Scope of Work For

20-011
Improving Estimates of Wind-Blown Dust from Natural and Agricultural Sources

Prepared for

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

By

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Ramboll
Novato, California

July 10, 2020
Version 3

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

NOTE: The workplan package consists of three independent documents: Scope of Work, Quality Assurance Project Plan (QAPP), and budget and justification. Please deliver each document (as well as all subsequent documents submitted to AQRP) in Microsoft Word format.

Approvals

This Scope of Work was approved electronically on **May 22, 2020** by Elena McDonald-Buller, The University of Texas at Austin

Elena McDonald-Buller
Project Manager, Texas Air Quality Research Program

This Scope of Work was approved electronically on **July 9, 2020** by Barry Exum, Texas Commission on Environmental Quality

Barry Exum
Project Liaison, Texas Commission on Environmental Quality

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1.0 Abstract

Ramboll will critically evaluate current windblown dust (WBD) emission models and identify and adapt alternative landcover, soil and activity datasets with which to update Ramboll's existing WBD emissions modeling framework. Using the Comprehensive Air quality Model with extensions (CAMx), we will assess the effects of the WBD emission updates on speciated particulate matter (PM) concentrations at monitoring sites located in federally protected Class I Areas throughout the south-central US. Our project directly addresses an AQRP priority research area by focusing on improving speciated, size-resolved WBD emission estimates for air quality modeling, in particular to support the Texas Commission on Environmental Quality's (TCEQ) current visibility modeling for the federal Regional Haze Rule (RHR).

Visibility impairment is predominantly caused by PM in fine and coarse size ranges. Whereas fine PM commonly includes a multitude of primary and secondary inorganic and organic compounds from a variety of sources, including crustal (soil-derived) components, the majority of coarse PM derives from direct emissions of crustal material. Current TCEQ modeling exhibits especially large underestimates of coarse crustal PM concentrations, indicating a need to improve emission estimates from dust sources. Soil emissions are especially difficult to estimate given the variety of source mechanisms and environmental conditions that lead to high spatial and temporal variations. Improving dust emissions and modeled concentrations requires refined vegetative and soil datasets and emission parameterizations. Visibility simulations will benefit from enhanced WBD modeling and explicit treatment of elemental species (e.g., Ca, Fe, Mn), which influence secondary PM chemistry (e.g., sulfate, nitrate) and enable more refined model evaluation because they are explicitly monitored. The CAMx WBD emission model provides an existing framework to efficiently test updated parameterizations and to incorporate enhanced and/or more locally specific landcover, soil and activity data. Computing dust emissions outside CAMx (in a preprocessor) is more flexible and transparent than implementing an "in-line" dust scheme inside CAMx.

2.0 Background

The Commission on Environmental Quality (TCEQ) is conducting photochemical modeling to support the Texas State Implementation Plan (SIP) for the federal Regional Haze Rule (RHR). The TCEQ is applying the Comprehensive Air quality Model with extensions (CAMx; Ramboll, 2018) for this purpose, the same tool employed for Texas ozone nonattainment areas, and is using Source Apportionment Technology (SAT) to estimate culpability to visibility impairment by emissions sector and geographic region. Visibility impairment is predominantly caused by particulate matter (PM) in two size modes: fine ($PM_{2.5}$) with aerodynamic diameters <2.5 microns, and coarse (>2.5 microns). Whereas $PM_{2.5}$ commonly includes a multitude of primary (directly emitted) and secondary (chemically-formed) inorganic and organic compounds from a large variety of sources, the majority of coarse PM derives from direct emissions of crustal material (soil-derived dust). Each of these different PM sizes and species possess different light extinction characteristics. Therefore, photochemical models must address a variety of chemical species, complex pathways, sources and sinks by which to correctly estimate PM mass budgets and their effects on visibility.

Both coarse and fine dust are generated from diverse natural and anthropogenic emission sources. Dust emissions are especially difficult to estimate given the variety of source mechanisms and environmental conditions that lead to high spatial and temporal variability. Such sources include "active" processes such as fugitive road dust and other anthropogenic activities (agriculture, mining, construction, industry) and windblown dust (WBD) from "passive" emissive areas (barren lands, dry mineral-rich lakebeds and playas, tilled croplands). Understandably, WBD represents an appreciable fraction of the total uncertainty in dust emissions, and dust impacts at monitoring sites can be highly influenced by local emissions that may not be sufficiently resolved by grid models.

