

Via E-Mail

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**Subject: Explanations for Delay in Western States Regional Haze Modeling**

Dear Mary:

This letter documents and provides reasons for delays in the chronology of Ramboll's completion and delivery of the Regional Haze (RH) photochemical modeling results since late 2018, for the western states on the WRAP Technical Support System (TSS). The TSS is our delivery target since western states and other WRAP partners use it for Round 2 RH State Implementation Plans (SIPs) due July 2021. This work for WESTAR-WRAP has been done mainly under WESTAR Contract 19-01. First and foremost, I want to emphasize how much we value WESTAR-WRAP membership and the western states in particular as important clients and these delays in no way indicate a lack of commitment by Ramboll or us not placing this work as highest priority. This is the most important project that I and my staff have right now, and we are trying to finish delivery of high quality RH technical work products as quickly as we can.

The WRAP western state RH CAMx source apportionment is quite complex and complicated integrating numerous sources of data (e.g., 2014NEI, WRAP states data, EPA 2016v1 platform, natural and international emissions, data products of WRAP workgroups and projects etc.), because the vast majority of emissions affecting RH planning are out of the control of the states, but must be thoroughly assessed with photochemical modeling per EPA RH planning guidance. The work tasks in Contract 19-01 involved a lot of moving parts and pieces of data that needed to be properly implemented presenting multiple opportunities for mistakes. However, that is not an excuse as Ramboll has a reputation and track record on performing such complicated and high-quality air quality modeling studies.

In my over 40 years as an air quality consultant, I have never had a project that had so many setbacks for so many different reasons. Ramboll is not blameless in this as some delays are our fault and we have taken a financial penalty by all the re-running of modeling scenarios, not to mention the emotional and stressful aspects of these delays. But many of the delays have been unique and due to unforeseen circumstances that were out of our control, including:

- Federal government shut-down in December 2018 and January 2019 delayed getting EPA's 2014 modeling platform at the outset of the project.

- EPA's 2014 GEOS-Chem simulation that we planned to use for Boundary Conditions (BCs) was flawed with June & July SO<sub>2</sub>/SO<sub>4</sub> overestimation and year-round ozone overestimation. As a result, we had to conduct our own unplanned 2014 GEOS-Chem simulation to correct it that took several months.
- Delays and data processing decisions at EPA in releasing the National Emissions Inventory Collaborative (NEIC) 2016v1 modeling platform and 2023 and 2028 future year emission projections caused delays in getting future year emissions, as well as errors in the data, as noted below.
- Ramboll modeling computer servers for this work are located in northern California. The Pacific Gas & Electric utility instituted Public Service Power Shutoffs (PSPS) to prevent wildfires that shut down the power to the computers doing the modeling during portions of September-October 2019.
- In November 2019, California Air Resources Board discovered errors in the 2014v2/RepBase fugitive dust emissions they provided that caused delays while we re-processed the emissions and re-ran model simulations.
- COVID-19 Shelter-in-place from March 2020 to the present disrupted and slowed down the modeling. It took a while to figure out how to work effectively remotely. Also with no one in the office, when a computer goes down, hangs or there is a need to mount a new disk to make disk space, there are longer delays than normal as someone has to make a trip to the office.
- In June 2020 we found that some anthropogenic state-controllable sources for RH planning were both incorrect and/or double-counted in the NEIC 2016v1 modeling platform data, in both of the key scenarios for RH planning, the already-completed RepBase and 2028OTBa projection scenarios in the WESTAR-WRAP modeling effort, that caused a 3-month delay (Jun-Jul-Aug 2020). The emissions had to be reviewed by Ramboll and the states for corrections, updated and fixed and SMOKE emissions modeling of re-done so new RepBase2 and 2028OTBa2 could be done.
- Because of the problems and reprocessing required for the NEIC 2016v1 and 2028 emissions, technical decisions were made by WESTAR-WRAP members in RH work groups, to change some of the emissions sector datasets to be used in the new RepBase2 and 2028OTBa2 scenarios from what was in Ramboll's contract necessitating re-processing and some additional delays. The effect of these decisions was non-zero in terms of Ramboll effort, but were timely and improved the representativeness of the RepBase2 and 2028OTBa2 modeling results for RH planning.
- Unprecedented wildfires in Northern California August through November 2020 interfered with staff working as PM<sub>2.5</sub> concentrations in excess of 200 µg/m<sup>3</sup> blanketed the region making going outdoors and travel dangerous. Many staff were on-call prepared for evacuation and worked much less efficiently under stressful conditions.
- Coding errors in the Ramboll CAMx model caused two re-runs of the CAMx RepBase2 and 2028OTBa2 source apportionment simulations in late 2020. As these runs take ~28 days to run, each re-run can cause a 1-2 month delay as we have to debug what the error is, fix it and re-run.

