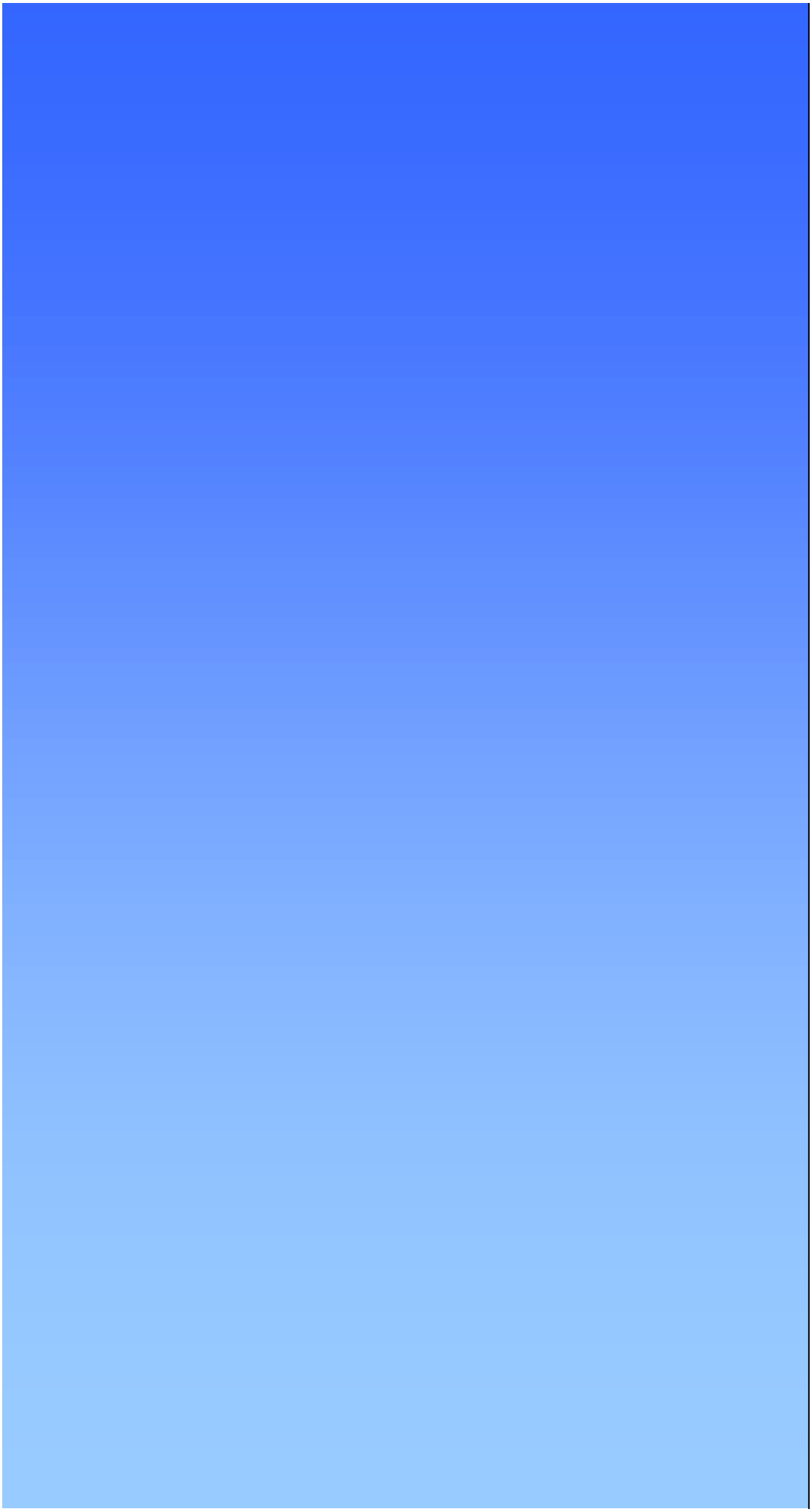

AIR SCIENCES INC.

