Scope of Work For

Project 16-010
MOVES-Based NO_x Analyses for Urban Case Studies in Texas

Prepared for

Air Quality Research Program (AQRP)
The University of Texas at Austin

By

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QA Requirements: Audits of Data Quality: 10% Required
Report of QA Findings: Required in Final Report

Approvals

This Scope of Work was approved electronically on September 19, 2016 by Gary McGaughey, The University of Texas at Austin

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Project Manager, Texas Air Quality Research Program

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1.0 Abstract

Emissions inventories are an important component of air quality planning and a key input to photochemical grid models that support air quality assessments. Findings from recent studies suggest that emissions of nitrogen oxides (NO_x) may be overestimated in the U.S. Environmental Protection Agency's (EPA) National Emissions Inventory (NEI), perhaps by as much as a factor of two. This overestimate has generally been attributed to the mobile source sector, for which emission estimates are prepared using EPA's Motor Vehicle Emissions Simulator (MOVES) model. A number of potential issues have been identified with MOVES, including reliance on the model's default input data rather than more representative local inputs.

Sonoma Technology, Inc. (STI) will build on previous work by examining MOVES emission estimates at the local scale using near-road monitoring data. Specifically, the STI team will compare MOVES emission results with ambient monitoring data, using well-established emissions reconciliation techniques that STI has applied in numerous urban areas across the United States. These analyses will be performed for case studies in three Texas metropolitan areas: Dallas-Fort Worth, Houston, and El Paso. In addition, STI will perform sensitivity analyses comparing MOVES emission results from default vs. local data, to identify which input parameters have the greatest influence on NO_x emission estimates. STI will collect local MOVES input data from planning agencies such as the North Central Texas Council of Governments (NCTCOG) and the Houston-Galveston Area Council (H-GAC).

The results of this work will support emissions inventory development and air quality management efforts in Texas by providing information on the accuracy of current MOVES NO_x emission estimates and the input parameters for which local data are critical.

2.0 Background

Emissions inventories are key inputs to photochemical grid models in air quality modeling. Findings from recent studies evaluating ozone concentrations and emissions of ozone precursors suggest that NO_x emissions are overestimated in the EPA's National Emissions Inventory. This overestimate, which in some cases has been reported to be as large as a factor of two, has generally been attributed to the mobile source sector (Fujita et al., 2012; Anderson et al., 2014; Canty et al., 2015), as NO_x emissions from power plants are thought to be well-characterized by Continuous Emissions Monitoring Systems (CEMS) data (Frost et al., 2006; Peischl et al., 2010). A previous AQRP-funded project that constrained NO_x emissions over Southeast Texas using an inverse modeling approach estimated that mobile source NO_x emissions in the 2011 NEI should be reduced by a factor of two in Houston for 2013 ozone modeling (Choi et al., 2015).[1]

Mobile source emissions estimates are primarily developed using EPA's MOVES model, which includes a default database of county-level input data for the entire United States. EPA

[1] Some NO_x reduction between 2011 and 2013 would be expected because of vehicle fleet turnover and other effects, so the extent to which this factor of two represents an overestimate is not clear.

recommends that, where possible, these default data be updated with local inputs, such as vehicle miles traveled (VMT), fleet age distributions, meteorological data, and fuel specifications (U.S. Environmental Protection Agency, 2015). Studies evaluating NO_x overestimates in the NEI identified several potential issues with MOVES, including the model's treatment of catalytic converter degradation (Anderson et al., 2014), cold-start activity (Wang, 2013), contributions from super-emitters within the fleet (Liu and Frey, 2015), and reliance on MOVES default data rather than more accurate local inputs (Koupal et al., 2013).

This project will build on the previous NO_x emissions analyses outlined above by using near-road monitoring data to examine MOVES emissions estimates at the local scale. Such comparisons between emissions and ambient data (often called "emissions reconciliation") are used to identify omissions or inaccuracies in an emissions inventory, leading to further investigation and inventory improvement. The basic approaches used to perform emissions reconciliation analyses have been in use for more than 20 years (Fujita et al., 1992) and include selective, quantitative comparisons of emissions inventory- and ambient-derived molar pollutant ratios (e.g., VOC/NO_x or CO/NO_x), as well as comparisons of emissions inventory- and ambient-derived hydrocarbon compositions. Typically, these comparisons are made for morning commute periods when emission rates are high and mixing depths are low, minimizing the impact of confounding factors such as transported and chemically changed pollutants (Chinkin et al., 2005). Previous emissions reconciliation analyses have identified specific issues with on-road mobile source emissions estimates, such as improper characterization of weekend travel activity patterns for heavy-duty vehicles in the Upper Midwest (Reid et al., 2011).