Ramboll was originally teamed with a Subcontractor whose role was to do most of the SMOKE emissions modeling. The same Subcontractor had a similar role when Ramboll developed the WRAP WestJumpAQMS 2008 and IWDW-WAQS 2011 modeling platforms and performed well.

Attachment 1 has a chronology of events that occurred and caused delays in delivering products on schedule. Below we discuss how some of these specific events delayed some of the key project deliverables.

- The schedule for the first big deliverable was WRAP-WAQS Shake-Out 2014v1 CMAQ and CAMx platforms, model evaluation and Close-Out meeting by March 2019. The Close-Out meeting occurred in April 2019 and delivery of the 2014v1 platform to IWDW in May. The causes for these delays are as follows:
  - Initial contract award was received December 11, 2018, affecting the proposed schedule from Ramboll. If we had started December 1, 2018 as originally planned we likely would have noticed the missing files for EPA's 2014 platform on their ftp site before the unexpected government shut-down.
  - Federal government shut-down December 22, 2018 through January 25, 2019 that delayed getting the EPA 2014 modeling platform by over a month as the EPA ftp site did not include all of the files and EPA staff were unavailable to provide them.
  - In February 2019 we found that the EPA 2014 GEOS-Chem had overestimation issues and in March 2019 EPA re-ran June and July to fix one of the problems so that final 2014v1 CMAQ/CAMx simulations, MPE and database transfer were delayed from the March target timeframe until April-May 2019.
- The next big deliverables, as identified in the May 29, 2019 WESTAR 19-01 Amendment#2 (A2), was 2014v2 emissions modeling, 2014 GEOS-Chem modeling and 2014v2 CMAQ/CAMx modeling to be completed by July 2019 and Representative Baseline (RepBase) modeling to be completed by August 2019. In reality, the first CAMx 2014v2 simulation was not completed until September 2019 and a series of emission updates were made so that the final 2014v2 CAMx base case was not completed until early December 2019. The first RepBase run was not completed until January 2020. The reasons for the delays of the final 2014v2 and initial RepBase simulations are as follows:
  - The July 2019 deadline for the 2014v2 platform was probably overly ambitious, but August should have been doable.
  - A key update in the 2014v2 platform was 2014 emissions for California that CARB provided to the SMOKE emissions Subcontractor in May 2019. In July the Subcontractor started asking questions and needing updates to the 2014 California inventory, so it appears they sat on and didn't look at the data for two months. 2014v2 SMOKE emissions processing was delayed as the Subcontractor's SMOKE modeler had many trips, such as to Korea (June), South America (July) and the EPA Emissions Inventory Conference in Dallas (August). Ramboll finally received the disk drive with the 2014v2 emissions on August 29, 2019. Note that Ramboll has worked very well with this Subcontractor in past studies (e.g., 2008 and 2011 platforms), but personnel

changes appear to have affected their ability to deliver in a timely fashion. Ramboll ultimately took over the SMOKE emissions modeling so that it could be performed in a more timely manner.

- Ramboll's initial CAMx 2014v2 simulation in September 2019 produced high ozone in northeast Wyoming that was traced to an emissions modeling error that allocated all the annual average O&G emissions to January in some counties.
- The Subcontractor corrected the 2014v2 O&G emissions and a revised CAMx 2014v2 simulation was conducted in October 2019.
- The California Air Resources Board informed us in November 2019 that there were errors in California's 2014v2/RepBase fugitive dust emissions and sent corrections that were incorporated into the RepBase emissions delaying the RepBase CAMx simulation until January 2020.
- Also in November 2019, we discovered errors in the RepBase fire emissions files provided by the WRAP Fire & Smoke Work Group (FSWG) contractor that produced negative PM<sub>2.5</sub> emissions that had to be corrected by the FSWG contractor. Identification of these sort of issues for fire and many other source categories is a common and required task for assembly of air quality modeling scenarios in a platform. The evaluation and correction of the fire emissions files was another delay in the sequence to assemble RepBase.
- Errors in EPA's proprietary and lightly documented AMET MPE Tool that EPA did not fix until January 2020 (and only EPA can fix), that we use to calculate performance statistics to be in compliance with EPA modeling guidance, meant that some of the model performance evaluation (MPE) products for the 2014v2 simulations were delayed.
- WESTAR Contract 19-01 Amendment#5 (A5) dated November 22, 2019 had several deliverables with the key ones as follows: (1) 2002 Dynamic Evaluation (2002DE) CAMx simulation completed by February 2020; (2) 2028OTB CAMx done by February 2020; and (3) CAMx 2028 source apportionment done by March 2020. There were numerous iterations in these simulations so that they were not finally completed until January 2021 for the following reasons:
  - After these milestones were set in the contract and in discussion with Regional Technical Operations Work Group Co-Chairs and WESTAR-WRAP staff and to meet objectives (e.g., obtain separate fire and U.S. anthropogenic emission contributions), the RepBase, 2028OTBa and 2002DE were turned into source apportionment simulations each of which takes ~28 days to run. Thus, the original schedule in A5 as the awarded contract required was physically impossible to meet given the changes in the run times from a CAMx standard model run (~5 days) to a source apportionment run (~28 days).
  - The delays in the 2014v2 and RepBase simulations meant that A5 modeling could not start until January 2020 instead of November 2019 as originally envisioned. This meant that the 2028OTB emissions and first CAMx 2028OTB simulations and visibility projections were completed in March-April instead of February 2020.