Ramboll has recently developed the "WBDUST" emission model, which is an adaptation of the dust scheme and global soil properties compiled by Klingmueller et al. (2017). The TCEQ's visibility modeling using WBDUST indicates a need to improve emission estimates from dust sources because the model consistently under predicts soil-derived PM, especially in the coarse mode, according to speciated monitoring within federally protected Class I Wilderness Areas and National Parks (Ramboll, 2019). Ramboll has also consistently noted insufficient dust emissions estimates from WBDUST for several modeling applications over regional, continental and hemispheric scales. Our implementation of minor updates to WBDUST that relax certain restrictions on the numerous criteria that must align to emit dust have resulted in limited improvements. Further improvements require refined vegetative and soil datasets and emission modeling approaches. Visibility simulations will benefit from enhanced WBD modeling and the explicit treatment of elemental species (Fe, Mg, Mn, Ca, K, Al, Si, Ti), which explicitly influence certain secondary PM chemistry pathways and better align with current speciated monitoring.

The CAMx WBDUST emission model provides an existing framework that will be improved in this project with updated parameterizations and enhanced, more locally specific and more temporally resolved landcover and soil data. The project will review and evaluate current WBD models, adapt alternative methods, identify/incorporate improved datasets characterizing soil types and vegetative cover, and reevaluate WBD results using CAMx to quantify performance improvements in Class I areas throughout the south-central US. Our project directly addresses one of the priority research areas listed for the 2020-21 biennium: "…identify the most promising algorithms for processing soil data and partitioning soil types into chemical species that will react chemically with existing PM thermodynamic modules and into inert fractions that will become windblown dust."

3.0 Objectives

The project objectives include:

1. Review the current CAMx WBDUST algorithm with respect to methodology, soil/landcover input data, speciation, and CAMx performance against measurements;
2. Compare the CAMx WBD algorithm to techniques employed within other models (e.g., CMAQ, WRF-Chem), consider advantages and disadvantages among each, and adapt best approaches for an improved CAMx emission model for speciated WBD;
3. Review available landcover, cropland/agricultural activity, and speciation datasets to further improve characterization of WBD from the agricultural sector, and develop a methodology to process such data for direct use in the updated WBD emissions processor;
4. Document changes in CAMx performance for dust species, especially in the coarse mode, using an existing national modeling dataset.

4.0 Task Descriptions

Task 4.1. Review Current CAMx WBDUST Estimates

The TCEQ has developed a CAMx Modeling Platform (MP) for the year 2016 to assess visibility progress in Texas and across the south-central US. The TCEQ MP is largely based on the US Environmental Protection Agency's (EPA) 2016 national MP dataset (EPA, 2019a), which employs a North American domain with 36 km grid resolution, and a nested US domain with 12 km grid resolution. The EPA and multi-jurisdictional planning organizations (MJOs) compiled emissions in a joint Inventory Collaborative Study (NEIC, 2019). Annual, county-level fugitive dust emissions from anthropogenic sources (i.e., agricultural activities, roads, etc.) are included in the nonpoint sector according to the 2014 V2 National Emission Inventory (NEI). During processing to model input files, EPA reduces these emissions on days when at least 0.01 inches of precipitation occurred or when there is snow cover; wind conditions are not accounted for. This methodology is consistent with fugitive dust estimates developed in other regulatory MPs, however, WBD is not included in EPA's model input files because the EPA MP supports the Community Multiscale Air Quality (CMAQ; EPA, 2019b) model, which possesses an in-line WBD algorithm.

The TCEQ has derived its own meteorological fields for the EPA MP and has developed its own emission estimates for certain sectors (biogenic, fires, oceanic, and lightning NOx). The TCEQ also estimated WBD based on its meteorological datasets using Ramboll's WBDUST program. Ramboll and TCEQ have evaluated 2016 MP performance in replicating total PM mass and species component concentrations at numerous Class I Area IMPROVE[1] monitoring sites within and near Texas, as shown in Figure 1 (Ramboll, 2019). Figure 2 shows examples of these comparisons at three Class I sites that report large PM fractions of crustal material. TCEQ's modeling exhibits especially large underestimates of coarse mass (CM), which may be due in part to highly localized emissions that the model cannot resolve.