DENVER • PORTLAND

E C/R Incorporated

Development of 2000-04 Baseline Period and 2018 Projection Year Emission Inventories

WORK PLAN

PREPARED FOR:

WESTERN GOVERNORS' ASSOCIATION
WESTERN REGIONAL AIR PARTNERSHIP
FIRE EMISSIONS JOINT FORUM

PROJECT 178-8
AUGUST 3, 2005 – FINAL

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SECTION 1

INTRODUCTION

The Project Work Plan (Work Plan) is the guide to be used by the Project Team consisting of Air Sciences Inc. (Air Sciences) and EC/R Incorporated (EC/R) to conduct the necessary analyses and successfully execute the tasks included in the proposed Scope of Work for this project.

SECTION 2

PROJECT TASKS AND DELIVERABLES

Task 1: Project Management

Task 1a: Work Plan

This Work Plan presents the methods and analyses for the Development of 2000-04 Baseline Period and 2018 Projection Year Emission Inventories. The Work Plan will be reviewed by the FEJF's Phase III/IV Task Team (Task Team) to revise the Work Plan as necessary. The Work Plan will carefully define the technical scope of work in as many areas as possible. Some aspects of the Work Plan may be presented in a way that maintains more flexibility for the FEJF to investigate technical aspects of the work and provide input to final methodologies and products. The Work Plan is prepared with sufficient detail for the Air Sciences – EC/R Project Team to meet the Task Team, FEJF, and WRAP's expectations for the technical deliverables, the project schedule, and budget estimate.

The final Work Plan will be submitted to the Task Team and Contract Officer for approval prior to implementation.

Task 1b: Quality Assurance Quality Control (QA/QC) Plan

The Work Plan contains a Quality Assurance/Quality Control (QA/QC) plan as an appendix. The QA/QC section has three primary purposes: (1) to increase the FEJF's confidence in the quality and accuracy of the baseline and projected inventories, (2) to serve as a manual for the Project Team to implement QA/QC routines, and (3) to serve as a portion of the documentation that the WRAP states and Tribes may need to provide in their Regional Haze state implementation plan (SIP) and tribal implementation plan (TIP) submittals to EPA. To fulfill this third purpose, the contents and organization of the QA/QC section will be consistent with available guidance, model plans, and/or checklists developed by the U.S. EPA as part of its Emission Inventory Improvement Program (EIIP).

In general, the Project Team's approach to QA/QC includes:

- Automate QA/QC procedures (where possible).
- Apply the procedures systematically to the data set.
- Assign "flags" to data that reflect the results of the QA/QC procedures.
- Conduct record-by-record review of flagged data.
- Apply appropriate meta-data to flagged data.
- Remove, as appropriate, and retain flagged data in a companion database.
- Create exception reports for the documentation task (Task 4).

The QA/QC section includes the specific QA/QC criteria to be applied to the emission inventory. These criteria are likely to include, but are not necessarily limited to:

- Methods to assess the baseline inventories and projected inventories for representativeness or completeness.
- The method(s) to systematically and accurately apply the appropriate emission factors to fire events.
- The method(s) to systematically and accurately calculate emissions for fire events.
- A number of GIS routines used to augment and/or temporally and spatially allocate fire activity data. GIS routines may include, but are not necessarily limited to:
    - Assign other location information such as state and county Federal Information Processing Standards (FIPS) codes and time zones.
    - Allocate projected emissions to appropriate modeling grid cells (i.e., using the WRAP Regional Modeling Center [RMC] grid system for dispersion modeling).
    - Modify fuel loadings and or emission estimates to accommodate emission reduction techniques, measures implemented through application of smoke management programs, or to estimate the effect of regulations that curtail burning activity.
- A number of GIS routines used to QA/QC fire activity data. GIS routines may include, but are not necessarily limited to:
    - Identify fires located in incongruous areas, such as in water bodies or urban areas.
- Post-fire activity database development QA/QC routines to verify the representativeness of the fire activity information. These routines could include: comparison of total acres burned in the projection database(s) with the baseline database(s), and comparison and review of summary statistics (e.g., acres burned, number of events, emission estimates) from one projection scenario to another (e.g., "high" to "low").
- Post-emission calculation QA/QC routines to verify the accuracy of the emission calculation methods. These routines could include: comparison of the ratios of emission estimates to the ratios of emission factors, cradle-to-grave spot checks of individual records to verify appropriate assignment and use of fuel loading, consumption rates, emission factors, etc.
- Post model-ready text file (e.g., PT files for input into the Sparse Matrix Operator Kernel Emissions [SMOKE] modeling system and National Emission Inventory 3.0 [NIF3.0]) QA/QC routines to verify the accuracy of writing the fire event information in the database to the strictly formatted text file. These routines could include:

