INTERMOUNTAIN WEST DATA WAREHOUSE – WESTERN AIR QUALITY STUDY (IWDW-WAQS)

FINAL WORK PLAN [DATED: SEPTEMBER 28, 2018]

I. Background of IWDW-WAQS

The National Environmental Policy Act (NEPA) and federal Clean Air Act (CAA) require air quality planning studies and projects by federal, state, and local agencies. These detailed air quality assessments address actions that may significantly affect the environment or are needed to adopt emissions controls to achieve health and welfare air quality standards and rules. The air quality assessments may include a qualitative analysis that describes the air quality issues or impacts using available monitoring data and studies. The air quality assessments may also include a quantitative analysis that involves the use of air quality models to assess potential impacts to air quality and Air Quality-Related Values (AQRVs), such as visibility and atmospheric deposition.

A plume dispersion model (e.g., AERMOD) and a photochemical grid model (PGM) (e.g., CAMx and CMAQ) are typically used to quantitatively assess the potential air quality impacts associated with a proposed development or air quality improvements resulting from mitigation strategies. These models require emissions and meteorological information to estimate the concentration and dispersion of pollutants that are known to impact air quality. Considerable resources are needed to develop the model inputs and to conduct the air quality modeling analyses. As a result, multiple federal and state agencies in the intermountain west identified a need to more efficiently and expeditiously collect air quality data and conduct air quality modeling. To address the need, the agencies entered into a Memorandum of Understanding (MOU) in 2011 to initiate a pilot project (Three State Air Quality Study (3SAQS))[1] that would add ambient air quality monitoring stations and develop an air quality modeling platform to assess the air quality in the intermountain west. The 3SAQS also developed the Intermountain West Data Warehouse (IWDW) to maintain the ambient monitoring data, emission inventories, meteorology, and air quality modeling inputs and outputs. After the 3SAQS culminated in 2014, the Cooperating Agencies of the study

[1] Memorandum of Understanding for the Three State Study Data Warehouse Pilot Among U.S. Environmental Protection Agency Region 8, Bureau of Land Management – Colorado, Utah, Wyoming State Offices, U.S. Forest Service Region 2 and 4, National Park Service Intermountain Region, Colorado Department of Public Health and Environment, Wyoming Department of Environmental Quality and Utah Department of Environmental Quality, January 2011. http://views.cira.colostate.edu/tsdw/Resources/project_documents/MOU3State.pdf

decided to continue the efforts and refer to the study as the Western Air Quality Study (WAQS).[2,3]

The on-going goals of the IWDW-WAQS include:

- Maintaining the IWDW-WAQS air quality monitors, and assessing the collective air quality monitoring network to ensure the coverage and monitoring parameters are well-understood and help meet the needs of the IWDW-WAQS. The collective review of the monitoring networks is also important for understanding air quality trends and to support Model Performance Evaluations (MPEs).
- Developing and maintaining an air quality modeling platform every three years to coincide with the National Emissions Inventory (NEI) cycle and incorporate the most recent data, science, and tools for air quality assessments in the intermountain west.
- Operating and maintaining an on-going data warehouse (i.e., the IWDW) with current, representative, and complete data and tools.
- Working under analysis protocols and data criteria that are commonly agreed to by the Cooperating Agencies.
- Effectively communicating project status and activities internally and externally to the Cooperating Agencies.
- Establishing and maintaining a future funding mechanism to ensure sustainability of monitoring sites, air quality modeling platform, and the IWDW.

II. Purpose of this Work Plan

This work plan outlines the tasks to be completed by the IWDW-WAQS for the next air quality modeling platform. The work will commence in fall of 2018, with work products being produced over the following three years. The components of this work plan include monitoring, emissions inventory and modeling, meteorological modeling, air quality modeling, and maintaining the data warehouse, which support the goals of the IWDW-WAQS. This work plan also describes the general objectives, oversight and management of work tasks, work tasks, deliverables, milestones and timeline, and an anticipated budget for the work activities.

This work plan is structured into two types of tasks given the uncertainty of future resources. The tasks discussed in the main body of the work plan are core tasks that are a priority to the

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[2] Memorandum of Understanding for the Intermountain West Data Warehouse for Air Quality Among U.S. Environmental Protection Agency Region 8, Bureau of Land Management – Colorado, Utah, Wyoming and New Mexico State Offices, U.S. Forest Service Rocky Mountain Region, Intermountain Region and Southwestern Region (14-MU-11020000-042), National Park Service Intermountain Region, Fish and Wildlife Service, Mountain-Prairie Region 6, Colorado Department of Public Health and Environment, Wyoming Department of Environmental Quality, Utah Department of Environmental Quality, and New Mexico Environment Department, 2017. http://views.cira.colostate.edu/tsdw/Resources/project_documents/Intermountain%20West%20MOU.pdf

[3] AMENDMENT ONE to the Memorandum of Understanding for the Intermountain West Data Warehouse for Air Quality Among U.S. Environmental Protection Agency, Region 8, Bureau of Land Management (BLM, Colorado, Utah, Wyoming, New Mexico, and Montana/Dakotas), U.S. Forest Service [14-MU-11020000-042, Modification 2], Rocky Mountain Region, Intermountain Region, Southwestern Region, and Northern Region, National Park Service Intermountain Region, U.S. Fish and Wildlife Service Natural Resource Program Center, Colorado Department of Public Health and Environment, Wyoming Department of Environmental Quality, Utah Department of Environmental Quality, and New Mexico Environment Department, June 2018.

Cooperators based on upcoming or anticipated air quality planning projects. To cover the costs associated to these tasks, the Oversight Committee has explored and identified opportunities to leverage resources from other groups. In particular, many tasks outlined in this work plan overlap with the work plan developed by the Western States Air Resources (WESTAR) Council - Western Regional Air Partnership (WRAP) organization (WESTAR-WRAP). Therefore, many tasks will be coordinated and leveraged with WESTAR-WRAP.

