initial functionality hierarchy consisted of five major categories that included:

Store and Document Multiple Emission Scenarios

Users were to be provided the functionality to easily change input data variables used by different scenarios. The program would store documentation and pointers to the scenario data so it could be easily selected at a later date. Each scenario was to be stored so that it could be individually retrieved and combined with other scenarios to create a complete emission inventory.

Reporting

The generation of seasonal and annual emission rate totals in emission reports was a top reporting requirement. The report section was to allow for viewing, printing and saving the reports and to generate tabular reports, including summaries by user selected category(ies), county(ies) and pollutant(s) for a user-specified timer period.

Base Data Flexibility

County-specific data and related input variables (including emission factors, activity data, rule effectiveness, control efficiencies and growth factors) for each category type were identified as inputs to be accepted from the user. The tool was to allow the user to easily create, update, delete and reuse user-specific activity data. Documentation for the inputs and variables was to be recorded and used to identify scenarios for future runs.

What-If Scenarios

The analysis dictated that the resulting tool should allow users to run a number of "what-if" scenarios to evaluate changes in control efficiency, rule effectiveness, rule penetration, activity levels or other quantitative parameters. The tool should allow for comparison of scenarios by year, county,

pollutant and by tier categories.

Data Conversion/Transfer

Once the emission inventory data are derived, the tool should provide the functionality to allow the user to specify a county (or set of counties), a year and/or a season. The tool should produce National Emission Inventory Input Format (NIF) Version 2.0 files in Access or ASCII format. EPS2 files were also to be produced for input into the Emissions Preprocessing System Version 2 model for urban scale domains.

In addition to the above main criteria, four other critical functionalities were identified. The additional functionalities included:

Pollutant List - Maintain a table of pollutants for use in the system that contained the criteria pollutants, hazardous air pollutants, greenhouse gases and speciates of volatile organic compounds (VOC).

Dynamic Periods - Provide the capability to track emissions by day, week, month, season and/or year.

Equations - Provide the user with the capability to enter category specific equations for calculating emissions. Provide the capability to document the equation and be able to apply the equation to specific scenarios.

Geo-location - Maintain a table of counties and enable the user to group them according to user needs such as attainment versus nonattainment, counties in the west versus counties in the east, counties with large cities versus counties without large cities.

Design Parameters

Before the analysis began, the development platform for the product was dictated to be Microsoft Access 2000, front-end and back-end inclusive. Access was chosen because it provided the TNRCC Air Quality Division with flexibility in implementation, distribution and enhancement choices. Initially, it was recommended that the tool be constructed with a Visual Basic front-end application that tied to an Oracle back-end database. Oracle databases can be problematic for small organizational units at TNRCC because the agency's Information Resources Division controls all Oracle-based systems. This could limit the flexibility, which the Area and Mobile Emissions Inventory Section would have to make changes to the application. The base database with lookup tables and growth factors for multiple projection and back cast years was projected to be in the 1 gigabyte range. According to Microsoft specifications, Access 2000 databases have a limit of 2 gigabytes. Given the "what-if" functionality of the software, the database was expected to exceed 2 gigabytes. The database design team considered these constraints in developing the database design.

Data Base Design

ASAT's database design took into account the possibility of the Access databases growing larger than 2 gigabytes. To circumvent an individual database from becoming too large, the application was built so that each case scenario would be run with the results stored in its own individual database. The database design utilized open database connectivity (ODBC) so that in the future a more robust and efficient database could be used on the back-end in the place of Access.

The internal database design features a relational-rich data structure where tables are related by

internal primary and secondary keys. This design feature allows the index keys to remain small and to provide enhanced query capabilities for the end-user. All fields were designed with the end goal of transferring the data to the NIF. The NIF structure was used as a basis for field constraints (type, length and decimals). This design feature would expedite the transfer of data to the NIF and would circumvent potential data overflow and data mismatch problems.

A high-level entity relationship diagram for ASAT is shown in Figure 1.

Program Flow

The order of selection/entry for ASAT to calculate emissions for area source emission inventories is depicted by the flowchart in Figure 2.

Before defining the first scenario, the ASAT user begins by building desired county groupings which consist of one or more counties grouped together in some logical fashion (FIPS codes are provided in ASAT), (re)defines the tier groupings of SCCs (EPA tier groupings are built into ASAT), defines the pollutant list from which to derive emissions (a list of pollutant codes and their descriptions are preloaded into ASAT), and develops equations from which emission estimates will be derived. Once the equations are defined, the ASAT user can populate the emission factor, activity tables and growth factor tables either manually or by data import. Once all of the base data has been defined, the ASAT user can begin building the emission scenarios.

Defining a scenario begins the user's session with ASAT. The scenario is given a title description and the year of inventory and date period parameters are defined. Once the user has established the scenario title and date the user will then establish the county or county group for which emissions will be defined. ASAT presents the user with a county group selection. Once the geographic locations are selected, the tier categories for which emissions will be estimated are selected. ASAT presents the user with a set of tier selections from which to choose. ASAT then presents a pollutant list from which the user can select one or more pollutants. An equation is then selected to calculate emissions and the parameters for the equation are selected/entered. Once a scenario is completely defined the emissions can be calculated and applied to an emission inventory.

To estimate emissions for additional source categories for the same base year, the user initiates another scenario with similar dates, selecting a different tier category for which to estimate emissions. To estimate emissions for a different (set of) pollutant(s), the user would make the appropriate pollutant selection for the scenario. To estimate alternate emissions for pollutants already entered, the user could set up a similar scenario and select a different equation or different parameters for the equation. Once all of the emission scenarios are completed for a state, the user can merge selected scenarios (ones with desired controls, rule effectiveness, rule penetration, desired activity factors, etc…) together to form a final emission inventory. The reports feature can be used to derive total emissions for specific geo-locations and time period combinations.