statistical analysis to determine that the number of events, quantity of total emissions, etc., are the same in the database and the text file, and spot checks to verify strict formatting of the text file(s). In addition, the Project Team will implement data formatting routines and QC techniques to enable the NIF files to pass EPA's NIF Quality Assurance Checker. The final documentation for the report will include a section that documents these procedures and summarizes the results of the EPA QA Checker execution.

If necessary, additional QA/QC criteria that address concerns pertaining to planning emission inventories and their representativeness of baseline and future conditions will be included in the Work Plan.

Task 1c: Participation in Conference Calls and Meetings

Critical and appropriate members of the Project Team will participate in monthly calls with the Task Team and will participate in several upcoming FEJF or WRAP meetings. Participation in calls and meetings will play an important QC role for the project. These calls will be used to obtain technical input, guidance, and oversight of the technical methods and products.

The following participation in meetings is anticipated:

- At the June 7 through 8, 2005, FEJF meeting in Denver, Colorado, the Project Team presented a brief (60-minute) overview of the Work Plan (including the details of the QA/QC plan, and timeline for the project.) The overview emphasized the important role of state and tribal smoke managers in the development and review of the technical assumptions and procedures developed for the project. A schedule of project milestones was provided so that smoke managers can plan to accommodate critical review periods in their schedules.
- A one-day technical session (August) to (1) review and finalize the table of adjustments to be applied to the prescribed fire baseline inventory (see the "Prescribed Fire Baseline Inventory" section in Task 2 for details on the purpose of the potential baseline adjustments), and (2) establish the table of initial scalars to be applied to the projection inventories (see Task 3 for more details on the initial development of projection scalars).
- In October 2005, the Project Team will conduct a 1.5-day technical workshop on the planning inventories (including results and actions of the Quality Control Binder [QC Binder] review process), accommodation of emission reduction techniques (ERTs) in the projection inventories, and roll out the fire calculation tool. The workshop will be tailored to state and tribal smoke program managers.
- At the Winter (2005 – 2006) FEJF meeting, the Project Team will present a brief (90-minute) wrap-up of the project. The wrap-up will include a numeric presentation of

the planning inventories, technical limitations of the inventories, and guidance on the appropriate use of the planning inventories in the regional haze planning process.

Task 2: Baseline (2000 – 04) Fire Burning Levels and Emission Inventories

As the starting place for the WRAP's suite of planning inventories for fire, we will develop baseline (2000-04) inventories based upon the FEJF's Phase II inventories for wildfire, wildland fire use, prescribed burning, agricultural burning, and non-federal rangeland burning recently completed by Air Sciences (Air Sciences, July 2005). The baseline inventories will be prepared as "nominal" inventories comprised of events that are representative of baseline conditions in terms of size, location, and temporal distribution *but not comprised of any actual historic fire activity data*. Using nominal inventories will accommodate the preparation of projection planning inventories (2018) that can be directly compared to the baseline inventories in dispersion modeling analyses and in the Regional Haze SIP and TIP process. For each fire type, the Project Team will execute several steps to gather information, analyze the technical methods implemented, review the resulting nominal fire data, and make modifications to the 2002 Phase II inventory data to derive the baseline inventories.

Emissions will be calculated for all events in the baseline emissions inventories by using fuel loading look-up tables (e.g., WRAP's modified National Fire Danger Rating System [NFDRS] fuel consumption table and agricultural residue loading tables) and fire-type-specific emission factor look-up tables. Each event will be categorized and coded appropriately as natural or anthropogenic emissions per the WRAP's Fire Categorization Policy (November 15, 2001) and through the application of technical data processing methods approved by the Task Team and FEJF. The baseline period EI files will be prepared in the proper format (NIF 3.0) and loaded into the WRAP Emissions Data Management System (EDMS).