3.0 Objectives

The overall goals of this project are to examine MOVES emissions estimates at the local scale using near-road monitoring data and identify which input parameters have the greatest influence on NO_x emissions estimates. The results of this work will support emissions inventory development and air quality management efforts in Texas by providing information on (1) the accuracy of current MOVES emissions estimates for NO_x, and (2) the MOVES input parameters for which local data collection is most important. This information will help planning agencies in Texas identify potential biases in existing on-road mobile source NO_x emissions estimates and prioritize data collection efforts for future emissions inventory development efforts.

4.0 Task Descriptions

Task 4.1 Emissions Reconciliation Analyses

In this task, STI will leverage the recent national near-road data assessment performed as part of the Near-Road Air Quality Research Transportation Pooled Fund. STI has gathered and processed 2014-2015 near-road monitoring data collected by state and local agencies (the most recent data available and certified as final by May 1, 2016) and conducted a national-scale review of near-road pollutant concentrations (DeWinter et al., 2015). From this group of monitors, which are within approximately 50 m of a major roadway, STI has identified sites in Fort Worth, Houston, and El Paso that can be used for Texas case study analyses (**Table 1**). The

Fort Worth and Houston sites are part of the official EPA near-road monitoring network and monitor NO_x, CO, and $PM_{2.5}$ (24-hr average). The El Paso site is not an official EPA near-road site but is located close to a highway; it monitors NO_x, CO, hourly $PM_{2.5}$, and VOC. As part of this project, the STI team will look for additional sites in these three metropolitan areas that are suitable for the proposed analyses (i.e., sites that are somewhat further than 50 m from major roadways but are still primarily influenced by mobile source emissions).

Table 1. Near-road monitors and pollutants measured for the case study analyses.

Location	EPA AIRS/AQS Site ID	Official Near-Road Monitor?	Road	Distance to Road (m)	Met Data	NO_x	CO	Hourly $PM_{2.5}$	VOC
Fort Worth	484391053	Yes	I-20	15	✓	✓	✓		
Houston	482011052	Yes	I-610	15	✓	✓	✓		
El Paso	481410037	No	Hwy 44	60	✓	✓	✓	✓	✓

For each site included in the analysis, the STI team will identify a suitable background monitoring site that can be used to characterize local pollutant concentrations in the absence of major roadways and other large emissions sources. Several key factors will be considered to determine potential background monitoring sites, such as the location similarities, distance, and wind patterns between the potential background site and the roadway area. It is very likely that a single suitable background monitoring site can be identified; however, in case that a single suitable monitor is not available, the STI team will consider another approach. For example, an interpolation approach can be considered to develop background concentrations from multiple appropriate monitoring sites; this approach will be based on EPA's guidance (U.S. Environmental Protection Agency, 2015a) to use the inverse distance between monitors as weights to calculate weighted average background concentrations. Background concentration data will be used to assess the incremental increase in pollutant concentrations caused by on-road emissions. In this analysis, the STI team will mainly focus on NO_x and CO, as concentrations of these pollutants will be dominated by mobile sources in the near-road environment. The team will also assess the available monitored $PM_{2.5}$ data to evaluate whether or not the incremental impact from on-road mobile sources can be identified. However, the use of monitored $PM_{2.5}$ data may be very limited, given that most near-road sites only provide 24-hr average (instead of hourly) $PM_{2.5}$ concentrations and that $PM_{2.5}$ concentrations are heavily influenced by secondary particulate formation.

For the monitoring sites and time period of interest (2014-2015), the STI team will conduct the following data processing and analysis:

- Select available hourly measurements for early morning hours (e.g., 6:00 a.m. – 9:00 a.m.) to minimize the influence of transported pollutants and chemical reactions on ambient measurements.
- Collect meteorological data (e.g., wind speed and wind direction) from co-located or nearby meteorological monitors for the time periods of interest.
- Calculate ambient-based pollutant ratios (e.g., CO/NO_x) for each monitoring site and examine variations in these ratios by season, day of the week, and periods when the site is upwind or downwind of the nearby roadway.

