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OZONE FORMATION STUDY: MODELING QUALITY ASSURANCE PROJECT PLAN

LOUISVILLE METRO AIR POLLUTION CONTROL DISTRICT

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AMET	Atmospheric Model Evaluation Tool
AQM	air quality model
BenMAP	Benefits Mapping and Analysis Program
CAMx	Comprehensive Air Quality Model with Extensions
CSA	Combined Statistical Area
FTP	file transfer protocol
HRVOCs	highly reactive VOCs
IN	Indiana
KY	Kentucky
Louisville NAA	Louisville-Jefferson County, Kentucky-Indiana ozone nonattainment area
Louisville MSA	Louisville-Jefferson County Kentucky-Indiana Metro Statistical Area
LMAPCD	Louisville Metro Air Pollution Control District
MPE	model performance evaluation
MSA	metropolitan statistical area
NAA	ozone nonattainment area
NAAQS	National Ambient Air Quality Standard
NOx	oxides of nitrogen
ppm	parts per million
QAAP	Quality Assurance Project Plan
SIP	State Implementation Plan
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1. PROJECT DESCRIPTION AND OBJECTIVES

Ramboll has prepared this Quality Assurance Project Plan (QAPP) for the Louisville Jefferson County Metro Air Pollution Control District (LMAPCD) for the Louisville Ozone Formation Study following United States Environmental Protection Agency's (USEPA) guidelines (2002a, 2002b).

1.1 Purpose of Study

On June 4, 2018, USEPA designated a portion of the Louisville/Jefferson County – Elizabethtown – Madison, Kentucky-Indiana Combined Statistical Area (CSA) as Marginal nonattainment for the 2015 ozone National Ambient Air Quality Standard (NAAQS), effective August 3, 2018 (Federal Register Volume 83, Number 107, p. 25776). The 2015 ozone NAAQS is 0.070 parts per million (ppm). The annual fourth-highest daily maximum 8-hour concentration averaged over 3 years is not to exceed the 2015 ozone NAAQS. The Louisville CSA counties designated as nonattainment by USEPA for the 2015 ozone NAAQS included Bullitt, Jefferson, and Oldham in Kentucky (KY) and Clark and Floyd in Indiana (IN). The nonattainment designation was based on ozone design value[1] concentrations measured in 2014 through 2016 in the Louisville CSA (USEPA 2018a), when the Cannons Lane NCore monitoring site (site identifier 21-111-0067) had a 2014-2016 design value of 0.074 ppm. The USEPA completed a 5-factor analysis to determine the nonattainment area boundaries and classification for the Louisville, KY-IN nonattainment area (USEPA 2018a). The Louisville-Jefferson County Kentucky-Indiana ozone nonattainment area is referred to as the Louisville NAA.

On December 6, 2018, the USEPA finalized the Implementation Rule for the 2015 ozone NAAQS, which includes State Implementation Plan (SIP) requirements (Federal Register Volume 83 Number 234, p. 62998). Areas classified as Marginal nonattainment, such as the Louisville NAA, have 3 years from the date of designation to attain the standard (i.e., August 3, 2021 for the Louisville NAA). If an ozone monitor in the Louisville NAA exceeds the 2018 ozone NAAQS during the 2018-2020 ozone season, the area could be reclassified to the more stringent "Moderate" nonattainment level. Moderate nonattainment levels have additional SIP requirements, including a requirement to demonstrate attainment by the future attainment date using an air quality model.

In order to better understand ozone precursor emissions and ozone formation processes in the Louisville NAA area, LMAPCD is undertaking this Ozone Formation Study. Ozone is formed in the atmosphere through a set of complex nonlinear photochemical reactions involving oxides of nitrogen (NOx) and Volatile Organic Compounds (VOCs) in the presence of sunlight. Ozone formation within the LMA has previously been characterized as being either NOx-limited or VOC-limited (radical-limited); for example, typically earlier in the day ozone formation is limited by the rate of radical initiation so is more VOC (radical)-limited and by the afternoon, when photochemical reactions are greatest, ozone formation tends to be more NOx-limited. The level of precursor limitation can also vary greatly across an urban area. For example, in areas with high NOx emissions (such as urban downtowns where mobile source emissions predominate or downwind of large NOx point sources) ozone formation may be more VOC-limited, while a few km away in the suburbs ozone formation may be more NOx-limited. Beyond a certain ratio of VOC to NOx, however, further NOx reductions may act to increase ozone formation through radical initiated reactions of VOC and subsequent photochemical reactions that produce ozone, the so-called NOx disbenefit.

