GIS-Integrated Emissions Inventory Software Solution

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ABSTRACT

The Tribal Emissions Inventory Software Solution (TEISS) provides a graphical, user-friendly application for creating and maintaining a comprehensive emission inventory. The system includes an integrated GIS platform providing all users with the tools to visualize and query inventory data within a spatial environment. TEISS incorporates all related emissions guidance and models into one central, unified interface where results and computations are compiled and stored in an SQL database. The data handling solution allows database vendor independence making the system compatible with any of the major Database Management Systems, such as ORACLE, MS-SQL Server, MySQL, and Interbase.

The system supports emissions estimations based on AP-42, NEI, and EIIP guidelines through a series of real-time, GIS-based calculators. Over 200 calculators address emissions from a variety of sources and processes while also providing extensive descriptions for each process. System flexibility is extended by the ability of any emissions calculator to be modified or added without negative impacts on the system.

Emissions estimation models are tightly integrated allowing for seamless model execution and sharing of data from widely accepted models. Some of these emissions models, included in TEISS, are NONROAD, MOBILE6, WATER9, and FIRE. A complete graphical user interface for MOBILE6 was developed and integrated to TEISS. This removes much of the complexity commonly associated with vehicle emissions estimation.

TEISS allows for rapid review of emissions data and enables production of reports and data export to several formats including EPA NEI Input File format (NIF 2.0/3.0) for easy incorporation of data into national databases. The technologies and database design behind TEISS are explained while demonstrating the importance of a unified, GIS-based emissions inventory solution.

INTRODUCTION

Interest in emissions inventories for tribal lands continues to grow, and to facilitate the collection, analysis, and sharing of such data the need for a unified, graphical system became apparent.

The requirements for the Tribal Emissions Inventory Software Solution (TEISS) were established by the Institute for Tribal Environmental Professionals (ITEP), located at Northern Arizona University, and the Tribal Data Development Working Group (TDDWG). The overall objective is to increase the quantity, quality and utility of tribal air emissions data from tribes in the WRAP region and across the United States.

TEISS provides a graphical, user-friendly application for creating and maintaining a comprehensive emission inventory. The system is designed to guide the user through the creation of an emissions inventory from estimating emissions through to exporting data for the National Emissions Inventory (NEI).

The TEISS system integrates all related emissions guidance and models into one central, unified interface where results and computations are compiled and stored in an SQL database. A central interface is necessary to maintain ease-of-use for the user and to properly organize emissions data in order to perform effective data analyses and visualization.

Integrated GIS technologies ensure all users benefit from the visualization and querying approaches that a GIS offers, without the need for a third-party application to be installed on their computers.

GIS-BASED EMISSIONS INVENTORY SYSTEM

The user-friendly interface enables users to quickly perform any modeling or calculations and readily visualize the results in a graphical GIS environment. It is from this interface that data can be manually entered, analyzed or new emissions can be modeled using EPA models and calculators based on AP-42, EIIP and NEI guidance. Figure 1 illustrates the primary interface for TEISS.

The integrated GIS technologies are fully compatible with industry standards such as ArcView from ESRI. In addition to visualization of geographic datasets the solution enables graphical definition of site and source locations. Emissions inventory data for any entity can be reviewed with a single click within the graphical view.

The system includes a variety of quality assurance/quality control (QAQC) features to ensure no duplication of site specific sources and related properties. TEISS also includes range checks of parameter values throughout the inventorying process. Proper completion of required data is constantly reviewed and summarized for the user. Any missing data is brought to their attention prior to critical actions such as exporting data for the National Emissions Inventory.

Figure 1. Outline window displaying Release Point Information dialog.