For the emissions analysis, the team will follow these steps:

- Identify a "zone of influence" around each monitoring site by using average wind speeds during early morning hours to approximate air parcel travel distance during that time period. This analysis will help determine which roadways and sections of roadways are likely to impact monitored concentrations when winds are from various directions.
- Work with NCTCOG and other local planning agencies to acquire local MOVES inputs (e.g., hourly traffic volumes and vehicle speeds, vehicle age distributions, fleet mix) for the road networks within each zone of interest. These data will be used with local meteorological measurements in MOVES to estimate on-road emissions for the road network around each monitoring site.
- Run MOVES2014a to develop emissions estimates, and then convert them from mass to molar basis so that pollutant ratios will be comparable to ambient-based ratios.

After all pollutant ratios are calculated, emissions- and ambient-based ratios will be compared by site, season, day of the week, and wind direction. Because of the inherent uncertainties associated with this analysis method, ambient- and emissions-derived ratios that are within approximately 25-50% of each other are considered to be in good agreement (California Air Resources Board, 1997). Larger differences may point to inaccuracies or biases in the emissions inventory; for example, emissions-derived CO/NO_x ratios that are lower than corresponding ambient-derived ratios may indicate that, in the emissions inventory, CO is underestimated, NO_x is overestimated, or both. Comparisons across multiple sites and pollutants can help to identify specific issues with the emissions data.

Deliverables and Schedule: See schedule for deliverables in Section 7.0.

Task 4.2 MOVES Sensitivity Analyses

The MOVES model includes a database of default input data for every county in the United States. EPA recommends replacing these default data with local information where possible to ensure that emissions estimates are representative of local conditions (U.S. Environmental Protection Agency, 2015b). Recent research has indicated that over-reliance on MOVES default data rather than more accurate local inputs may have led to issues with the accuracy of on-road NO_x estimates in the NEI (Koupal et al., 2013).

In this task, the STI team will conduct sensitivity analyses comparing MOVES emissions outputs generated from inputs of default data vs. local data (e.g., vehicle activity and fleet data acquired

from NCTCOG) to identify which input parameters have the largest effect on NO_x emissions estimates. The team will follow several working steps:

- Develop MOVES testing cases with default, local data, and other assumed levels of key modeling parameters (e.g., vehicle activities, vehicle age distributions, and fleet mix).
- Use the MOVES County Data Manager (see **Figure 1**) to incorporate input data for different testing cases, run MOVES2014a for each test case, and assess the changes in NO_x emissions estimates generated by MOVES for various cases.
- Re-calculate MOVES-based pollutant ratios for cases involving default input data to see whether those ratios compare more or less favorably with ambient-derived ratios than the MOVES-based ratios developed with local input data under Task 4.1.