This work plan also outlines tasks in the appendices. The tasks included in the appendices are also important to the Cooperators. However, additional information and resources will need to be collected to determine if the new tasks are technically and monetary feasible. Therefore, it will be imperative for the Oversight Committee to continue their discussions related to these tasks, and to continue their efforts in finding funding. The Oversight Committee, in coordination with the Technical Committee, will re-visit these tasks throughout this work plan cycle. When sufficient information and resources are obtained to complete the work, a supplement to this work plan will be developed and approved by the Cooperators prior to commencing the work.

It should be noted that the BLM has introduced new NEPA work products related to future-year projection scenarios that have the potential to benefit many Cooperators by increasing efficiencies and reducing costs. These new products proposed by the BLM are being discussed and explored by the Cooperators to determine the most technically-feasible approach for completing the work within the IWDW-WAQS framework or within this work plan. Currently, these work products are discussed in Appendix A because the approach and associated resources are still under development. However, the Oversight Committee will continue their discussions to develop a viable approach that addresses the BLM's needs for future NEPA projects. The Oversight Committee does not need to have final tasks determined for these new work products prior to approving this work plan because other modeling work needs to be completed before working on these new work products. The details of the new products and the status of the approach are included in Appendix A.

III. Scope of Technical Work

The IWDW-WAQS will complete a base and future year air quality modeling platform that includes monitoring data and a base case model performance evaluation (MPE) for years associated with the NEI. All modeling activities and results from the modeling efforts will be documented in an air quality modeling protocol and air quality modeling report, respectively. These documents will be reviewed and approved by the Cooperating Agencies, and posted on the IWDW upon completion for the public and data users.

Preparation of the NEI is on a triennial cycle and based on actual emissions reported to EPA by state, tribal, and local agencies. Previous inventories have been completed for calendar years 2008, 2011, and 2014. Multiple reviews of a single NEI are completed to ensure accuracy and completeness. As a result, the final NEI is typically released about three to four years after the NEI year (e.g., early 2018 for the 2014 NEI). With approval by the Cooperating Agencies, the IWDW-WAQS may also complete a base model platform for non-NEI cycle years or additional future-year model platforms, or the Cooperators may revise this work plan within the work-cycle to account for additional work. In particular, EPA – Office of Air Quality Planning and Standards (OAQPS), multi-jurisdictional organizations like WESTAR-WRAP, and many States have been involved in a collaborative effort to develop a national 2016 Emissions Modeling Platform. This effort started in 2018 and will continue through the end of 2019. The Cooperators will need to consider the evaluation, utilization of the 2016 Emissions modeling Platform in western air quality planning, and storing the work products, which include future-year emissions projections, in the IWDW (additional details provided below in section XI).

Two photochemical grid models are available and used to assess air quality impacts or conditions, including the Comprehensive Air Quality Model with eXtensions (CAMx) and the Community Model for Air Quality (CMAQ). The IWDW-WAQS modeling efforts will include both PGMs and some combination of 36/12/4 kilometer (km) nested model domains that sufficiently cover the Cooperating Agencies' areas of interest. The levels of resolution and size of model domains will be documented in a modeling protocol that has been reviewed and approved by the Cooperating Agencies, unless changes are documented in a supplement to the approved modeling protocol. The IWDW-WAQS modeling efforts will not include dispersion models, such as the AERMOD and CALPUFF models.

IV. Oversight and Management

On behalf of the Cooperating Agencies, it will be necessary for the IWDW-WAQS Project Lead Agency, the National Park Service (NPS) for financial management, and WESTAR-WRAP in the IWDW-WAQS coordinator role, to work together to ensure that the appropriate technical and funding resources are available to accomplish the tasks outlined in this work plan in a cost-effective and timely manner. The group will also ensure that resources are leveraged with other external groups that are working on similar air quality issues, such as WESTAR-WRAP and research and academic groups.

For the Lead Agency, this includes:
- Providing regular updates to the Governing Board and the Oversight Committee;
- Promoting collaboration with other projects that may be synergistic;
- Facilitating technical training and capacity building within Cooperating Agencies;
- Supporting and enabling communications and outreach activities; and
- Providing logistical and facilitation support.

For NPS, this includes:
- Continuing and updating cooperative agreements for IWDW operations and IWDW-WAQS coordination;
- Providing regular updates to the Governing Board and the Oversight Committee;
- Managing the receipt and use of project monies; and
- Providing logistical and facilitation support.

For WESTAR-WRAP, this includes:
- Overseeing and coordinating the day-to-day operations and longer-term strategic planning for the IWDW;

- Overseeing and coordinating the WAQS modeling contractor(s) in consultation with the Technical Committee and with review and endorsement of final work products by the Oversight Committee;
- Assuming timely sufficient resources, assuring the bidding and awarding of firm, fixed price contracts for modeling and analysis with defined deliverables over time to perform the technical work which includes emission inventory development, modeling, and associated analyses in consultation with the Technical and Oversight Committees;
- Providing regular updates to the Governing Board and the Oversight Committee;
- Promoting collaboration with other projects that may be synergistic;
- Facilitating technical training and capacity building within Cooperating Agencies as needed;
- Managing the receipt and use of project monies;
- Coordinating and supporting communications and outreach activities; and
- Providing logistical and facilitation support, within available resource constraints.

All groups will work together to ensure that the IWDW has the capacity to accommodate the IWDW-WAQS work products and user needs.

Each work plan component described in the following sections will include protocols, progress reports, final reports of the activities, and outputs from work (i.e., tools, files, analyses, etc.). These documents and products will be reviewed and endorsed by the Technical and Oversight Committees. Periodic meetings among the Cooperating Agencies will also occur throughout the work plan cycle to discuss the progress, challenges, and potential changes to the work. All associated documents and meeting notes will be prepared by staff from the Cooperating Agencies, WESTAR-WRAP, CIRA, and contractors, and maintained on the IWDW.