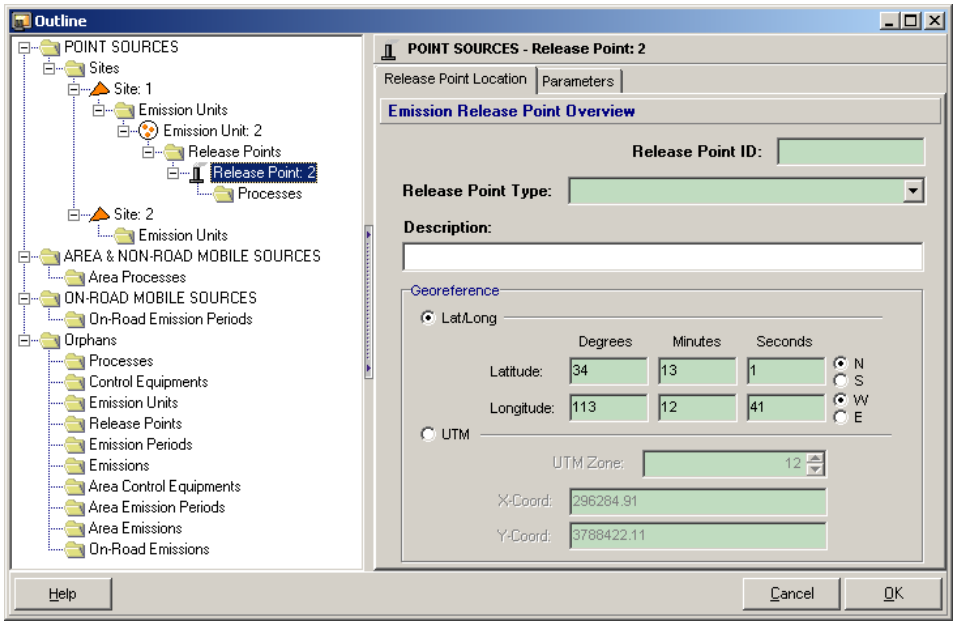
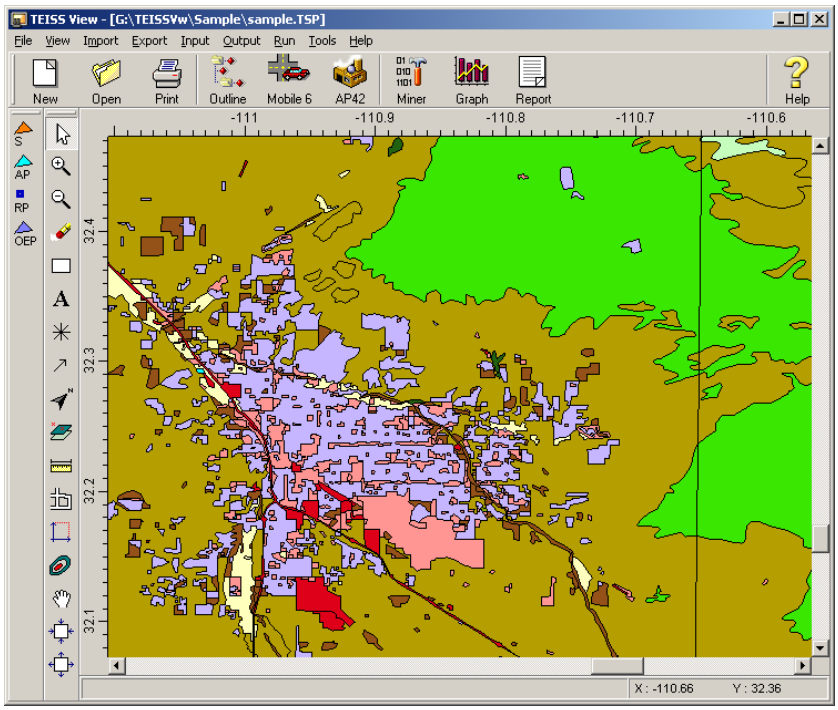


Figure 2. Primary interface of Tribal Emissions Inventory Software Solution (TEISS) displaying Land Use GIS data for the Tuscon region in Arizona.



Data Sharing

TEISS was designed to support easy exchange of data among tribal members and entities such as the U.S. EPA. Data exchange is facilitated by the ability to import and export GIS data in shapefile format, with complete metadata, and direct support for the NIF 2.0/3.0 standard.