For the EDMS files, the baseline period inventories will include event emissions totals, hourly plume characteristics (including the minimum height of the bottom of the plume [PBOT], the maximum height of the top of the plume [PTOP], and the percentage of the emissions plume that is fumigated into the first vertical layer [LAY1F] [see Appendix B]), chemical speciation profiles, and fire-type-specific diurnal burning profiles patterns for use by the WRAP RMC. All inventories will be delivered in export format and in spreadsheet form including all input variables used to calculate emissions estimates (see Task 4).

Wildfire Baseline Inventory

A single scenario for wildfire activity will be developed that will represent wildfire in the baseline (2000-04) and projection (2018) cases. In addition to the "static" baseline/projection inventory for wildfire, a potential range of emissions (from low to high) for wildfire will be estimated from historical data and included in the final documentation for the project. All events

in the wildfire inventory will be categorized as "natural" per the WRAP's Fire Categorization Policy, and emissions from these wildfire events will be classified as non-controllable.

The WRAP's Phase II wildfire inventory for 2002 (which has been reviewed by state, Tribal, and federal agencies through the Phase II QC process) will serve as the starting place for the wildfire baseline inventory. Any technical justification to adjust 2002 wildfire data in order to create the wildfire baseline inventory will be developed through the following procedures:

- Obtain Wildland Fire Assessment System (WFAS) data for 1986-96 wildfire point data for federal and state databases.

  The WFAS data has been identified as the best repository of long-term federal and state event-based data. The time period of 1986 through 1996 is the time period that the WFAS database covers. Initial examination of the WFAS data shows a fairly regular pattern of wildfire activity over this 10-year period (which gives the Project Team confidence that we can build representative statistics for the baseline period).

- Obtain summary fire statistics from the National Interagency Fire Center (NIFC) (including data from the baseline period 2000 through 2004).
- Obtain summary data maintained by the United States Department of Agriculture – Forest Service (USDA–FS) – Washington Office for 2000-04.
- Categorize the Phase II wildfire EI and WFAS events by size and plot the distribution of fires by plume class into Bailey's Ecoregions ("Province" level). The fire size classes for this analysis are shown in Table 1:

Table 1: Fire Size Classes to Determine Historic Distributions

Fire Size Class	Size Range (acres)
1	> 0
2	>= 0.5
3	>= 1.0
4	>= 5.0
5	>= 10
6	>= 100
7	>= 1,000
8	>= 5,000
9	>= 10,000
10	>= 100,000

- Summarize the multi-year WFAS wildfire activity by state for a general spatial distribution. Calculate an "average year" WFAS inventory based on the contiguous 11 years of the WFAS data.
- Compare the distribution of wildfire events in the Phase II EI to the distribution of events in the WFAS "average year." Summarize the Phase II data as appropriate to compare to the NIFC and USDA–FS – Washington Office summary data. Comparisons will include temporal distribution, fire size distributions, spatial distribution, and variations in wildfire intensity. The NIFC and USDA-FS – Washington Office sources of wildfire summary statistical data for 2000-04 will be used to generally characterize the wildfire conditions of the WRAP's baseline period and to inform the selection of the "average" year in the WFAS data.
- Provide recommendations for adjusting the Phase II wildfire data. Recommendations will be based on the cursory statistical evaluation described above. To confirm (or modify) the recommendations, the Project Team will review summary fire statistics from the NIFC (including data from the baseline period 2000 through 2004).
- Based on results of the above steps, the Project Team, with advice from the Task Team, will create the baseline wildfire EI by Adjusting the Phase II WF inventory by adding and/or removing events (by Ecoregion Province) from the Phase II inventory.

Wildland Fire Use Baseline Inventory

Air Sciences' experience in preparing the Wildland Fire Use (WFU) Phase II EI suggests that, in general, WFU activity data is incorporated in the wildfire activity data sets. The Project Team will execute a brief Strawman review process that presents the approach of applying the 2002 ratio of WFU to wildfire (by ecoregion or state) to the baseline wildfire inventory to create the baseline WFU inventory. The Strawman review will include a review of the 2000 through 2004 time period to confirm that the 2002 ratio of WFU to wildfire is appropriate to represent WFU in the baseline period. The accuracy of the findings of this review will depend on the availability of WFU data for the baseline period. The results of the Strawman approach will be implemented.