[1] A design value is the monitored concentration reported in the form of the NAAQS. For both the 2008 and the 2015 ozone NAAQS, the design value is the 3-year average of the annual forth highest daily maximum 8-hour average ozone concentration.

Louisville NAA has a unique heterogenous source mixture. While Louisville NAA has conditions like many other urban areas containing an urban core surrounded by suburban and rural areas, the industrial sources in the county are highly diverse, both from the perspective of industrial activities (such as power generation, automotive manufacturing, chemical manufacturing, commercial product manufacturing, petroleum terminals, sewage treatment, landfills, etc.), as well as air quality emissions. Furthermore, some areas, such as Rubbertown, have a high density of highly reactive VOCs (HRVOCs) while other areas have relatively large distances between NOx emissions sources or low reactivity VOCs.

A photochemical model is the best tool to assess spatial and temporal variations in ozone formation, as found in Louisville NAA, and analyze the sensitivity of ozone formation to NOx versus VOC precursors. Photochemical models are also the USEPA -recommended tool for ozone modeling (USEPA 2018b). In order to better understand the ozone formation processes contributing to elevated periods of ozone in Louisville NAA, ozone modeling will be conducted with an existing air quality model (AQM) with an existing air quality database.

Emissions inputs will be refined based on LMAPCD information to better represent the unique source characteristics and emissions profiles in Louisville NAA, as described in Louisville Metro Air Pollution Control District Emissions Inventory Quality Assurance Project Plan (Ramboll 2019a) and Inventory Preparation Plan (Ramboll 2019b). These emissions inputs generated specifically for the Louisville Ozone Formation Study will be used in combination with other publicly available data in an AQM to assess:

1. The extent to which areas and periods of elevated ozone in Louisville NAA are NOx-limited or VOC-limited, and
2. For VOC-limited areas/periods, the ozone formation potential of VOC emissions.

This information can inform voluntary ozone reduction measures to attain compliance with the ozone NAAQS by the Marginal attainment date (August 3, 2021) as well as inform potential future control strategies should the area be reclassified to Moderate. Model results can also be used to assess health effects using the USEPA Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) model (USEPA 2019).

1.2 Project Objectives

The purpose of the Louisville Ozone Formation Study is to assess whether Louisville NAA is NOx-limited or VOC-limited and, for areas and periods that are VOC-limited, assess the ozone formation potential of VOC emissions. To meet the project objectives, ozone modeling will be performed. Model performance will be assessed via a model performance evaluation (MPE) to determine if the model is performing sufficiently well to rely on results.

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 Responsibilities of Project Participants

This study will be conducted by Ramboll under contract to the LMAPCD. The Ramboll team working on this project and their specific responsibilities are listed in Table 1. The LMAPCD staff and Advisory Board members, listed in Table 2, will review the analysis of model results and provide comments. The reporting and communication structure are shown in Figure 1.

Table 1 The Ramboll Project Team Participants and Responsibilities

Participant	Project Responsibility
Greg Yarwood	Principal Investigator, technical consultant, quality assurance review
Courtney Taylor	Project Manager with technical oversight of the CAMx model performance evaluation, sensitivity analysis, and preparation of final project report and presentation
Marco Rodriguez Lynsey Karen Parker Chao-Jung Chien Jeremy Horne Jean Guo	Various tasks including CAMx post-processing & model evaluation, sensitivity analyses, and preparation of inputs for BenMAP