Shapefile Import/Export

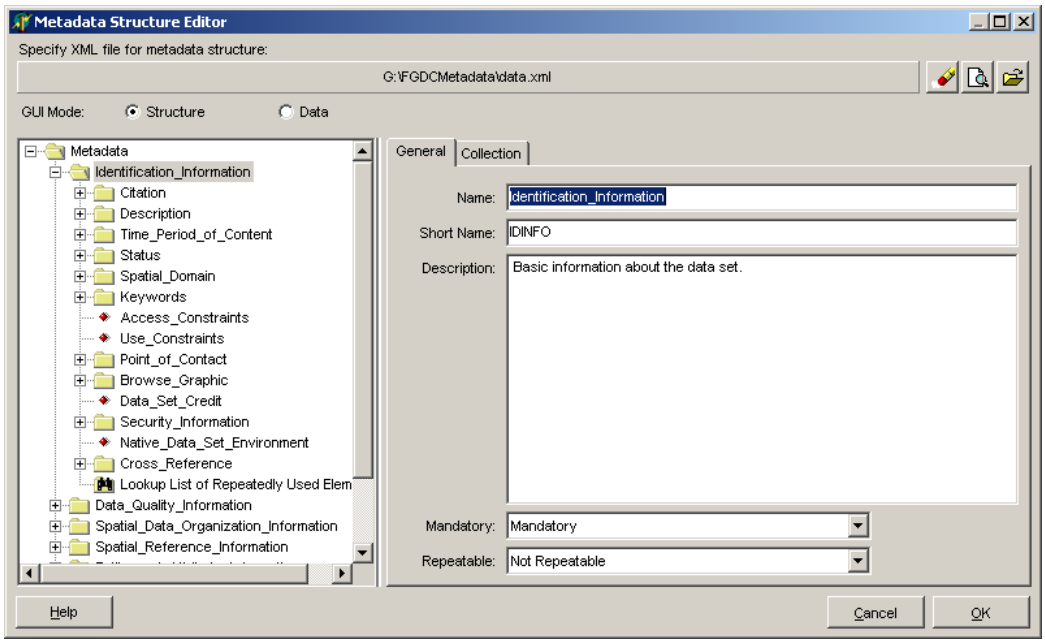
All GIS data can be imported and exported from TEISS to standard shapefiles. Users control what layers they want exported as shapefile themes by simple selection of existing layers. The resulting shapefiles can then be easily shared with colleagues, with the option to include standardized metadata.

FGDC Metadata

Metadata continues to play an important role in the use and distribution of GIS data. The Federal Geographic Data Committee's (FGDC) *Content Standard for Digital Geospatial Metadata* is one of the most widely adopted metadata standards for GIS data.

TEISS has the capability to generate GIS metadata according to the FGDC's standard. This enables professional and efficient sharing of GIS data by ensuring all users have a complete understanding and description of the data they share.

Figure 3. FGDC GIS Metadata tool.



NIF Support

The NEI Input Format (NIF) is the commonly used standard format that states, local agencies and tribes use to submit data to the National Emissions Inventory (NEI). TEISS guides users through completing the necessary data elements in their emissions inventory project and summarizes overall data completeness according to NIF requirements. TEISS can also import NEI data from NIF2.0 and NIF3.0.

Emissions Calculators

TEISS includes support for emissions estimation methods as outlined in AP-42, EIIP and NEI guidance. A complete series of user-friendly calculators based on these methodologies allow for estimations for any of several hundred processes and activities to be determined and automatically integrated into the current TEISS project .

All of the calculators feature easy-to-use interfaces, with each source category including default options with applicable and user-definable fields. All the calculators work as a wizard, where small data input steps are integrated with plenty of background information.

Each calculator consists of a *Process Info* dialog and one or more *Results* dialogs depending on the source category. Figure 4 displays the *Process Info* dialog from a sample calculator for *Solid Waste Disposal: Open Burning*. In the *Process Info* the user specifies the applicable category from a pull-down list, amount of refuse and related options and when complete, presses the *Calculate* button. The results are computed and the user can then view them by clicking on the desired *Results* button. For this example, Figure 5 has been included to provide *PAH Emissions* results for the sample scenario.

Figure 4. *Process Info* dialog from sample AP-42 Solid Waste Disposal: Open Burning calculator.