[1] Interagency Monitoring of Protected Visual Environments (http://vista.cira.colostate.edu/Improve/)

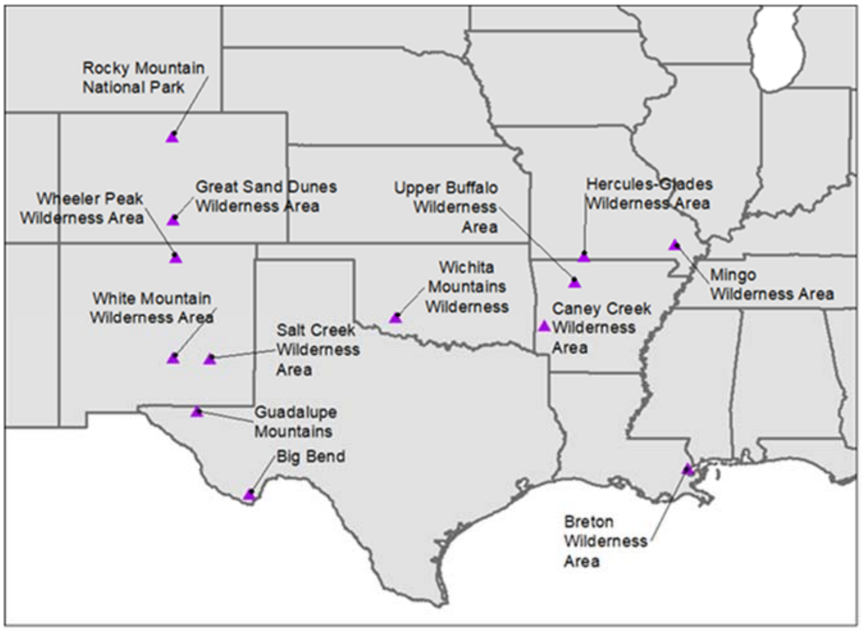

Figure 1. Federal Class I Areas with PM monitoring sites operated by the IMPROVE network in Texas and nearby states.

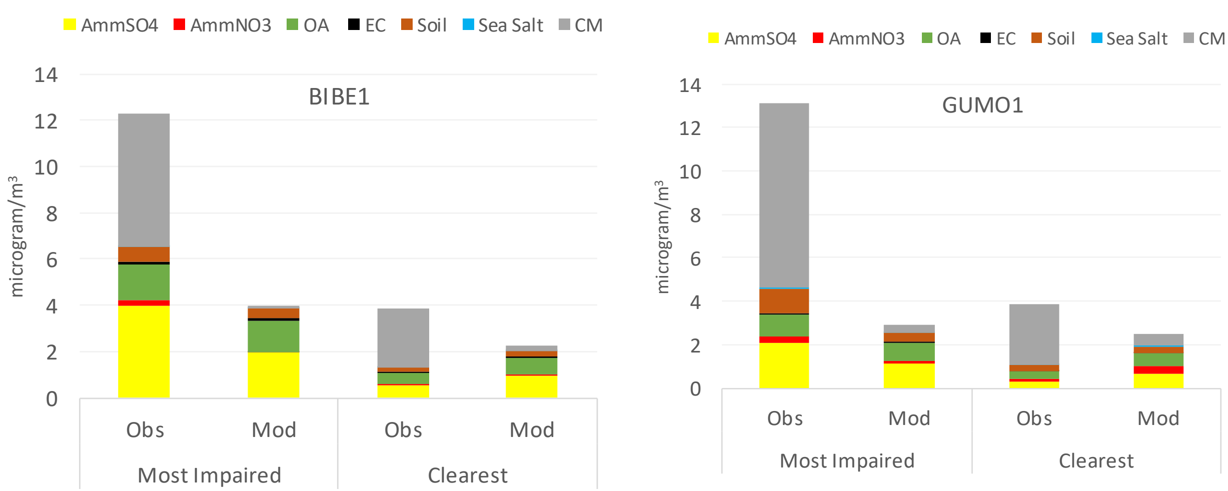

Figure 2. Comparison of observed ("Obs") and CAMx-predicted ("Mod") PM component concentrations ($\mu g/m^3$) at Big Bend (BIBE1) and Guadalupe Mountain (GUMO1) IMPROVE monitoring sites. In all cases, results are for the observed 20% most impaired and clearest days in 2016, which are the set of days required for visibility projections. Coarse mass ("CM") is a large contributor and is mostly crustal; "Soil" refers to the $PM_{2.5}$ dust constituent.