V. Air Quality Monitoring

It will be necessary to periodically review the monitoring networks operated by Cooperating Agencies across the geographic area of the IWDW-WAQS to ensure the coverage and monitoring parameters are well-understood and help meet the needs of the IWDW-WAQS. The collective review of the monitoring networks is important for understanding air quality trends and to support MPEs. An evaluation of the air quality monitoring networks, with respect to the networks configurations and parameters, will occur once in a 3-year technical cycle that aligns with the air quality modeling work. The evaluation is needed to support the on-going operation of monitoring sites important to tracking of air quality impacts in the intermountain-west, and to obtain consensus among Cooperators prior to site closures or changes by an individual Cooperator agency.

The general objectives of the monitoring network assessment include:

1. Assess the adequacy of the available air quality monitoring networks (i.e., AQS, CASTNET, etc.) to determine whether:
    - The current monitoring networks meet objectives of the Cooperating Agencies to understand air quality trends and support MPE;

- The regional air quality monitoring networks can characterize impacts from existing and potential future sources; and
- AQRVs in representative Class I and sensitive Class II areas, as determined by the Cooperating Agencies, are adequately monitored.

2. Recommendations for the optimal collective networks' configuration among the agencies operating monitors, that include:
    - Additional monitoring sites;
    - Opportunities to remove or re-locate redundant monitors to save money where possible;
    - Measurements of other pollutants or AQRVs; and
    - Incorporation of new equipment or new technologies.

The approach of the collective monitoring networks' assessment will also include:

1. Review of previous assessments for lessons learned and to build upon for new work.
2. Analyses of monitoring programs' goals and individual networks' configurations to ensure they are understood by and coordinated with the other Cooperating Agencies.
3. Data gathering that includes:
    - Complete list of monitoring sites, parameters measured, period of record, AQS monitoring objective (i.e., population oriented, source oriented, background), etc.;
    - Trends analyses of annual and seasonal pollutants at each monitoring site;
    - Summaries of emissions by oil and gas basins for each state, area and mobile sources by county, major point sources within each state; and
    - Maps of monitoring sites, active oil and gas wells, major point sources, surface ownership, political boundaries, population density, seasonal wind and temperature climatology and key episodic conditions (e.g., winter stagnation or cold pool events).
4. Literature review of new technologies that could be beneficial for the study.
5. Cost analyses to support decision-making among the Cooperating Agencies for:
    - new monitoring sites;
    - potential site removal or re-location;
    - funding needs and sources; and
    - costs associated with current network.

The deliverables of the monitoring network assessment will include:

1. An analysis protocol outlining specific work objectives, procedures, and activities, types of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the Protocol, and resources.
3. Monitoring Network Assessment Final Report that addresses the objectives of the evaluation and provides recommendations to the Cooperating Agencies.
4. Transfer of all work products to the IWDW.

VI. General Air Quality Modeling Platform Configuration

The Cooperators should make fundamental decisions about the air quality modeling platform to ensure that resources, such as time and funding, are available to complete the work needed for the upcoming air quality planning projects. This work plan recommends using existing, leveraged, and well-documented data resources and modeling results from EPA's national modeling efforts, academia, and other sources to the greatest degree possible.

Some configuration components or options are common and consistent across all the models that makeup the air quality modeling platform (i.e., emissions, meteorology, and air quality models). In particular, the size and resolution of the model domains and the calendar years for the emissions need to be determined for the modeling activities. This section outlines the specifications of the model domain (i.e., size and resolution), as well as the calendar years that will be used for the base and future year scenarios. Execution of the activities outlined in the work plan will be documented in various forms, including study plans, protocols, and wiki pages.

Previous air quality modeling work included 36/12/4 km model grid resolutions with intent that the 4-km model domain would be utilized in future projects. With the expansion of the study to include additional states in the IWDW-WAQS region, the air quality modeling platform includes a large model domain that will be computationally expensive to conduct at the typical 36/12/4 km resolutions. Further, the Cooperators have found that finer grid resolutions, particularly the 4 km and 1.33 km grid resolutions, may not always equate to better model performance in all areas and in some cases, degrade the model performance.

Given the existing IWDW-WAQS funding and uncertainty in future funding, the emissions, meteorology, and air quality modeling described in this work plan will be completed using a 12-km grid resolution nested into a 36-km North American grid. The modeling will also be performed with 2-way processing, using global modeling fluxes as boundary conditions for the 36-km grid. This means that all base-year and future-year processing at a higher resolution in the IWDW-WAQS region, such as a 4-km nested grid, will be completed separately and on an as-needed basis, after the 36/12 km modeling studies are processed and fully evaluated by the Cooperators. Additional details about the model resolutions are provided in section XIII.

To support upcoming projects, the calendar years for base and future year scenarios will also include:

- **2014:** Base year for model evaluation and continuation of IWDW-WAQS 3-year modeling platform cycle.
- **2016 National Platform:** A decision by the Cooperators will be needed to determine the extent of evaluation and applicability to future air quality planning projects as a IWDW-WAQS-supported platform.
- **2013-2017 Planning Baseline (through WRAP Effort):** Development of a 2013-2017 representative baseline modeling scenario for the basis of Regional Haze planning in the west. Evaluate and use (with potential modifications) the EPRI/WEST Associates' International Haze Study platform for the 36 km and 12 km CONUS modeling domains.

- **<u>2023 and 2028:</u>** Emission projections for regional air quality using emissions "rules on the books" scenarios. These are key milestone years in CAA-required planning, as well as in NEPA studies.
- **<u>2028 (through WRAP Effort):</u>** Processing and modeling of additional control scenarios and evaluation of visibility improvement for 2028 Regional Haze planning "reasonable progress goals" at over 100 western Class I areas.

The general objectives, approach, and deliverables associated with the work for the model domains and the emissions linked to the calendar years outlined above are discussed in the subsequent sections.

Additional tasks related to other base and future model years for both NEPA and CAA projects are discussed in Appendix A and Appendix B, respectively. These tasks will be re-visited throughout this work plan cycle to assess the needs, timing, and resources.