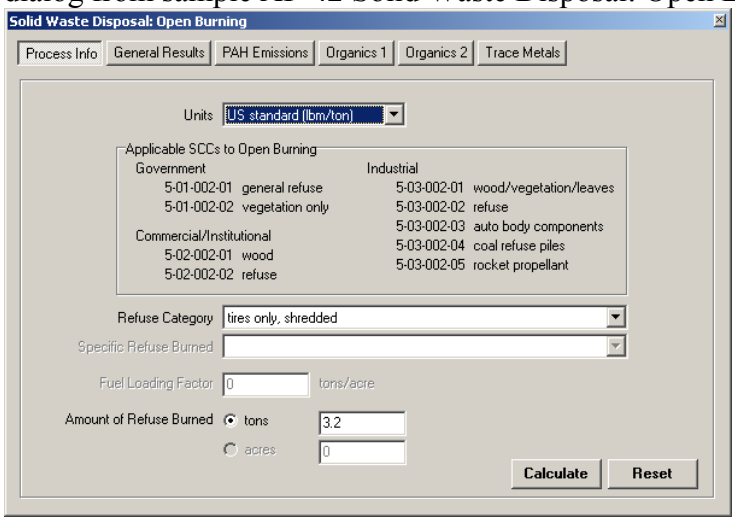
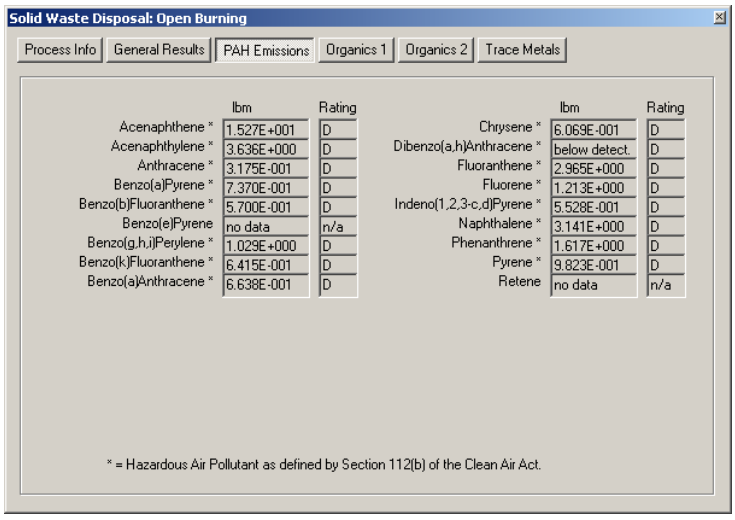


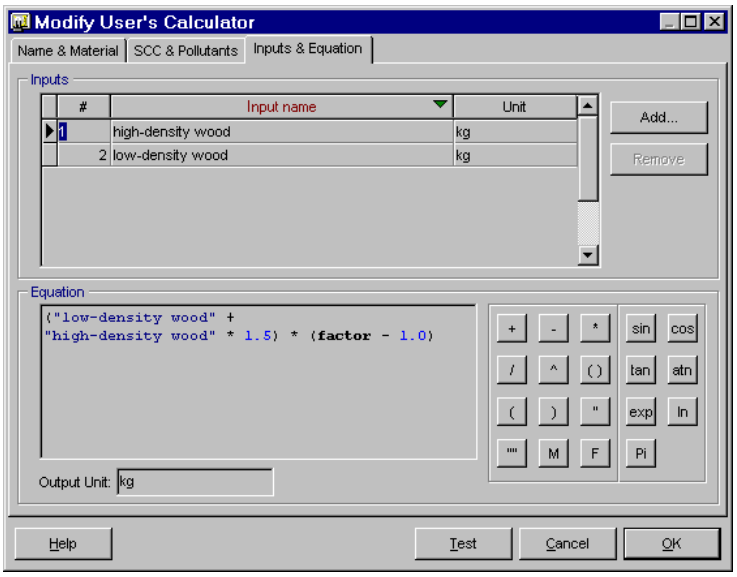
Figure 5. *PAH Emissions* results dialog from sample AP-42 Solid Waste Disposal: Open Burning calculator.



The data produced by all of the calculators is then recognized by the TEISS central interface and results are stored accordingly, including details such as date and time of emissions estimation. The data can then be ultimately visualized, reported and exported to any necessary formats.

Emissions estimation approaches are continually evolving, and different regions may base estimations on different procedures. TEISS accommodates the need for control over the emissions estimation methodology by enabling creation and modification of emissions calculations. Equations can be created and customized to ensure estimations are being performed using the appropriate methodologies. Figure 6 illustrates the user-definable emissions estimation dialog.

Figure 6. The user-definable emissions estimation tool enables the creation and modification of custom estimation calculations.