Ramboll will more fully investigate the contribution of current CAMx WBD estimates to PM predictions in the 2016 MP, with particular emphasis on addressing the large CM underestimates. We understand that the TCEQ will not release its 2016 MP until after the visibility SIP is published. PM results documented in EPA (2019a) are based on the 2016 MP

”beta prime” emissions inventory, which has since been supplanted by MP “v1”. Therefore, we will conduct our analyses using the EPA 2016 MP v1.

Ramboll will apply the WBDUST emission program using EPA MP meteorological inputs to generate emissions of total fine and coarse PM emissions (as was performed for the TCEQ), as well as speciated elemental $PM_{2.5}$ components (Fe, Mg, Mn, Ca, K, Al, Si, Ti) that can be directly compared to the IMPROVE measurement data. We will conduct an annual CAMx v7 simulation with and without WBD emission estimates and calculate model performance statistics and time series for PM components at the IMPROVE sites shown in Figure 1. We will use CAMx Source Apportionment Technology to isolate contributing sources (i.e., natural vs. agricultural) to provide a comprehensive tally of the dust contributions in the MP. We will compare results to quantify the extent to which the current WBDUST model contributes toward soil and CM concentrations in the region, and any chemical impacts on secondary PM species concentrations derived from the elemental components. Based on prior experience, we anticipate that modeled WBD contributions will be negligible to marginal even during the days with highest soil measurements.

Deliverables: Task Technical Memorandum describing modeling, source apportionment results, and model evaluation of soil and CM concentrations.

Schedule: Complete by September 30, 2020.

Task 4.2. Review Alternative Methods and Datasets

Subtask 4.2.1: Compare Current Model with Alternative WBD Methods

Ramboll will review and document the technical approach, input datasets, and assumptions of the Klingmueller et al. (2017) algorithm as implemented in Ramboll’s WBDUST program. The review will also tabulate key strengths/weaknesses as well as Ramboll’s and TCEQ’s experiences to date using WBDUST in their modeling applications. Specific elements of the modeling system will be examined:

- CAMx input datasets (meteorology and landcover/vegetation type);
- Global input datasets (barren land mask, leaf area index or LAI, soil clay fraction and elemental composition);
- Dust emissions algorithm equations, assumptions, thresholds and requisite variables.

Ramboll will then conduct a literature review of WBD emission models employed in other modeling systems, such as the Weather Research and Forecasting model with chemistry (WRF-Chem; NCAR, 2019) and CMAQ (EPA, 2019b). Specifically, details of each methodology and sources of soil/vegetative cover and other key inputs will be compared to the current CAMx WBDUST modeling system. Key differences in methodology and input data will be noted and advantages and disadvantages of each approach will be tabulated as consistently as possible to the WBDUST review. We will conduct a literature review of scientific publications that assess each of the candidate methods in terms of performance in replicating measured dust concentrations. Based on this evaluation, we will select specific updates to the WBDUST parameterization or a full adaptation of a chosen alternative method into the WBDUST modeling system that will continue to operate using CAMx-ready input files for meteorology and landcover.

Deliverables: Task Technical Memorandum containing description of current WBDUST program, summary of literature review, and list of specific WBDUST updates.

Schedule: Complete by November 30, 2020.

Subtask 4.2.2: Alternative Landcover and Agricultural Datasets

The design objective of WBDUST was to provide the CAMx user community with a simple dust emission framework that supports multi-scale CAMx applications anywhere in the world. However, a key disadvantage of the current globally-oriented WBDUST system is the restriction of dust emissive areas to large permanent natural barren lands such as deserts, with limited regard to seasonal and spatial variations in smaller-scale erodible lands such as exposed agricultural fields associated with tilling cycles. This aspect of WBD is critically important to areas within and around Texas, and in this task Ramboll will conduct an extensive review of available datasets from which to enhance the set of WBDUST inputs for US applications.