VII. Emissions Inventories

The Cooperating Agencies will facilitate and support the data collection and analysis to jointly have the WAQS modeling contractor and IWDW support team develop a complete set of base year emissions that corresponds to the 2014 NEI. The WRAP effort has been comprehensively reviewing the 2014 NEIv2 released in February 2018, and has been making changes and correcting errors to the inventory. The resulting emissions inventory files will be provided to the IWDW-WAQS modeling contractor and used as the 2014 base inventory for emissions and subsequent air quality modeling. Future year emissions inventories associated with air quality planning milestones required by the CAA and NEPA, including Regional Haze planning, are to be provided through the WRAP effort by the WRAP Oil & Gas Work Group (OGWG), Fire & Smoke Work Group (FSWG), and western states for various key emissions sectors, and processed by the IWDW-WAQS modeling contractor. These future year emissions inventories will include projected future emissions changes relative to the base year inventory, including a "rules-on-the-books/no action" case that can be used as a basis for evaluating effects of proposed development projects in NEPA studies and other air quality management projects under the CAA. Projections will also be made for the purposes of source apportionment and sensitivity studies. The future projection years will be determined in the modeling protocol and reviewed and endorsed by the Cooperating Agencies based on the needs of upcoming air quality planning projects.

The general objectives of the emissions inventories work include:

1. Development of a complete set of base year emissions inventories for calendar year specified in section VI; and
2. Development of a complete set of future year emissions inventories for calendar years specified in section VI.

The approach for developing the emissions inventories includes:

1. A review of previous emissions inventory work for lessons learned and to build upon for new work.
2. Preparation, distribution, and evaluation of responses to a new round of oil and gas basin surveys for equipment and operational practices to accurately characterize oil

and gas sources and emissions in the study area. Work on this task is linked to the WRAP OGWG's Phase II Road Map contracted support.

3. Evaluation and use of the latest version of EPA's NEI and western air agency inputs to calculate emissions for the following source categories:
    - Point (permitted or registered)
    - Non-Point
    - Mobile
    - Ammonia
    - Methane
    - Fire (including recommendations from WRAP FSWG)
    - Dust (including recommendations from WRAP Regional Technical Operations Work Group)
    - Biogenics
4. Performing emissions quality assurance assessments recommended by the Cooperating Agencies.[4]
5. Completing an emissions trends analysis using previous emissions information.
6. Reviewing the available data sources, assess ready-to-use emissions projections data, and forecasting methods and tools for projecting a future year emissions inventory, including updates to projections of future year oil and gas emissions and the development of gridded emissions data for future projections of area, point and mobile source emissions.
7. Emissions estimates developed with the latest versions of available emissions models, including the Motor Vehicle Emission Simulator (MOVES) and the Model of Emissions of Gases and Aerosols from Nature (MEGAN).

The deliverables of the emissions inventory work include:

1. As part of the protocol, outline specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the protocol, and resources.
3. Quality assurance reports characterizing the completeness, representativeness, and uncertainty of each source category.
4. Survey data on activity, equipment, processes and gas compositions for the source categories.
5. Base and future-year emissions inventory files for all source categories as they are tracked and managed by Cooperating Agencies.
6. Base and future year model-ready gridded emissions files for all source categories.
7. Final report that addresses the objectives and summarizes the work products, trends analysis, and lessons learned in building the emissions inventories.
8. Transfer of all emissions inventories and work products to the IWDW for display and access.

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[4] Recommendations for Evaluating the Performance of the WSAQS Photochemical Grid Model Platform, August 2015.
http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/FINAL_Recommended_PGM_MPE_Analyses_WSAQS_v08172015.pdf

VIII. Initial and Boundary Conditions Modeling

Previous regional modeling analyses over the IWDW-WAQS region have shown significant influence from model boundary conditions on simulated pollutant concentrations within the domain. As a result, a qualitative assessment of the boundary conditions and their influence on simulated concentrations within the domain should be completed prior to using them for the air quality modeling. This evaluation will assist in determining how accurately the model platform simulates the transport of air pollution from outside the domain to locations within the domain using boundary conditions derived from a global model (GM) simulation (e.g., GEOS-Chem, CAM-Chem, AM3, hemispheric CMAQ, etc.).

There is potential that this work and associated evaluation of the initial and boundary conditions modeling will be completed by groups outside of the IWDW-WAQS. If this is the case, the IWDW-WAQS can leverage the work completed by the outside groups. However, if this work and evaluation is not completed by other groups, the IWDW-WAQS will need to complete any necessary work associated to the initial and boundary conditions modeling based on available resources.

The Cooperators will need to understand and accept the limitations and shortcomings of the global models, and determine how to address the uncertainty of initial and boundary conditions and their effects on the IWDW-WAQS regional modeling. If issues are identified as part of the initial evaluation, the Cooperators will determine whether a more intensive evaluation of the ozone and $PM_{2.5}$ boundary contributions could be completed to assist in determining whether days with large boundary contributions are a result of long-range/international transport, stratospheric intrusions, or fires. This additional work would be valuable to future projects given the interest and importance of transport and international contribution in this region.

Additional tasks related to initial and boundary conditions modeling are discussed in Appendix C. These tasks will be revisited throughout this work plan cycle to assess the needs, timing, and resources.

If needed, the general objective of the boundary conditions modeling work includes an initial assessment of boundary conditions and global model. Based on available resources, the options for the initial assessment of the boundary conditions could include:

1. Evaluation of the Global Model (GM): This assessment includes a review the MPE completed by the GM developers (if available), or performing an independent MPE to determine the adequacy of the GM performance. To the extent possible, an evaluation of this sort should consider performance aloft (where ozone transport is most important), as opposed to simple surface comparisons.
2. Estimating Lateral Boundary Inflow using a PGM Inert Simulation: This assessment includes a model simulation using boundary condition inputs without simulating emissions or chemistry. Relative to the other options, minimal resources would be needed to complete this evaluation. However, inert tracer runs have been shown to overestimate boundary ozone influence in some cases (Baker et al., 2015), so an evaluation of this type is not intended to provide a quantitative estimate of ozone lateral boundary inflow.

The approach for accomplishing this objective includes an evaluation of the GM performance using the recommended analyses by the Cooperating Agencies.[5] The deliverables of the boundary conditions modeling work include:

1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the Protocol, and resources.
3. Assessment report characterizing the completeness, representativeness, and uncertainty of boundary conditions and GM.
4. Model-ready files for the models.
5. Final report that addresses the objectives and summarizes the work products and lessons learned during the assessment of the boundary conditions and GMs.
6. Transfer all files and work products to the IWDW.