Prescribed Fire Baseline Inventory

The WRAP's Phase II prescribed fire inventory for 2002 (which has been reviewed by state, Tribal, and federal agencies through the Phase II QC process) will serve as the starting place for the prescribed fire baseline inventory. Each event in the Phase II prescribed fire inventory has been categorized as "natural" or "anthropogenic" according the categorization method approved by the ETT and the FEJF. The technical justification to adjust 2002 prescribed burning data in order to create the prescribed fire baseline inventory will be developed through the following procedures:

- Strawman. The Phase II 2002 prescribed fire event-based inventory will be summarized by natural and anthropogenic prescribed fire acres burned per agency (e.g., state, Tribe, federal), jurisdiction (e.g., USDOI – National Park Service Intermountain Region), and fuel category (e.g., NFDRS fuel model) using EXCEL pivot tables and hardcopy Baseline Binders. Summaries will be posted on the WRAP's web site in the interest of soliciting review and input from state and tribal smoke managers. A small group (5 – 10) of state/Tribal Smoke Management Program managers, federal burners, and subject matter experts will assemble to review the Baseline Binders and to consider whether the 2002 prescribed fire data are representative of baseline conditions (2000-04). Criteria to be used to determine representativeness include, but may not be limited to the following.

    - Weather/Fuel Conditions. Weather or fuel conditions did not promote more or less burning than would be considered representative of baseline conditions. (Did drought conditions mandate reduced prescribed burning activity in 2002?)
    - Temporal Allocation. The temporal allocation of prescribed burning activity would be considered representative of baseline conditions. (Did the prescribed burning season start a month earlier or later than usual?)
    - Fire Location. The location of prescribed burning events would be considered representative of baseline conditions. (Were an unusually high or low number of acres treated within 50 km of a Class I area?)
    - Fuel Categories. Prescribed fire activity took place in fuel categories that are representative of baseline conditions.
    - Broadcast/Pile Ratio. The ratio of acres treated with broadcast burns to acres treated with pile burns is representative of baseline conditions.
    - Extenuating Factors. There were no unusual factors (e.g., recent proximate wildfire events, blow-down events, beetle kill) that promoted more or less prescribed burning than would be considered representative of baseline conditions.
    - Regulatory Environment. The regulatory environment in 2002 (e.g., smoke management and burn permit programs) was representative of baseline conditions and did not result in more or less burning than would be expected in baseline conditions. (Did "no burn" days restrict prescribed burning to below baseline levels? Did legislation passed in 2003 significantly reduce or increase the allowable amount of prescribed burning?)
    - Funding. The level of funding made available for fuel management in 2002 was dedicated to prescribed burning in a manner that would be considered representative of baseline conditions. (Did fire suppression demands drain available funding for fuel treatment?)

- In instances where prescribed fire activities are determined to not be representative of baseline conditions, then the group will be asked to provide alternative activity rates (as gross acres-burned estimates per fuel category) and a brief justification for the change in activity rate. The group will also be asked to provide an estimate of the portion of anthropogenic emissions that are controllable with the application of ERTs. Lastly, the group will develop ERTs application rules appropriate for the baseline period. The ERTs application rules will be based on surrogate information available in the prescribed fire data (e.g., fuel arrangement [broadcast versus pile], NFDRS fuel model code). A draft of the ERTs application rules will be posted on the WRAP's web site for state and tribal smoke managers' review. The objective of the review of the ERTs application rules will be to address individual state and tribal smoke management program needs for their agency's regional haze plans, including the consideration of emerging fire emissions tools such as the Fire Tracking System and regional coordination. The final ERTs application rules will reflect input received from state and tribal managers' review. Work from the FEJF's ERTs Task Team will be utilized for this effort.
- The results of the Strawman effort will be used to inform adjustments of the actual 2002 burning levels in order to create the most representative prescribed burning levels for the baseline period.
- The Phase II 2002 inventory will be analyzed to derive critical prescribed fire statistics such as fire size distribution, fire occurrence on specific land ownership, and temporal distribution. These statistics will be derived at a reasonable geographic scale (expected to be Baily Ecoregion Province).
- The adjusted burning levels (from the Outreach Effort) and the Phase II 2002 inventory statistics will be used to create the "nominal" baseline inventory for prescribed burning.