- In March 2020, shelter-in-place orders were mandated due to the COVID-19 pandemic that caused a slow-down in the modeling for several reasons:
  - People had to move their work stations from the office to home where they do not have as efficient a work space (e.g., copier machines, access to computers, etc.).
  - It took some time for people to figure out how to work from home effectively and efficiencies suffered.
  - Schools and day cares closed so parents had full time responsibility for their children and had to assist teaching from home.
  - When the high performance Linux computers in the office went down, hung or we needed to mount disks for backups to make more disk space, someone had to physically come in to the office and there were restrictions on how that could be done.
- The 2002 Dynamic Evaluation emissions development to backcast 2014 emissions to 2002 turned out to be a much bigger task than originally scoped by Ramboll and as awarded in the contract. It was deemed less critical than the 2028OTB modeling so was de-emphasized compared to getting the 2028 visibility projections done.
- How to treat fires in the 2028 MID projections caused some delays as there were modeled fires on some days in the IMPROVE MID; MID are selected in part to limit fire contributions.
- Double-counted and/or incorrect anthropogenic state-controllable sources for RH planning were discovered in the NEIC 2016v1 modeling platform due in part to EPA emissions processing of the 2016v1 files having O&G sources in the Non-EGU Point files instead of in the O&G files. Several WESTAR-WRAP region states also identified incorrect emissions rates in the 2016v1 files. This caused a series of state-by-state review and correction actions and a 3-4 month delay at a critical point in the regional haze modeling. This was probably the single biggest issue that caused delays in the project and required the following corrective action:
  - Ramboll conducts intensive review of the EPA 2016v1 platform emissions to identify the problems.
  - Western states review and update their RepBase and 2028OTBa emissions to now be RepBase2 and 2028OTBa2 inputs.
  - The WESTAR-WRAP project manager decides not to continue to use the NEIC 2028 projections for some source sectors (e.g., WRAP non-EGU Point), in response to requests from the WESTAR-WRAP region states, in 2028OTBa2 modeling and use 2014 instead.
  - Ramboll creates harmonized emission inventories for RepBase2 and 2028OTBa2 and conducts SMOKE modeling.
  - Re-run RepBase2 and 2028OTBa2 source apportionment simulations.

- WESTAR Contract 19-01 Amendment#10 (A10) provided funding for updating the RepBase2 and 2028OTBa2 emissions to address the EPA double counting issue and had a detailed schedule: (1) CAMx RepBase2 H-L SA run done by Nov 17, 2020; (2) CAMx 2028OTBa2 H-L SA run done by Nov 28, 2020; (3) CAMx 2028OTBa2 L-L SA run done by Dec 30, 2020. In reality, the final RepBase2 and 2028OTBa2 H-L SA runs were not done until January 2021 due to multiple re-runs:
  - The RepBase2 and 2028OTBa2 H-L SA simulations take approximately 28 days to run. The first RepBase2 and 2028OTBa2 H-L SA runs were completed within the A10 schedule (Nov 2020), but a series of issues were discovered that caused re-runs as follows:
    - The way lightning NOx emissions were treated was changed from millions of virtual point sources to a netCDF 3-D input to be more computationally efficient. However, a coding error in the CAMx v7.0 model caused the netCDF 3-D inputs not to work correctly and it adversely affected the source apportionment results necessitating going back to the virtual point source input approach.
    - The second round of RepBase2 H-L SA runs was performed in December 2020, but was invalid due to missing New Mexico Non-EGU Point emissions (Ramboll's fault).
    - A third set of RepBase2 and 2028OTBa2 simulations were conducted the end of December 2020 into January 2021 and another coding error was discovered in CAMx v7.0 that dropped point source SO2 emissions.
    - The fourth set of RepBase2 and 2028OTBa2 H-L SA simulations finished in late January 2021 and were post-processed and transferred to the TSS by end of January.