IX. Meteorological Modeling

The combination of unique meteorological conditions, complex terrain, and types of development in the intermountain west can generate significant environmental impacts that do not typically exist in other parts of the United States. For instance, stagnant weather conditions, extensive snow cover, and shallow temperature inversions have the potential to trap pollutants and produce elevated ground-level ozone in winter that can be harmful to human health and the environment. The unique meteorological conditions in the intermountain west also produce elevated or unhealthy ozone and particulate matter concentrations from international transport, stratospheric intrusions, dust events, and wildfires. Therefore, it is imperative for the IWDW-WAQS to utilize state-of-the-science information and tools to predict the meteorological conditions needed for the emissions model and PGMs.

Meteorological information is needed for the emissions model and photochemical grid models (PGMs) to predict air quality impacts. The meteorological information will be obtained using the latest version of the Weather Research and Forecasting (WRF) model or equivalent. The latest version of WRF (version 4.0, released June 2018) has incorporated a host of new default option settings and updates that could improve the model performance for this region. In particular, updates to the dynamics were made to use a hybrid vertical coordinate system. This change could limit the vertical mixing of ozone down to the surface, especially of high terrain, which has been a challenge for this region. Another update included improvements to estimating flow in complex terrain by allowing for more integrated-time steps. Again, this could result in better performance in complex terrain.

The general objective of the meteorological work includes the development of meteorological files for the emissions model and PGMs. The approach for accomplishing this objective includes:

[5] Recommendations for Evaluating the Performance of the WSAQS Photochemical Grid Model Platform, August 2015.

1. Review of previous 2014 meteorological modeling work for lessons learned and to build upon for new work. Previous modeling work would include IWDW-WAQS[6] and EPA[7] 2014 WRF modeling.
2. The IWDW-WAQS modeling contractor will complete an analysis and provide recommendations about tradeoffs in cost, timing, WRF model version, and performance of the previous 2014 meteorological modeling before completing additional 2014 WRF simulations.
3. If the Cooperators determine that a new 2014 WRF simulation is needed, the WRF simulation will use the most accurate and representative input data and configuration options, such as different land surface models (LSM).
4. Evaluation of the model performance using the recommended analyses by the Cooperating Agencies.[8]

The deliverables of the meteorological work include:

1. Updates to the existing WAQS WRF Protocol[9] outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the Protocol, and resources.
3. MPE report (revised if/as needed) characterizing the completeness, representativeness, and uncertainty of meteorology.
4. Model-ready files for emissions model and PGMs.
5. Final report that addresses the objectives and summarizes the work products and lessons learned for building meteorological platform.
6. Transfer all files and work products to the IWDW.

X. Emissions Modeling

The emissions inventories need to be processed and formatted for the PGMs to predict air quality impacts. The latest version of the Sparse Matrix Operator Kernel Emissions (SMOKE) model should be used to process the emissions for the PGMs.

The general objective of the emissions modeling work includes the development of emissions files for the PGMs for the calendar years specified in section VI above. The approach for accomplishing this objective includes:

1. Review previous emissions modeling work for lessons learned and to build upon for new work.
2. Running SMOKE with the most accurate and representative input data and configuration options.

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[6] Weather Research Forecast (WRF Version 3.6.1) Advanced Research WRF (WRF---ARW)

[7] Citation TBD

[8] Recommendations for Evaluating the Performance of the WSAQS Photochemical Grid Model Platform, August 2015.
http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/FINAL_Recommended_PGM_MPE_Analyses_WSAQS_v08172015.pdf

[9] WAQS WRF Meteorological Model Final Modeling Protocol 2014 Modeling Year, September 2015.

The deliverables of the emissions modeling work include:
1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the Protocol, and resources.
3. Model-ready files for PGMs.
4. Final Report that addresses the objectives and summarizes the work products and lessons learned to build the emissions modeling platform.
5. Transfer all files and work products to the IWDW.

XI. Base Year and Baseline Air Quality Modeling

The IWDW-WAQS will complete the base year and baseline modeling, complete the MPE, and provide model input files for users to run the PGMs for individual air quality projects. To give the Cooperating Agencies and their contractors more flexibility, the IWDW-WAQS will run both the CMAQ model and CAMx model. The Cooperating Agencies will also review the advances made to the PGMs to ensure the models can characterize and predict air quality impacts at a high level of accuracy and to determine whether model improvements and additional model simulations are necessary.

The objectives of the air quality modeling work include:
1. Develop and evaluate base year CMAQ and CAMx platforms.
2. Provide a detailed assessment of the base year CMAQ and CAMx platforms for the National Ambient Air Quality Standards (NAAQS) pollutants and AQRVs (i.e., visibility and deposition), including quantitative evaluation of background and transport.

The approach for accomplishing this objective includes:
1. Review previous air quality modeling work for lessons learned and to build upon for new work. Previous work includes IWDW and EPA's 2014 NATA[10] platform.
2. Evaluation of the PGM performance using the recommended analyses by the Cooperating Agencies.[11]
3. Comparison of CMAQ and CAMx model results.

The deliverables of the air quality modeling work include:
1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the protocol, and resources.
3. MPE report characterizing the completeness, representativeness, and uncertainty of the PGMs. The report should also outline any performance issues and recommend specific configuration of sensitivity tests to inform model improvements.

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[10] https://www.epa.gov/national-air-toxics-assessment/nata-overview
[11] Recommendations for Evaluating the Performance of the WSAQS Photochemical Grid Model Platform, August 2015.

4. Final report that addresses the objectives and summarizes the work products, lessons learned for building the air quality model platforms, and when/how the PGMs should be used in future air quality projects.
5. Transfer all files and work products to the IWDW.