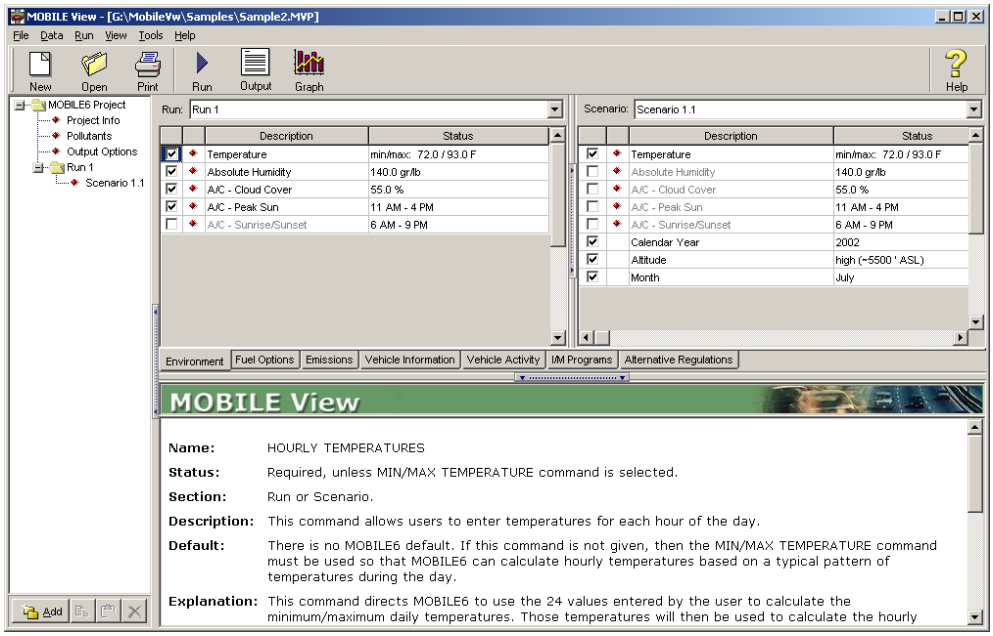
Widely Accepted Emissions Models

TEISS incorporates support for several U.S. EPA emissions models, including:

- MOBILE6
- NONROAD
- WATER9
- LANDGEM
- TANKS
- FIRE

All of these models, with the exception of MOBILE6, are normally distributed with Windows-based interfaces. To maintain ease of use, a graphical user interface for MOBILE6 was developed by *Lakes Environmental* for TEISS. This removes much of the complexity commonly associated with vehicle emissions estimation. An illustration of the main MOBILE6 graphical user interface can be seen in Figure 7.

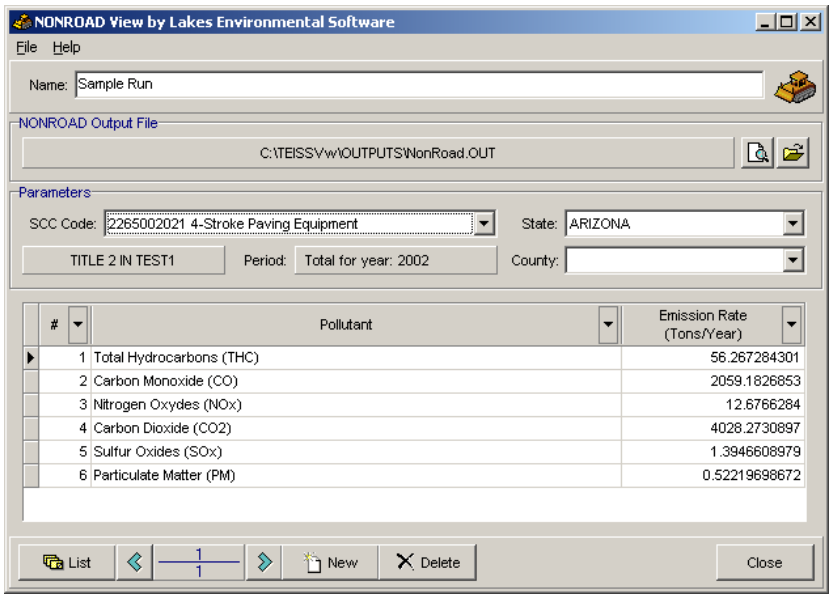
Figure 7. MOBILE View™, the graphical user interface for MOBILE6, integrated into TEISS.



TEISS will be used by individuals with a wide-range of expertise. The integration of graphical user interfaces for models that are typically DOS-based further increases the productivity of all users and eases the learning curve for entry-level users.

All of the emissions models feature complete integration of results with TEISS. The models can perform their estimation calculations in their unique graphical user interfaces, and the final results for the desired pollutants can then be graphically selected for instant use with the current TEISS project. This is demonstrated in Figure 8, which makes use of results from NONROAD.

Figure 8. TEISS incorporates complete support and data exchange for several U.S. EPA emissions models including NONROAD.