In the WBDUST model, erodible lands are prescribed based on a global barren land mask (0.05° or ~5 km, annual 2001-2012), a global soil composition dataset (0.1° or ~10 km, time-invariant), and CAMx input land use data on the modeling grid (most often mapped from WRF land cover output). Ramboll will review publicly available landuse datasets that can be adapted to improve spatial landcover characterization in the US. A leading data source is the recent US Geological Survey (USGS) 2016 National Landcover Database (NLCD) (USGS, 2019). NLCD provides a nation-wide dataset (48 conterminous states) at 30-meter resolution and contains spatial reference and descriptive data for characteristics of the land surface such as thematic class (e.g., urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. This same dataset is used in the Model of Emissions of Gases and Aerosols from Nature (MEGAN, Guenther et al., 2012), and so provides consistency between biogenic and WBD emission estimates. The 30-m resolution data will be aggregated to a national 1 km resolution database. WBDUST will be updated to alternatively read these data, map to the CAMx grid, and generate an alternative CAMx input landcover file for consistency in air quality simulations.

Correctly representing the spatial and temporal variations in surface vegetation is also important due to its various effects on dust generation including drag partitioning, local wind acceleration, near-source removal, and protective coverage. The WBDUST model uses a global Leaf Area Index (LAI) dataset (0.1° or ~10 km, monthly 2000-2015) as a surrogate for vegetation cover. Global LAI products are available from the Moderate Resolution Imaging

Spectroradiometer (MODIS) that can be used to develop better high-resolution (1 km) time-varying (8-day) vegetation coverage. Ramboll will adapt this global MODIS LAI data product as an alternative input to the WBDUST model.

Agricultural tilling exposes land tracts to seasonal wind erosion, and except through the current LAI input, this type of WBD source is not well resolved temporally or spatially. We will review the National Agricultural Statistics Service (NASS) "CropScape" mapping tool (NASS, 2012) and crop calendar data. CropScape provides detailed land use data by crop type as shown in Figure 3. From our review, Ramboll will develop a methodology to use these valuable sources of data in WBDUST to improve the characterization of agricultural land cover types and particularly the specific areas and times that croplands are exposed for wind erosion.

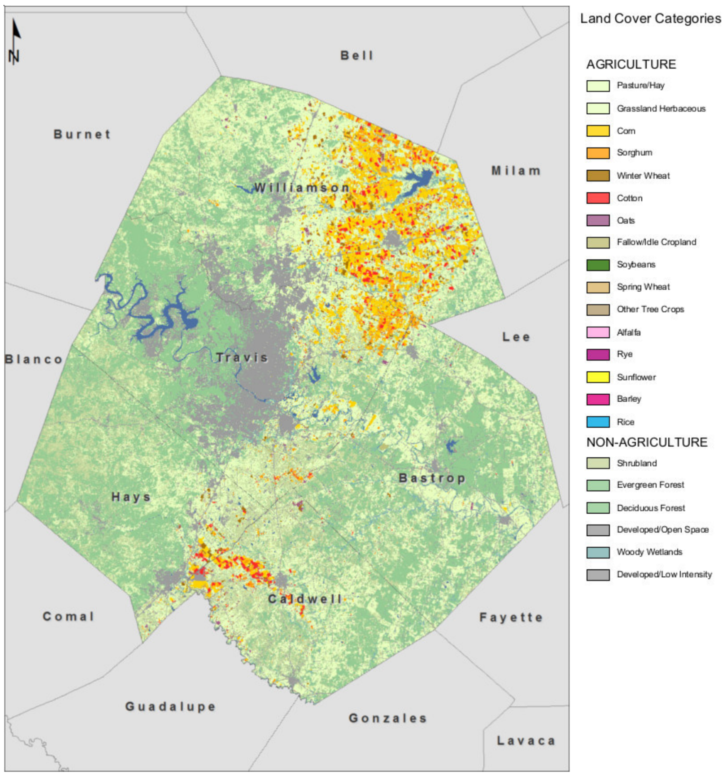

Figure 3. An example of "CropScape" data for Austin MSA region (NASS, 2012).

Deliverables: Task Technical Memorandum describing our review of available landcover, LAI and agricultural datasets for use in WBDUST, and approaches and programs developed to ingest new datasets into the WBDUST model.

Schedule: Complete by January 29, 2021.