XII. Source Apportionment Modeling

Source attribution has been used to support various policy purposes under the CAA. Common scientific applications include tracking intercontinental transport of ozone and ozone precursors and delineating anthropogenic and non-anthropogenic contribution to ozone and regional haze in North America. Separate source apportionment contributions from NEPA planning and project areas are also assessed for federal-authorized and non-federal-authorized oil and gas development, as well as for existing and already authorized oil and gas development activities. Both CMAQ and CAMx have methods to track contributions from source groups and regions to ambient levels and deposited amounts of pollutants.

The general objective of the source apportionment modeling work includes the use of CAMx and CMAQ source apportionment tools. A significant portion of the source apportionment work and sensitivity studies with the 2014 emissions and future year emissions will be done under the WRAP workplan effort. To the degree that the Cooperators want to conduct source apportionment studies, the approach for accomplishing this objective includes surveying the Cooperating Agencies for the groups that would be most applicable for their projects.

The deliverables of the source apportionment modeling work include:

1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the protocol, and resources.
3. Final report that addresses the objectives and summarizes the work products, lessons learned for building the air quality model platforms, and when/how the PGMs should be used in future air quality projects.
4. Transfer all files and work products to the IWDW.

XIII. Model Grids – Extracting and Nesting Higher-Resolution Model Domains

In the past, the IWDW-WAQS modeling platform included a 36/12/4 km grid resolution and the Cooperators had agreed that future air quality projects would generally utilize the 4-km model domain products. The Cooperators also anticipated that the projects would use the full model domains provided by the IWDW because users have found significant differences in model results or degradation in model performance when the model domains were reduced or nested to a finer resolution.[12]

[12] NATIONAL ENVIRONMENTAL POLICY ACT – INTERMOUTAIN WEST DATA WAREHOUSE PROCESS OUTLINE [VERSION: September 19, 2016]: http://views.cira.colostate.edu/TSDW/Resources/ProceduralDocuments/FINAL_NEPA_IWDW_Process_Outline_Sept19_2016.pdf

Given that the IWDW-WAQS does not have the resources to complete a full 36/12/4 km model platform, a nested 4-km domain within the regional IWDW-WAQS 36/12 km domain will be completed on a case-by-case basis. The Cooperators will develop an approach and tools for completing any nested 4-km modeling, and determine the unit-costs associated to this work.

The Cooperators have also realized that it may not be feasible to use the IWDW-WAQS products "as-is" from the IWDW. To address this challenge, the Cooperators will develop a method and tools to reduce the available model domain to specific geographic areas, and determine the unit-costs associated to this work.

Until the tools are developed and the resources become available for nesting and extracting portions of the available model domains, it will be up to the Cooperator's Agency and affiliated contractors to develop or obtain the software tools for nesting and extracting portions of the boundary conditions, emissions, and meteorology data from the available domains, and demonstrate in a model performance evaluation that the veracity and robustness of the approach will significantly improve the model results.

If the Cooperator's Agency provides resources to the IWDW-WAQS and identify the advance timing and level of detail in writing for approval by the Cooperators, this work could be completed through the IWDW-WAQS to reduce the computational time and costs incurred by outside users. This work will also maintain the high-quality of the modeling products and provide maximum utility for the life of the modeling platform.

The general objective includes developing an approach and tools to allow Cooperators to complete nested 4-km modeling and work with smaller portions of the available model domains. The approach for accomplishing this objective includes:

1. WAQS Technical Committee, in coordination with the modeling contractors, evaluating and determining approaches for conducting nested 4-km modeling and extracting smaller portions of the available model domains.
2. WAQS Technical Committee, in coordination with the modeling contractors, evaluating the model performance issues that may result from nesting and resizing model domains and identify criteria for users to implement approach appropriately.
3. WAQS Technical Committee, in coordination with the modeling contractors, determine unit-costs to complete nested 4-km modeling and extracting smaller portions of the available model domains within the IWDW-WAQS framework.
4. WAQS Technical Committee will develop a protocol for users to use to implement approach and use tools.

The deliverables of the work should include:

1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the Protocol, and resources.
3. Final Report that addresses the objectives and summarizes the work products, lessons learned for building the tools, and when/how the tools should be used in future air quality projects.

4. Documented approach for nesting and extracting smaller portions of the available model domains.
5. Tools to nest and resize model domains.
6. Transfer all files and work products to the IWDW.

XIV. Intermountain West Data Warehouse Maintenance

One goal of the IWDW-WAQS is to maintain a robust and reliable data warehouse to store and distribute work products to the Cooperating Agencies and the public. Another goal is to provide tools for visualization and quality assurance (QA) of modeling results, along with data mining capabilities for various types of data, housed within the data warehouse. The data warehouse will contain large volumes of air quality modeling input and output data, along with all available ambient monitoring data in the region to accomplish these goals.

The data warehouse will require periodic updates as the volume of data grows, as improvements are identified, as user needs evolve, and as software changes. The number and complexity of the PGM files will also require the data warehouse team to assure that the modeling contractors have provided all the necessary files and assure that these files are complete, uncorrupted, properly formatted, and suitable for transfer. This effort is very significant and largely dependent on the modeling contractor during the development of a new modeling platform. To ensure the sustainability of the data warehouse, the data warehouse needs and workload of the data warehouse team will need to occur on an annual basis.

The general objectives of the data warehouse assessment include:

1. Assess the hardware and software needs to maintain a robust and reliable data warehouse for storing and distributing the IWDW-WAQS products;
2. Update or develop new visualization tools to review model results and monitoring data, including tools that align with the WAQS MPE Checklist[13] and tools coordinated with the modeling contractors that visual model output as results become available ("real-time") to assist in QA checks; and
3. Assure that the modeling contractors have provided all the necessary files and assure that these files are complete, uncorrupted, properly formatted, and suitable for transfer.

The approach of the data warehouse assessment includes:

1. Outline the current and future hardware and software specifications/configurations, volume of data, file transfer capability, remaining resources available, and future resources needed to sustain the data warehouse.
2. Outline current and future visualization tools needed by the Cooperators.
3. Cost analyses to address the data warehouse needs and sustainability.
4. Obtain feedback from modeling contractors on level-of-effort/resources to coordinate efforts with IWDW and develop tools to address Cooperators requests pertaining to visualization tools.