Table 2 The LMAPCD Project Team Participants

Participant	Role	Expertise	Email	Phone
Byron Gary	Project Coordinator	Regulatory Coordinator	Byron.Gary@Louisvilleky.gov	(502) 574-7253
Michelle King	Project Sponsor	Director of Program Planning and Executive Administrator	Michelle.King@Louisvilleky.gov	(502) 574-7252
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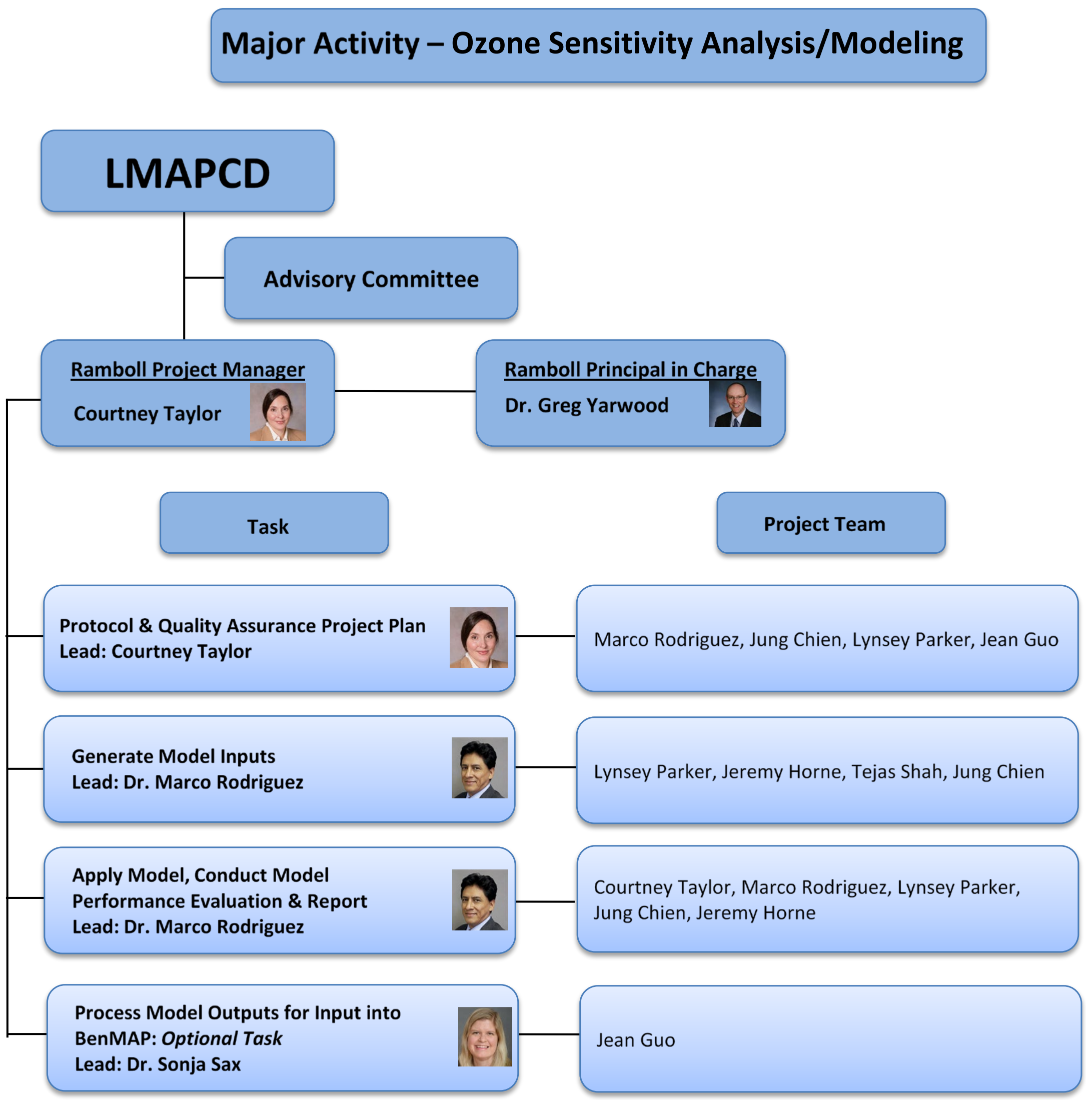
Rachael Hamilton	Champion	Assistant Director of LMAPCD	Rachael.Hamilton@Louisvilleky.gov	(502) 574-5218
Matt King	Champion	Permitting	Matt.King@Louisvilleky.gov	(502) 574-6714
Steven Gravatte	Champion	Excess Emissions	Steven.Gravatte@Louisvilleky.gov	(502) 574-7232
Billy Dewitt	Team Member	Ambient and Meteorological Monitoring	Billy.DeWitt@Louisvilleky.gov	(502) 574-7274
Bryan Paris	Team Member	Ambient and Meteorological Monitoring	Bryan.Paris@Louisvilleky.gov	(502) 574-7251
Karen Thorne	Team Member	Emissions Inventory	Karen.Thorne@Louisvilleky.gov	(502) 574-5153