I hope you find this letter useful in helping to explain why the regional haze modeling for the WESTAR-WRAP region is delayed. I believe these issues are behind us and the regional haze modeling results are now being populated onto the WRAP TSS. I do not foresee any remaining modeling or data delivery issues for the remaining tasks over the next 2-3 months, and Ramboll is closely coordinating with WESTAR-WRAP staff and the RTOWG Co-Chairs.

If you need more information or want me to personally talk to EPA or any of the States with WESTAR-WRAP staff in attendance, please let me know as I am always available and always try to live up to my commitments and responsibilities.

Best Regards,



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cc. Tom Moore

**Attachment 1. Timeline of events that caused delays in the WRAP western states regional haze modeling.**

Approximate Date	Event
Dec 11, 2018	Initial WESTAR Contract 18-12 to development 2014 Shake-Out platform was received 10 days after project start date (Dec 1, 2018)
Dec 2018-Jan 2019	Federal government shut-down Dec 22, 2018 – Jan 25, 2019 caused over a month plus delay in getting all files from EPA's 2014 modeling platform as the 2014 platform files on the EPA ftp site were incomplete.
Feb 2019	Found that EPA's 2014 GEOS-Chem run that was planned to be used for BCs was flawed as it had too high SO <sub>2</sub> /SO <sub>4</sub> in Jun & Jul and overstated O <sub>3</sub> year-round. This meant Ramboll had to perform an unplanned 2014 GEOS-Chem run that took several months to complete.
Mar 2019	EPA re-runs GEOS-Chem for Jun & Jul without volcano eruption fixing Jun & Jul SO <sub>2</sub> /SO <sub>4</sub> overestimation problem in BCs but causing delays in delivering the 2014v1 Shake-Out modeling platform in March 2019.
Jun – Aug 2019	2014v2 SMOKE emissions modeling delayed 3 months due to unavailability of Subcontractors SMOKE modeler.
Sep 2019	Corrections needed for error in SMOKE emissions modeling of 2014v2 (overstates Wyoming Jan O&G emissions) caused another month delay.
Sep – Oct 2019	PG&E Public Service Power Shutoffs (PSPS) cut-off power to Ramboll's Linux computers in their Novato, CA office shutting down progress on 2014v2, RepBase2 and 2028OTB modeling.
Nov 2019	California Air Resources Board informs us that California Fugitive Dust emissions are in error in 2014v2/RepBase and sends update that caused delays.
Nov 2019	The RepBase fires from the FSWG have errors that produce negative PM <sub>2.5</sub> emission that need to be fixed
Dec 2019	EPA's AMET MPE tool does not work right and does not generate all the MPE products that are needed. EPA AMET contact goes on holiday and issue is not fixed until after they come back in Jan 2020.
Jan 2020	Modeling for 2028OTB and 2002DE that was supposed to start in November 2019 started in Jan 2020 instead due to delays and finishing up 2014v2 and RepBase modeling.
Mar 2020 - present	COVID-19 shelter-in-place disrupts modeling as people can no longer go to the office and must work from home. That reduces efficiency and modeling takes longer due to more computer down time.
Apr – May 2020	Extra time to determine how to treat modeled fires in visibility projections for the MID that are not supposed to have any episodic fire.
Jun – Sep 2020	Double counted sources in EPA's 2016v1 modeling platform caused a stop of the modeling and have Ramboll and the states re-work the emissions, fix them and redo the SMOKE modeling causing a 3-4 month delay.
Jun – Sep 2020	Given problems with EPA 2016v1 platform 2028 emission projections, WRAP decides to change what emissions are being used in 2028OTB emission scenarios from what was in Ramboll's contract.
Aug – Nov 2020	Massive wildfires in California caused extremely high PM <sub>2.5</sub> concentrations, limited travel in the region and caused inefficiencies in work.
Nov 2020	RepBase2 and 2028OTBa2 H-L SA runs have to be re-done due to coding error in CAMx v7.0 treatment of netCDF 3-D lightning NO <sub>x</sub> inputs.
Dec 2020	Second RepBase2 H-L SA run has to be re-done due to missing New Mexico non-EGU point source emissions.
Dec 2020 – Jan 2021	Third RepBase2 and 2028OTBa2 H-L SA runs have to be re-done due to coding error in source apportionment species mappings that dropped point source SO <sub>2</sub> emissions.
Jan 2021	Fourth RepBase2 and 2028OTBa2 H-L SA runs have satisfied all the QA checks and appear correct so that 2028 visibility projections and other data will be transferred to the WRAP TSS by the end of January 2021.