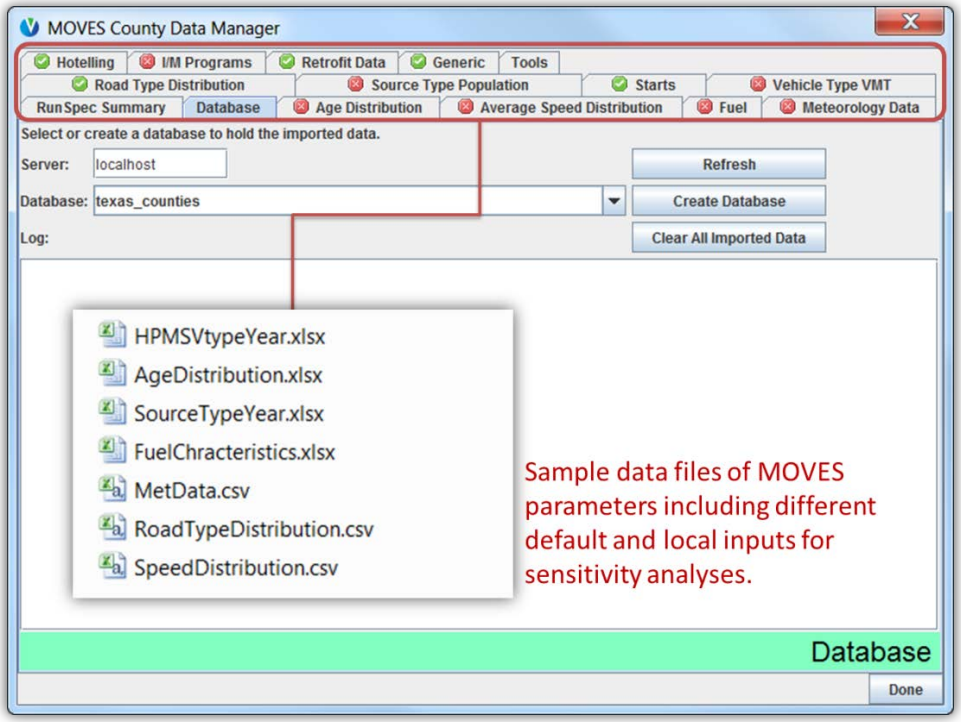

Figure 1. The MOVES County Data Manager will be used to facilitate sensitivity analyses.

Findings from this task will provide Texas planning agencies with insights and recommendations related to local data collection priorities for MOVES modeling efforts.

Deliverables and Schedule: See schedule for deliverables in Section 7.0.

Task 4.3 Project Reporting and Presentation

As specified in Section 7.0, “Deliverables,” of this Scope of Work, AQRP requires the regular and timely submission of monthly technical, monthly financial status, and quarterly reports as well as an abstract at project initiation and, near the end of the project, submission of the draft final and final reports. Additionally, at least one member of the project team will attend and present

at the AQRP data workshop. Song Bai, the project Co- PI, will electronically submit each report to both the AQRP and TCEQ liaisons and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. The report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceer.utexas.edu/ will be followed. In addition, draft copies of any planned presentations (such as at technical conferences) or manuscripts to be submitted for publication resulting from this project will be provided to both the AQRP project manager and the TCEQ liaison per the Publication/Publicity Guidelines included in Attachment G of the Master Subaward UTA16-000792. Finally, our team will prepare and submit our final project data and associated metadata to the AQRP archive.

5.0 Project Participants and Responsibilities

Table 2 provides a summary of participants and their responsibilities.

Table 2. Project participants and their roles and responsibilities.

Participant	Organization	Role	Responsibilities
Stephen Reid	STI	Principal Investigator	Provide technical direction for ambient data analysis aspects of the project
Song Bai	STI	Co-PI	Provide overall technical direction to the project and serve as the primary point of contact with AQRP
Yuan Du	STI	Emissions Modeler	Prepare input data for MOVES analyses, perform MOVES model runs, and post-process model outputs
Ashley Graham	STI	Data Analyst	Acquire, process, and analyze ambient air quality and meteorological data
Annie Seagram	STI	Data Analyst	Support ambient data analyses and comparisons between ambient data and MOVES outputs
Lyle Chinkin	STI	Quality Assurance Lead	Oversee quality assurance reviews for the project
Mary Jo Teplitz	STI	Technical Editor	Edit written deliverables and technical presentations
Jana Schwartz	STI	Technical Editor	Provide a final review of project deliverables
Jenny Narvaez	NCTCOG	In-Kind Support	Provide in-kind support, including the provision of local MOVES inputs for the Dallas-Fort Worth region and review of project findings

6.0 Timeline

Table 3 provides a schedule of project activities for each task defined in Section 4.0.

Table 3. Schedule of Project Activities.

Task	Activity	Completion Date
1. Emissions Reconciliation Analysis	Complete emissions reconciliation analyses	January 31, 2017
2. MOVES Sensitivity Analyses	Complete MOVES sensitivity analyses	May 31, 2017
3. Reporting and Presentations	Quarterly reports	See the schedule in Table 4
3. Reporting and Presentations	Monthly technical reports	See the schedule in Table 5
3. Reporting and Presentations	Financial status reports	See the schedule in Table 6
3. Reporting and Presentations	Draft final report	August 1, 2017
3. Reporting and Presentations	Final report	August 31, 2017
3. Reporting and Presentations	Presentation of findings at AQRP workshop	First half of August 2017

7.0 Deliverables

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. A description of the specific reports to be submitted and their due dates are outlined below. One report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI will submit the reports, unless that responsibility is otherwise delegated with the approval of the Project Manager. All reports will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceer.utexas.edu/ will be followed.

Abstract: At the beginning of the project, an Abstract needs to be submitted to the Project Manager for use on the AQRP website. The Abstract provides a brief description of the planned project activities, and will be written for a non-technical audience.