Chris Gerstle	Team Member	Emissions Inventory	Chris.Gerstle@Louisvilleky.gov	(502) 574-7257
Craig Butler	Team Member	Modeling/MOVES	Craig.Butler@Louisvilleky.gov	(502) 574-7237
Torend Collins	Team Member	Stakeholder Engagement	Torend.Collins@Louisvilleky.gov	(502) 574-5237

Figure 1 Organizational Chart



2.2 Project Schedule

The modeling project schedule and milestones are shown in Table 3.

Table 3 Modeling Schedule and Milestones

Work Element	Completion Date
1.1 Draft Modeling Protocol 1.2 Final Modeling Protocol	June 5, 2019 June 26, 2019
1.1 Draft Modeling Quality Assurance Project Plan 1.2 Final Modeling Quality Assurance Project Plan	June 5, 2019 June 26, 2019
Generate Model Inputs (excluding emissions)	July 31, 2019
Run Base Case and Conduct Model Performance Evaluation	August 21, 2019
Conduct Sensitivity Test #1 (NOx Emissions Reduction)	August 28, 2019
Conduct Sensitivity Test #2 (VOC Emissions Reduction)	September 4, 2019
3.1 Draft Model Performance Evaluation and Sensitivity Test Report 3.2 Final Model Performance Evaluation and Sensitivity Test Report	September 4, 2019 September 25, 2019
4.0 Produce BenMAP inputs	October 2, 2019
5.0 Data Transfer	October 2, 2019

3. SCIENTIFIC APPROACH

3.1 Data Needed to Meet Project Objectives

The modeling study will rely on the existing USEPA 2016 Beta platform with emissions modified as described by Louisville Metro Air Pollution Control District Inventory Preparation Plan (Ramboll 2019b) and slight changes to ancillary inputs as described in Louisville Metro Air Pollution Control District Modeling Protocol (Ramboll 2019c). CAMx photochemical modeling output data would be produced throughout the final Louisville 12-km domain, which is a subset of the USEPA CONUS2 domain. The ambient data will be used for evaluation of the CAMx model's performance using USEPA's Atmospheric Model Evaluation Tool (AMET) (AAI 2014). The minimum requirements for the data are that they provide information that is accurate and representative for the modeling domain and the temporal extent of the simulation period. The data should derive from sources and procedures that have been peer-reviewed and the methods used in applying the data should be consistent with best current scientific practices.

3.2 Data Sources

3.2.1 CAMx Modeling Data

CAMx model-ready meteorological data and ancillary input data will be obtained from USEPA for their 2016 Beta modeling platform. The 2016 ozone season will be simulated. Ozone season for this study has been defined to be March 1 through October 31 consistent with the monitoring ozone season for LMAPCD. Initial conditions would be derived from emissions and meteorological parameters for the 10 days preceding March 1 ozone season to initialize the model.

Ramboll would develop boundary conditions for the Louisville 12-km domain. Boundary condition information would be extracted from the USEPA 2016 Beta platform full CONUS2 12-km domains. The USEPA CONUS2 12-km domains would be run to produce the necessary three-dimensional concentration files. Concentrations from the three-dimensional files would be extracted along the lateral boundaries of the Louisville 12-km domain.

To get an accurate assessment of the ozone formation sensitivity to precursors in Jefferson County, Kentucky, the AQM grid resolution needs to be fine enough to resolve the chemical regimes in the various locations in Louisville (e.g., downtown mobile source dominated, Rubbertown and other areas with point sources). A 4-km domain will be simulated through the use of "flexi-nesting" technique. Data a 4-km resolution is not necessary when using flexi-nesting, so no additional data sources are anticipated.