Agricultural Burning Baseline Inventory

The WRAP's Phase II agricultural burning inventory for 2002 (which has been reviewed by state and Tribal agencies through the Phase II QC process) will serve as the starting place for the agricultural burning baseline inventory. Each event in the Phase II agricultural burning fire inventory has been categorized as "anthropogenic" according the categorization method approved by the ETT and the FEJF.

The Phase II agricultural burning inventory is comprised of a combination of event-based and allocated summary burning data. Given the nature of the burning activity data, the Phase II inventory is assessed to be representative of agricultural burning during the baseline period. Air Sciences has identified a limited amount of essential gap-filling tasks in order to fill obvious gaps in the Phase II inventory (e.g., limited agricultural burning in Nevada). The gap-filling will be

done employing a top-down approach to estimate burning activity levels. Using data in states and/or counties in which the ETT has high confidence, the relationship of residue burning to National Agricultural Statistics Service (NASS) harvest information by county by crop will be established. As reality checks for the top-down gap-filling method, several spot checks of NASS-based burn estimates compared to Phase II EI data will be performed. For the identified gap-filling areas, the NASS-based burn totals will be estimated and allocated to the appropriate temporal and spatial distribution and dropped into the baseline data set as representatively sized events. WRAP region agricultural burning regulations (rules and ordinances) and Smoke Management Plans will be compiled and applied to baseline agricultural inventory as appropriate.

The Phase II 2002 agricultural burning inventory will be analyzed to derive critical fire statistics such as fire size distribution and temporal distribution. These statistics will be derived from the event-based agricultural burning data (e.g., California and Washington) in the Phase II inventory. The burning statistics will be as crop-specific and sub-regional specific as the raw data will allow. The Phase II agricultural burning levels plus the burning levels derived through the essential gap-filling exercise and the Phase II 2002 inventory statistics will be used to create the "nominal" baseline inventory for agricultural burning.

Non-Federal Rangeland Burning Baseline Inventory

The WRAP's Phase II non-federal rangeland prescribed burning inventory for 2002 (the development of which was recently approved by the ETT and reviewed by the FEJF) will serve as the starting place for the non-federal rangeland burning baseline inventory. Each event in the Phase II rangeland burning fire inventory has been categorized as "natural" based on the typically low fuel loading levels and the reasonable opinion of the FEJF that non-federal rangeland burning is typically done to maintain natural fuel conditions.

The Phase II 2002 non-federal rangeland burning inventory is comprised entirely of allocated summary data and is assessed to be representative of the baseline 2000-04. The top-down approach to estimate rangeland burning activity is documented in the Phase II report (Air Sciences, July 2005). Because of the nature of the Phase II non-federal rangeland burning level data and the fact that the inventory is "nominal" by design (i.e., no actual, event-based rangeland burning data is included in the inventory), the Phase II 2002 non-federal rangeland inventory will be used "as is" as the baseline inventory. To increase confidence in the representativeness of the rangeland inventory, a brief reality check will be performed. We propose to compare the Phase II 2002 non-federal rangeland acres burned by state to total rangeland existing per state appearing in the National Resources Inventory (NRI). A brief analysis of the consistency of the ratio of burned acres to rangeland acres across states and a brief discussion of whether discrepancies are technically justifiable or warrant a re-investigation of the Phase II data will be included in the documentation for the project.

Allocation Scheme for Creating Event-Based Inventories from Baseline Burning Levels

For all fire types, baseline burning levels will be allocated to nominally sized events, distributed to appropriate locations on the landscape, and distributed to appropriate calendar days. Ten fire size classes for broadcast fires and two "typical" size profiles for piles (i.e., small pile and large pile) will be used as the starting point for determining the suite of nominal fire sizes. Of note, plume parameters will be "inherited" from the five broader plume classes. Thus, this size class refinement does not necessitate revisiting the established plume methods. The ten fire size classes delineated in Table 1 will be tailored to precise acres for the nominal events. The final fire size classes will be developed by analyzing the Phase II data and will be presented in the prescribed fire baseline Strawman.