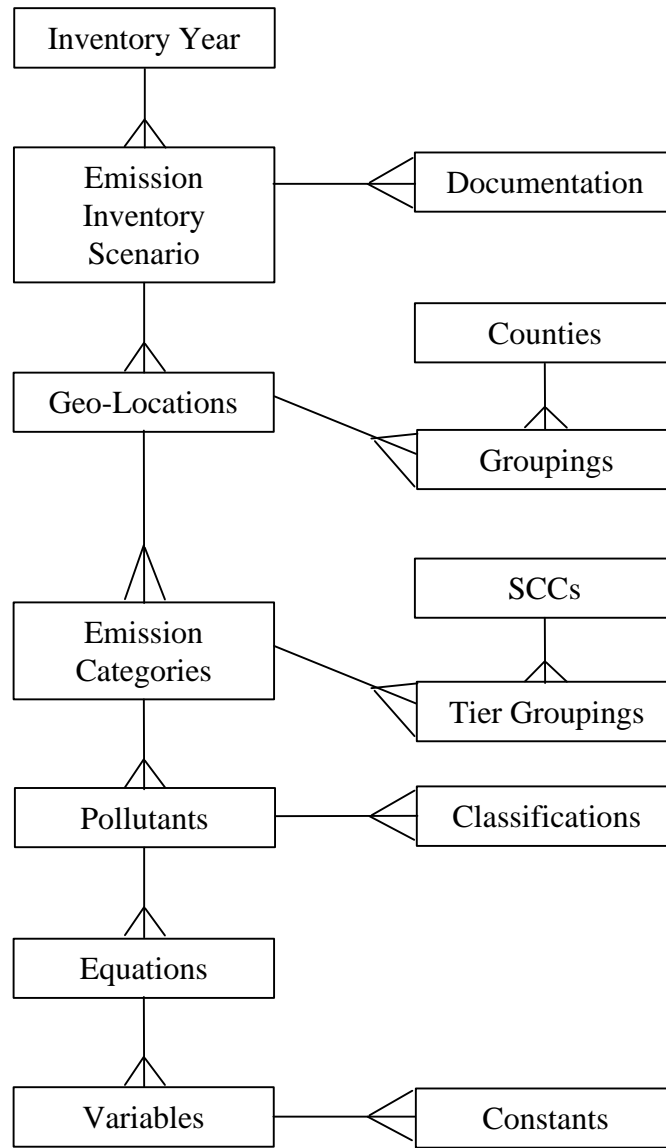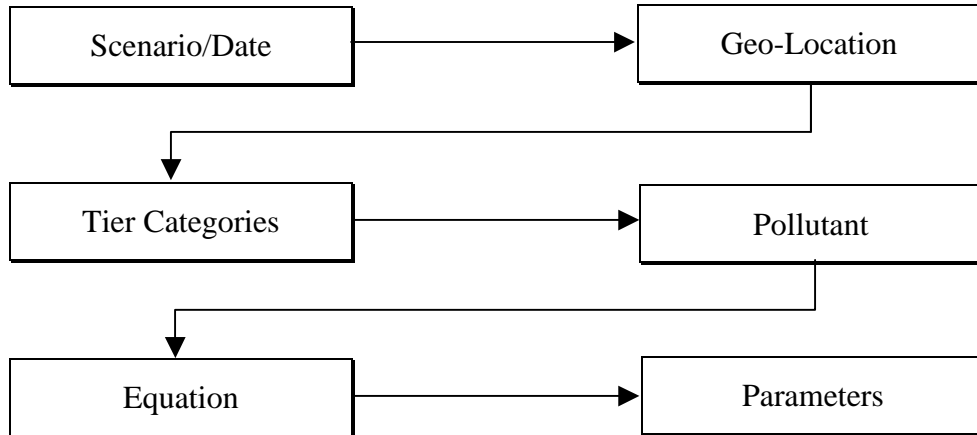**Figure 1.** ASAT high-level entity relationship diagram.

Figure 2. ASAT program flow.

```
┌─────────────────┐                    ┌─────────────────┐
│  Scenario/Date  │ ─────────────────> │  Geo-Location   │
└─────────────────┘                    └─────────────────┘
         │                                      │
         ▼                                      │
┌─────────────────┐                    ┌─────────────────┐
│ Tier Categories │ ─────────────────> │    Pollutant    │
└─────────────────┘                    └─────────────────┘
         │                                      │
         ▼                                      │
┌─────────────────┐                    ┌─────────────────┐
│    Equation     │ ─────────────────> │   Parameters    │
└─────────────────┘                    └─────────────────┘
```

NEXT STEPS/ENHANCEMENTS

ASAT is a prototype area source emission inventory system to be implemented and used by a state/local/tribal agency to develop a complete area source emission inventory. There are several features that if added to ASAT would make it a more robust system. Because of constraints of time, budget and implementation issues during the initial project, the NIF and EPS2 interface and transfer remains to be constructed. An upgrade to the user interface, multi-user security and a more robust database are potential upgrades for ASAT. Implementing ASAT as a web application would enable states with regional offices to compile an area source emission inventory without merging datasets from various locations.

In short, ASAT is an off-the-shelf application that facilitates the compilation of an area source emission inventory, and the flexibility and compatibility of ASAT provides the necessary functionality to launch the inventory effort in the right direction providing organization, documentation and calculation capabilities. It is the responsibility of the user to populate the system with emissions factors, activity data and efficiency values that best represent the spacial and temporal local domains of interest.

Key Words:

Air
Area Sources
Assessment
Database
Emissions Inventory
Tool
Software