Satellite data collected by Ozone Mapping Profiler Suite for 2016 (NASA 2019) will be used to generate ozone column data for this study rather than the 2015 OMI data used by USEPA.

CAMx model output data will be evaluated relative to available monitoring data throughout the final Louisville 12-km domain using the USEPA's Atmospheric Model Evaluation Tool (AMET).

3.2.2 Observational Data

Observational data for 2016 will be used from AMET. No other additional data sources have been identified.

4. QUALITY METRICS

In this section, we specify the quality requirements for the data used in this study and describe the procedures for determining the quality of the secondary data.

4.1 CAMx Modeling Data

As a quality assurance measure, Ramboll will review available MPE analyses for the 2016 Beta platform and summarize performance in the central region surrounding Louisville NAA. This will provide early indication of the adequacy of the existing 2016 Beta modeling platform.

Once the CAMx modeling is conducted for the Louisville Ozone Formation Study, Ramboll will analyze the 2016 CAMx model output using visualization and model performance software to verify that the model and its inputs were configured correctly. Animations of hourly ozone and other model output species for the entire episode will be reviewed to ensure that the modeling is carried out correctly and that model output is consistent with the emission inventory and meteorological model inputs. A standard ozone MPE examines ozone model performance statistics averaged over days and monitoring sites. However, when using the PGM for projecting future year ozone concentrations, the 10 highest base year modeled MDA8 ozone concentrations days are used. Thus, our MPE would pay particular focus on the model's ability to simulate the highest observed MDA8 ozone days at the key monitoring sites in the Louisville NAA. Results will be compared to USEPA model performance criteria for ozone as recommended in USEPA Guidance (2018a) as well as the original USEPA Beta 2016 model platform MPE.

4.2 Observational Data

Ambient air quality measurements collected within the Louisville-Jefferson County Kentucky-Indiana Metro Statistical Area (Louisville MSA) during 2016 as available from AMET will be compared with model results. This data is already quality-controlled.

5. DATA ANALYSIS, INTERPRETATION AND MANAGEMENT

5.1 Analysis of CAMx Model Output

Ramboll has evaluated CAMx model performance in simulating observed near-surface ozone and precursors using both graphical and statistical methods. Statistical methods will include computation of metrics for bias and error between predictions and observations for the species listed above. Standard statistical metrics as described in the USEPA air quality modeling guidance (USEPA, 2018a) will be calculated and reported. In addition, the sensitivity of ozone formation to a single perturbation of emissions using two runs, a base case and emissions perturbation sensitivity case will be conducted for a 25% reduction of anthropogenic VOC and another case will be conducted for a 25% reduction of anthropogenic NOx emissions.

5.2 Data Storage Requirements

Data generated for this project, including model inputs, final model outputs and various air quality observational data and statistical performance calculations, will be securely archived during the project on portable hard drives and stored for a period of at least five years following the completion of the project. All data obtained for this project will be stored in electronic format. Our teams' experience has been that 2 or 4 TB hard drives provide an accessible and portable system for storing data files of the size routinely encountered in the type of modeling activities similar to this study.

6. REPORTING

6.1 Project Deliverables

The schedule for all deliverables is presented in Section 2, Table 3.

6.2 Final Project Deliverables

Draft and Final Model Performance Evaluation and Ozone Sensitivity Report will be delivered to the LMACPD Project Manager electronically (i.e., via file transfer protocol (FTP) or e-mail) in Microsoft Word format no later than the deliverable due date shown in Table 3. Input and output files for CAMx Base Year, as well as pre-processing and post-processing steps will be transferred on external hard drives formatted for Windows computers. The Reports will detail the methods and results and will include the following components:

1. An executive summary or abstract
2. A brief introduction discussing the background and objectives, including relationships to other studies if applicable
3. A discussion of the pertinent accomplishments, shortfalls, and limitations of the work completed.
4. Recommendations, if any, for what should be considered next as a new study.

The Final Report will provide a comprehensive overview of activities undertaken and data collected and analyzed during the work. The Final Report will highlight major activities and key findings, describe problems encountered and associated corrective actions, and detail relevant statistics including data, parameter, or model completeness, accuracy, and precision.

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