Abstract Due Date: Wednesday, August 31, 2016
(STI delivered the Abstract on August 29, 2016)

Quarterly Reports: Each Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Microsoft Word file. It will not

exceed 2 pages and will be text only. No cover page is required. This document will be inserted into an AQRP compiled report to the TCEQ.

Table 4. Quarterly Report Due Dates

Report	Period Covered	Due Date
Nov2016 Quarterly Report	September, October, November 2016	Wednesday, November 30, 2016
Feb2017 Quarterly Report	December 2016, January & February 2017	Tuesday, February 28, 2017
May2017 Quarterly Report	March, April, May 2017	Wednesday, May 31, 2017
Aug2017 Quarterly Report	June, July, August 2017	Thursday, August 31, 2017

Monthly Technical Reports (MTRs): Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison in Microsoft Word format using the AQRP FY16-17 MTR Template found on the AQRP website.

Table 5. MTR Due Dates

Report	Period Covered	Due Date
Sep2016 MTR	September 1 - 30, 2016	Monday, October 10, 2016
Oct2016 MTR	October 1 - 31, 2016	Tuesday, November 8, 2016
Nov2016 MTR	November 1 - 30 2016	Thursday, December 8, 2016
Dec2016 MTR	December 1 - 31, 2016	Monday, January 9, 2017
Jan2017 MTR	January 1 - 31, 2017	Wednesday, February 8, 2017
Feb2017 MTR	February 1 - 28, 2017	Wednesday, March 8, 2017
Mar2017 MTR	March 1 - 31, 2017	Monday, April 10, 2017
Apr2017 MTR	April 1 - 30, 2017	Monday, May 8, 2017
May2017 MTR	May 1 - 31, 2017	Thursday, June 8, 2017
Jun2017 MTR	June 1 - 30, 2017	Monday, July 10, 2017
Jul2017 MTR	July 1 - 31, 2017	Tuesday, August 8, 2017

Financial Status Reports (FSRs): Financial Status Reports will be submitted monthly to the AQRP Grant Manager (Maria Stanzione) by each institution on the project using the AQRP FY16-17 FSR Template found on the AQRP website.

Table 6. FSR Due Dates

Report	Period Covered	Due Date
Sep2016 FSR	September 1 - 30, 2016	Monday, October 17, 2016
Oct2016 FSR	October 1 - 31, 2016	Tuesday, November 15, 2016
Nov2016 FSR	November 1 - 30 2016	Thursday, December 15, 2016
Dec2016 FSR	December 1 - 31, 2016	Tuesday, January 17, 2017
Jan2017 FSR	January 1 - 31, 2017	Wednesday, February 15, 2017
Feb2017 FSR	February 1 - 28, 2017	Wednesday, March 15, 2017
Mar2017 FSR	March 1 - 31, 2017	Monday, April 17, 2017
Apr2017 FSR	April 1 - 30, 2017	Monday, May 15, 2017
May2017 FSR	May 1 - 31, 2017	Thursday, June 15, 2017
Jun2017 FSR	June 1 - 30, 2017	Monday, July 17, 2017
Jul2017 FSR	July 1 - 31, 2017	Tuesday, August 15, 2017
Aug2017 FSR	August 1 - 31, 2017	Friday, September 15, 2017
FINAL FSR	Final FSR	Monday, October 16, 2017

Draft Final Report: A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. It will also include a report of the QA findings.

Draft Final Report Due Date: Tuesday, August 1, 2017

Final Report: A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.

Final Report Due Date: Thursday, August 31, 2017

Project Data: All project data including but not limited to QA/QC measurement data, metadata, databases, modeling inputs and outputs, etc., will be submitted to the AQRP Project Manager within 30 days of project completion (September 29, 2017). The data will be submitted in a

format that will allow AQRP or TCEQ or other outside parties to utilize the information. It will also include a report of the QA findings.

AQRP Workshop: A representative from the project will present at the AQRP Workshop in the first half of August 2017.

Presentations and Publications/Posters: All data and other information developed under this project which is included in **published papers, symposia, presentations, press releases, websites and/or other publications** shall be submitted to the AQRP Project Manager and the TCEQ Liaison per the Publication/Publicity Guidelines included in Attachment G of the Subaward.

8.0 References

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