Task 4.3: Update the WBDUST Model and Evaluate Impacts in CAMx MP

Based upon our analyses from Task 2, Ramboll will enhance the CAMx WBDUST framework to ingest alternative landcover/vegetation, soil and/or agricultural activity datasets and to update the emission parameterization. The WBDUST emission program is written in Fortran90, so all algorithm and I/O updates will continue to be implemented in Fortran90. We anticipate that alternative geographic-based datasets will be available in GIS shapefile or various raster formats. We will develop new GIS or Python scripts as needed to prepare raw datasets in netCDF I/O structures for direct ingestion into the updated WBDUST program. The new system will be functionally evaluated and quality-assured in an idealized testbed simulation to ensure all updates are working correctly and giving reasonable results.

Ramboll will then generate new hourly, gridded, speciated WBD emission estimates for 2016, perform additional CAMx simulations with the EPA MP and evaluate effects on PM model performance at the IMPROVE sites shown in Figure 1. Differences from the current WBDUST results will be tabulated; any improvements and remaining performance issues will be documented. Recommendations to address remaining performance issues or the need for additional improvements will be enumerated. The new WBDUST modeling system and supporting datasets will be delivered to the AQRP and TCEQ along with instructions for installation, configuration and use.

Deliverable: Task Technical Memorandum describing new modeling using the updated WBDUST emission estimates and recommendations. Add datasets, program codes, models and model output to AQRP.

Schedule: Complete Task by May 31, 2021. Submit data, codes, models and output by September 20, 2021.

Task 4.4. Project Reporting and Presentation

At the start of the project, Ramboll will hold a kickoff call with AQRP and TCEQ representatives to discuss the work plan and specific details of the project, answer questions, and address anticipated issues.

As specified in Section 7 "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 Ramboll's project team will attend and present at the AQRP data workshop. Ramboll's Principal Investigator 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 reports will follow templates and accessibility guidelines available on the AQRP website http://aqrp.ceer.utexas.edu/.

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 and TCEQ liaisons per the Publication/Publicity Guidelines included in Attachment G of the subaward.

Finally, Ramboll's project team will prepare and submit our final project data and associated metadata to the AQRP archive.

Deliverables: Abstract, monthly technical reports, monthly financial status reports, quarterly reports, draft final report, final report, attendance and presentation at AQRP data workshop, submissions of presentations and manuscripts, project data and associated metadata.

Schedule: The schedule for Task 4.4 Deliverables are shown in Section 7.

5.0 Project Participants and Responsibilities

This project is being conducted by Ramboll under a grant from the Texas Air Quality Research Program (AQRP). The project Principal Investigator (PI) is Mr. Chris Emery, who will assume overall responsibility for the research and overall responsibility for quality assurance. Dr. Greg Yarwood will serve as a tchenical advisor for all tasks. Mr. Emery will be assisted by Mr. Tejas Shah, who will lead the review and development of landcover and agricultural datasets, and by Dr. Uarporn Nopmongcol, who will lead all modeling activities and performance evaluation. The personnel working on this project and their specific responsibilities are listed in Table 1.

The project will be overseen by AQRP Project Manager Dr. Elena McDonald-Buller and TCEQ Project Liaison Bob Gifford. They will review the project deliverables and documentation.

Table 1. Project participants and their key responsibilities.

Participant	**Key Responsibilities**
Chris Emery	Principal investigator, responsible for providing technical guidance, contribute to model development, develop and review reports and presentations, and overall quality assurance.
Greg Yarwood	Project technical advisor
Tejas Shah	Lead review of alternative landcover and agricultural activity datasets, their processing to support the development of model-ready WBD emission estimates and contribute to reporting.
Uarporn Nopmoncol	Lead all modeling activities, model performance evaluation against monitoring data, and contribute to reporting.

Participant	Key Responsibilities
Fiona Jiang	Assist with developing software to process raw landcover and agricultural data to useable formats for the WBD emissions model.
Yuge Shi	Assist with developing software to process raw landcover and agricultural data to useable formats for the WBD emissions model.
Sai Sreedhar Varada	Perform emission processing for photochemical model inputs.
Chao-Jung Chien	Assist with various modeling and data analysis tasks.
Marco Rodriguez	Assist with various modeling and data analysis tasks.
Pradeepa Vennam	Assist with various modeling and data analysis tasks.
Jean Guo	Assist with various modeling and data analysis tasks.