[13] Recommendations for Evaluating the Performance of the WSAQS Photochemical Grid Model Platform, August 2015.

The deliverables of the data warehouse work include:

1. Protocol outlining specific work objectives, procedures, and activities, type of assistance and information needed from the Cooperating Agencies, and timeframes.
2. Progress reports outlining completed and upcoming work, challenges, changes to the protocol, and resources.
3. Data warehouse assessment final report that addresses the objectives of the evaluation and provides recommendations to the Cooperating Agencies.
4. Transfer all work products to the IWDW.

XV. Milestones and Timeline

Projected emission inventory and air quality modeling work will begin upon selection of modeling contractor team in October 2018. A detailed timeline will be provided to the Cooperators once the tasks are coordinated with the contractor team. The work will commence in Fall 2018, with products being produced over the following two to three years.

XVI. Anticipated Budget

Emissions Inventory and Modeling Platform Budget: $1 million plus, roughly 40% from existing funding provided by IWDW-WAQS Cooperators. A detailed budget will be provided to the Cooperators once the tasks are coordinated with the contractor team.

APPENDIX A: ADDITIONAL FUTURE-YEAR SCENARIOS FOR NEPA ANALYSES

I. BACKGROUND

The BLM is typically the lead agency for oil and gas NEPA air quality assessments in the intermountain west. As a result, the BLM has had the opportunity to utilize and observe the benefits of the IWDW-WAQS products in numerous NEPA air quality assessments. The BLM has also identified some challenges in utilizing the IWDW-WAQS products. In particular, the BLM has identified a need for additional future-year scenarios that align more closely with their reasonably foreseeable development (RFD) to further support their project and planning efforts.

Currently, the approach approved by the Cooperators for requesting and using IWDW data in NEPA projects has been documented in the NEPA-IWDW Process Outline.[14] Briefly, the primary approach recommended for new NEPA projects includes running the future-year baseline PGM simulation with the project emissions scenario(s) and available products and model configurations from the IWDW (i.e., use IWDW products "as-is"). Any deviations from the process or changes to the model files could require additional model performance evaluations. However, the BLM has found that this approach does not support the NEPA projects in the BLM offices.

Given this information, the Cooperators will need to consider an approach that is technically feasible to assist NEPA assessments that cannot utilize the NEPA-IWDW Process Outline currently approved by the Cooperators.

II. DESCRIPTION OF NEW WORK PRODUCTS

Given the uncertainty in oil and gas development, the BLM has found that "high", "medium", and "low" future-year scenarios have the capability to capture the potential variability in the development, growth, controls, and other factors. This approach aligns with the "Overview and Example Design of a Reusable Modeling Framework for Air Quality Modeling" appended to the Memorandum of Understanding among the U.S. Department of Agriculture, U.S. Department of the Interior, and U.S. Environmental Protection Agency, regarding Air Quality Analyses and Mitigation for Federal Oil and Gas Decisions through the National Environmental Policy Act Process. Briefly, the concept of a Reusable Modeling Framework (RMF) is designed to work in conjunction with a regional scale photochemical model to evaluate potential impacts for criteria pollutants (NAAQS – focused primarily upon a cumulative regional assessment of ozone and secondary particulate) and AQRVs. This RMF is most appropriate when specific numbers, size, and location of development are not well known for a proposed project, typically at the resource management plan (RMP), forest plan (FP), or leasing stage. This RMF uses emissions sensitivities analyses to bracket potential impacts from future growth scenarios. If the emission projections for a stage of a new or modified project falls within the range of emissions growth used in prior sensitivity analyses, then existing modeling potentially satisfies analysis needs without having to perform additional air quality modeling.

[14] NATIONAL ENVIRONMENTAL POLICY ACT – INTERMOUTAIN WEST DATA WAREHOUSE PROCESS OUTLINE [VERSION: September 19, 2016]: http://views.cira.colostate.edu/TSDW/Resources/ProceduralDocuments/FINAL_NEPA_IWDW_Process_Outline_Sept19_2016.pdf

This RMF also suggests that regional air quality assessments for both base year and future years be conducted at predetermined intervals. These intervals usually occur, at a minimum, every three years, corresponding to the NEI cycle. Grid resolution should also adequately represent the geophysical characteristics of the domain and anticipated development. For future year emissions, projections should be made from the base year to 10-15 years forward to examine the potential for maximum growth in the planning area. Future year growth estimates should examine the potential for low, medium, and high development based on the anticipated regional growth. The most straight forward method to address emission sensitivities uses photochemical modeling runs to examine incremental growth in the O&G sector. This approach is often referred to as the "brute force method" which examines the impact of emission growth through successive model runs showing impacts from alternative growth scenarios (e.g., High, Medium, and Low). Other probing techniques, which are more sophisticated and costly, allow for the development of area specific source-receptor relationships. Examples include the Response Surface Methods (RSM), as developed from iterative model runs, and the Direct Decoupled Method (DDM), as developed within a particular photochemical model.

III. EXAMPLE OF FUTURE-YEAR SCENARIOS AND RMF EFFORTS USED BY BLM

The BLM has proposed implementing a CARMMS[15]-like modeling and analysis component to the next work plan. In general, CARMMS is based on the concepts of an RMF, as outlined in the MOU among the USDA, DOI, and EPA for Federal Oil and Gas Decisions. CARMMS also leverages the work products created by the IWDW, including the WRF meteorology, the CAMx model, and the base and future year emissions inventories associated with each platform.

Each CARMMS iteration provides for a range (low, medium, and high) of potential oil and gas development scenario analyses. The low scenario is simply based on the last 5 years of average oil and gas development within a defined geographic boundary (basis, county, field office, state), while the high scenario is structured to approximate BLM's projections for unrestricted development (RFD). Both scenarios are developed with emissions controls based on current regulatory requirements. The medium scenario has the same oil and gas development intensity as the high scenario, but with additional controls. The medium scenario provides the BLM with the ability to provide for a residual impacts disclosure (required for NEPA) based on the utilization of such controls (or similar) as mitigation. CARMMS utilizes a PGM's ability to track (source apportion) emissions from a geographic area of interest to determine impacts of the emissions associated with the tagged source(s). In general, BLM Colorado tags new federal oil and gas projections within each field office (or sub regional areas of interest, ex: Pawnee National Grass Lands, SUIT Reservation, Roan Plateau, etc.). In providing three development scenarios, the tagged source impacts provide BLM Colorado with the ability to interpolate between the results, which are generally linear between the scenarios. This ability to scale impacts relative to emissions for each area of interest allows BLM Colorado to use the model results to support any number of projects and planning efforts.