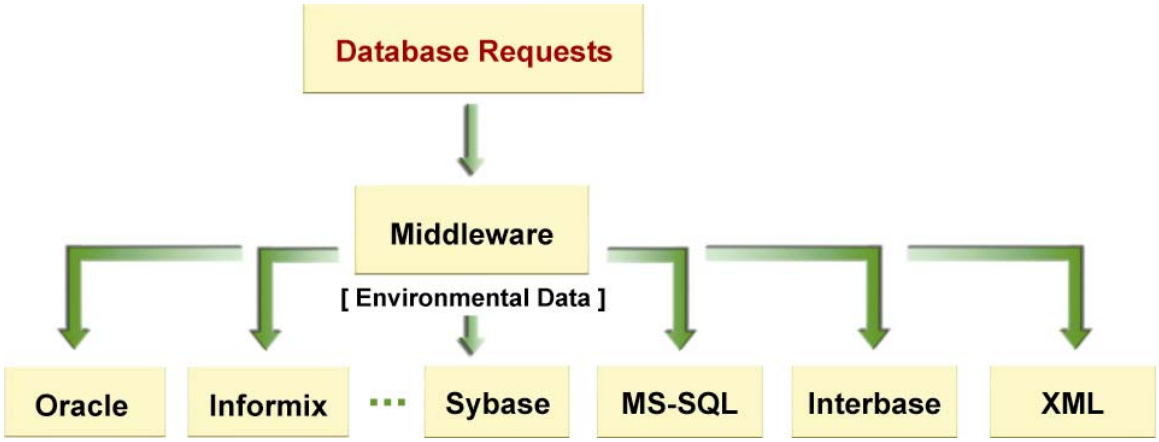
Database Management System

TEISS takes advantage of an SQL platform that offers a reliable, powerful database management system (DBMS) that is needed to ensure a firm foundation for the software. The InterBase database system is one of the major DBMS, along with MS-SQL 2000, Oracle and others. This database was recently released into Open Source and is ideal because of its power, dedication to SQL standards, and the ability to freely distribute it to all end-users. With a potential user base of hundreds of tribes, minimizing distribution costs while maintaining reliability and a powerful backend is essential.

Having such a solid foundation enables flexibility for future expansion while maintaining a high-quality, powerful data structure for immediate needs. However, through the implementation of a unique Middleware Layer, TEISS can interact with any SQL platform.

The Middleware Layer is a software component of the database architecture that makes the translation between the primary database and any existing environmental databases. As an example, with the middleware layer, TEISS can access information from databases in various formats. This is summarized in Figure 9.

Figure 9. Proposed solution and middleware layer interactions, and a sample of the database formats available to compile environmental datasets.



The middleware layer enables importation of all the desired environmental data from the existing databases and stores it centrally on a server. Since there are various implementations of the SQL "language", this solution can issue standard ANSI SQL commands and have it translate them into the supported database system, such as InterBase or ORACLE.

In summary, the advantages of the middleware layer are:

- Coordinate a single storage location.
- Allow for SQL database vendor independence, by allowing usage of different SQL dialects.
- Ability to scale if demands on the system increase, by the size of storage or number of simultaneous user requests.
- Facilitate Web enabling.

Emissions Allocation

TEISS incorporates support for spatial allocation of emissions estimates. There may be occasions where area source emissions overlap boundaries such as county borders or census tracts. TEISS can readily allocate the emissions to the appropriate spatial region reducing the time needed for populating the emissions inventory.

TEISS also handles point and area source reconciliation. In the event that both point and area source inventories include emissions from the same process, the area source emission should be adjusted to avoid double-counting of emissions (U.S. EPA, 1996). TEISS detects when this may occur and automatically reconciles the emissions, while ensuring the area source activity retains reasonable values (i.e. above zero emissions).

CONCLUSION

TEISS has enormously facilitated the creation of emissions inventories and will shift the way emissions inventory modeling is performed in the future. The system will be used by those new to emissions inventories and small facilities to expert state-wide regulators and advanced users.

The flexibility and organized character of the system allows for potential future uses to include permitting, tracking, and public distribution of information. The system can also extend to the creation of environmental model inputs for studies such as air dispersion modeling, environmental justice, and state-wide cumulative risk assessment. As a result, TEISS provides a scalable framework to estimate emissions and manage regulated sites.

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KEYWORDS

Emission Inventories
Geographic Information Systems (GIS)
Emissions Estimation
Tribal
MOBILE
NONROAD
WATER9
TANKS