6.0 Timeline

The planned duration of the project is 15 months (June 2020 – August 2021). An overall schedule of project activities by task is shown in Table 2. The schedule assumes a start date during June 2020 and end date of August 31, 2019.

Table 2. Schedule of project activities.

ID	Task	2020							2021							
		J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
	Kickoff Meeting	X														
1	Review WBDUST Estimates		X	X	X											
2.1	Alternative Emission Methods				X	X	X									
2.2	Alternative Landcover Data						X	X	X							
3	Update WBDUST & Evaluation									X	X	X	X			
4	Monthly Progress Reports	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Quarterly Progress Reports		X			X			X			X			X	
4	Draft Final														X	
4	Final															X
	AQRP Workshop															X

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

Abstract Due Date: Friday, July 31, 2020

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.

Quarterly Report Due Dates:

Report	Period Covered	Due Date
Quarterly Report #1	May, June, July 2020	Friday, July 31, 2020
Quarterly Report #2	August, September, October 2020	Friday, October 30, 2020
Quarterly Report #3	November, December 2020, January 2021	Friday, January 29, 2021
Quarterly Report #4	February, March, April 2021	Friday, April 30, 2021
Quarterly Report #5	May, June, July 2021	Friday, July 30, 2021

Monthly Technical Reports (MTRs): Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison in Microsoft Word format using the AQRP FY20-21 MTR Template found on the AQRP website.

MTR Due Dates:

Report	Period Covered	Due Date
Technical Report #1	Project Start - June 30, 2020	Friday, July 10, 2020
Technical Report #2	July 1 - 31, 2020	Monday, August 10, 2020
Technical Report #3	August 1 - 31, 2020	Thursday, September 10, 2020
Technical Report #4	September 1 - 30 2020	Friday, October 9, 2020
Technical Report #5	October 1 - 31, 2020	Tuesday, November 10, 2020
Technical Report #6	November 1 - 30, 2020	Thursday, December 10, 2020
Technical Report #7	December 1 - 31, 2020	Friday, January 8, 2021
Technical Report #8	January 1 - 31, 2021	Wednesday, February 10, 2021
Technical Report #9	February 1 - 28, 2021	Wednesday, March 10, 2021
Technical Report #10	March 1 - 31, 2021	Friday, April 9, 2021
Technical Report #11	April 1 - 30, 2021	Monday, May 10, 2021
Technical Report #12	May 1 - 31, 2021	Thursday, June 10, 2021
Technical Report #13	June 1 - 30, 2021	Friday, July 9, 2021

Financial Status Reports (FSRs): Financial Status Reports will be submitted monthly to the AQRP Grant Manager (RoseAnna Goewey) using the AQRP 20-21 FSR Template found on the AQRP website.

FSR Due Dates:

Report	Period Covered	Due Date
FSR #1	Project Start - June 30	Wednesday, July 15, 2020
FSR #2	July 1 - 31, 2020	Friday, August 14, 2020
FSR #3	August 1 - 31, 2020	Tuesday, September 15, 2020

FSR #4	**September 1 - 30 2020**	**Thursday, October 15, 2020**
FSR #5	**October 1 - 31, 2020**	**Friday, November 13, 2020**
FSR #6	**November 1 - 31, 2020**	**Tuesday, December 15, 2020**
FSR #7	**December 1 - 31, 2020**	**Friday, January 15, 2021**
FSR #8	**January 1 - 31, 2021**	**Monday, February 15, 2021**
FSR #9	**February 1 - 28, 2021**	**Monday, March 15, 2021**
FSR #10	**March 1 - 31, 2021**	**Thursday, April 15, 2021**
FSR #11	**April 1 - 30, 2021**	**Friday, May 14, 2021**
FSR #12	**May 1 - 31, 2021**	**Tuesday, June 15, 2021**
FSR #13	**June 1 - 30, 2021**	**Thursday, July 15, 2021**
FSR #14	**July 1 - 31, 2021**	**Friday, August 13, 2021**
FSR #15	**August 1 - 31, 2021**	**Wednesday, September 14, 2021**
FSR #16	**Final FSR**	**Friday, October 15, 2021**

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: Monday, August 2, 2021

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: Tuesday, August 31, 2021

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 20, 2021). 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 2021.

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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