IV. OBSERVED BENEFITS BY THE BLM

[15] CARMMS Report: https://www.blm.gov/programs/natural-resources/soil-air-water/air/colorado

To date, BLM Colorado has managed to fund two iterations of the CARMMS analysis leveraging both the 2008 and 2011b platforms developed by the IWDW. The CARMMS products have been used to support numerous initiatives, including the following:

- GJFO RMP Amendment
- UFO RMP Amendment
- RGFO RMP Amendment
- WRFO MPA EIS
- Roan Plateau SEIS
- Thompson Divide Lease Reinstatement EA
- FRAM MDP EA
- Pawnee National Grasslands Oil and Gas Leasing EIS
- Bull Mountain MDP EIS
- FFO RMP Amendment
- SJPLC SEIS ROD Modeling (Gothic Shale requirement)
- King II, West Elk, and 20 Mile Coal Mine Lease Mods
- Every Oil and Gas Lease Sale and APD processed by BLM Colorado since 2013

It is an understatement to suggest that this effort has not been anything but wildly successful. The actual time-savings alone is worth all the funding BLM has contributed to the IWDW project (previously Three State Study), as well as the additional BLM funds required to run the CARMMS projection scenarios (approximately $425K). While not an insignificant amount of money, the CARMMS projections are likely far more economical than having to prepare and run models for each of the projects listed above individually (potentially over $1 million per model platform per project).

V. WORK PLAN DEVELOPMENT

This is a new concept and work product that needs to be discussed among the Cooperators to develop goals, objectives, and deliverables, and ensure that resources are available to complete the work in a timely manner. The costs of the extra effort will need to be identified and a strict timeline will need to be enforced to ensure the deliverables are available for future NEPA air quality assessments.

The BLM acknowledges the need to provide for federal oil and gas projections for all the BLM field offices as input for each model iteration. The BLM also needs to determine the source apportionment groups needed by all the field offices, or if a less fine aggregation of emissions and impacts would work for disclosing impacts for NEPA. For example, CARMMS has over 20 source apportionment groups. This level of detail is not sustainable over the entirety of the fine resolution domain. The BLM acknowledges that the appropriate level of detail needs to be determined to satisfy NEPA and other air program requirements. BLM also acknowledges that partners outside of the IWDW-WAQS will need to be integrated and included into this approach to support the assumptions used in the projections, controls, source groups, etc. For instance, the partners that are linked to the policy and implementation of NEPA. While the IWDW-WAQS can support the completion of the modeling work, the NEPA policy and implementation of the approach is outside the scope of this work plan.

The Cooperators have compiled a list of topics that will be utilized to assist in the development of work tasks to address this need.

APPENDIX B: ADDITIONAL BASE AND FUTURE YEAR SCENARIOS FOR CLEAN AIR ACT PROGRAMS

- Consider 2016 base year as optional in the work plan because the initial 2016 emissions and modeling work being leveraged for the IWDW-WAQS is still under development (maintained/lead by EPA) and the availability/timing of the products is uncertain. Evaluate and use (with potential modifications) the 2016 state-MJO-EPA collaboration platform for the 36 km and 12 km CONUS modeling domains. When the 2016 products become available, the Cooperators should re-visit the 2016 work to assess the needs, timing, and resources.
- Consider evaluating and comparing the 2016 results to the 2014 results, particularly with respect to boundary conditions and global models' contributions of international anthropogenic and "natural" aerosols and gases. This will require and be contingent on obtaining the input files and assumptions from the EPA-State-MJO Collaborative.
- If utilization of the 2016 Emissions modeling Platform for western air quality planning is recommended and resources made available by the Cooperators, the work products will need to be stored, which include future-year emissions projections, in the IWDW.
- Consider 2020 future year as optional in work plan because the model results may not be relevant by the time the work is completed for this work cycle (i.e., model work may not be done until 2020). The Cooperators should re-visit the 2020 future year prior to commencing work to assess needs, timing, and resources.
- Future-Year Sensitivity Scenarios: Emission sensitivity scenarios for uncontrollable sources to be applied in future years' sensitivity studies, including, wildfire, dust, and international transport (both natural and anthropogenic sources). Future years will align and interact with modeling studies of ozone attainment in the Denver/Northern Front Range area and possibly other regional studies.
- Sensitivity Tests: Based on the model performance evaluation, perform sensitivity tests to improve identified performance issues, including emission inventories, boundary conditions, meteorological parameterizations, etc.

APPENDIX C: ADDITIONAL INITIAL AND BOUNDARY CONDITIONS MODELING

- Perform sensitivity tests to improve specific performance issues.
- After the base case PGM development is completed, more quantitative approaches can be used to assess boundary condition contributions. Three options for the quantitative assessment of the boundary conditions include:
    1. Estimating Lateral Boundary Inflow using a PGM Reactive Tracer Simulation: This assessment includes a model simulation tracking boundary condition inputs with reactive tracers to account for atmospheric chemistry. This option is preferred over using unreactive tracers when quantitative estimates of lateral boundary ozone contribution are desired. Examples include CAMx OSAT/PSAT, and CMAQ ISAM.

2. Estimating U.S. Background Contribution with a PGM Chemistry Simulation: This evaluation includes a simulation with chemistry and no U.S. anthropogenic emissions to assess U.S. background levels of ozone and $PM_{2.5}$.
3. Evaluation of a Full PGM Simulation: This assessment includes the PGM MPE operational evaluation with full-chemistry and full-emissions. The analysis would focus on rural or remote sites that have little influence from U.S. anthropogenic emissions.