The day of occurrence of the baseline allocation of events will be based on profiles created from the Phase II EI. The annual occurrence profiles will be developed at an appropriate spatial resolution for the source data (i.e., Baily Ecoregion Provinces for prescribed burning and wildland fire use, by groupings of states and crops for agricultural burning). Allocated events will be date-stamped to approximate this historic curve.

The spatial allocation of events will be based on the WRAP's 12-km modeling grid. For each fire type, the proportion of burning activity in each administrative unit will be used to allocate the nominal fire events to the grid cells within that administrative unit. The final coordinate for the event will be the center of the grid cell. The 12-km grid is the best resolution the WRAP dispersion modeling system accommodates (hence its choice as the spatial basis for these nominal inventories). In spite of this explicit spatial limitation, attribute information in the emission inventory will retain the exact fire source type, administrative unit, fuel model, etc. for each event. In this way, the true "origin" of each fire will be known independent of the land owner implied (almost by chance) at the coordinates of the center of the 12-km grid cell.

Task 3: Projection (2018) Fire Burning Levels and Emission Inventories

The WRAP's suite of projection (2018) planning inventories for fire will be developed from baseline (2000–04) inventories for wildland fire use, prescribed burning, agricultural burning, and non-federal rangeland burning. The wildfire baseline inventory will be used for the wildfire 2018 inventory. Basing the projection inventories on the nominal baseline inventories will accommodate direct comparison of the projection inventory to the baseline inventories in dispersion modeling analyses and in the Regional Haze SIP process. For each fire type, the Project Team will execute several steps (described below) to gather information, analyze the data and technical steps, and modify the baseline inventories in order to derive the projection inventories.

All events in the projection inventories will be categorized and coded appropriately as natural or anthropogenic emissions per the FEJF policy and/or through the application of technical data

processing methods approved by the ETT and FEJF. Also, anthropogenic events will be coded as controllable or non-controllable. The projection EI files will be prepared in the proper format (NIF3.0) and loaded into the WRAP EDMS. For the EDMS files, the baseline period EIs will include event emissions totals, plume characteristics (e.g., the PBOT, PTOP, and LAY1F parameters as derived for the Phase II events), chemical speciation profiles, and fire-type-specific diurnal burning profiles patterns for use by the WRAP RMC. All inventories will also be delivered in SMOKE IDA format and in spreadsheet form including all input variables used to calculate emissions estimates.

In general, the development of the projection inventories will follow the steps as prescribed in the request for proposal for this project. For each fire type, the projection inventories will be developed for three scenarios: high, medium, and low. The process of developing the projection inventories will start with a review of peer-reviewed literature and gathering and documenting expert opinion. The Project Team (sometimes with help of a technical Task Team) will analyze available information and determine any variation from the baseline inventories. All conclusions that produce controllable anthropogenic emissions in 2018 that vary markedly from the baseline inventories will be documented.

Specifically, the Project Team will develop the projection inventories for all fire types (wildland fire use, prescribed burning, agricultural burning, and non-federal rangeland burning) utilizing the following steps.

The baseline prescribed fire inventory will serve as the starting place for the prescribed fire projection inventories. The technical justification to adjust the baseline burning levels in order to create the projected inventories will be developed through the following procedures:

- Prepare a White Paper that presents the burning level projection topic, provides the appropriate context for developing projections, criteria for developing scalars (e.g., forest ecology, land management objectives, wildfire return intervals, climate trends, urban/forest interface consideration, emissions tradeoffs, administrative constraints), and the details of the process to develop projection scalars.
- Assemble a small group (ETT and other experts, as needed) to develop projection scalars. The scalars will be developed at an appropriate spatial resolution (i.e., Baily Ecoregion Provinces for prescribed burning and wildland fire use, state for rangeland, county for agricultural burning) with the ability to address a limited number of specific (and significant) administrative areas. Ultimately, the deliverable for this process will be a table of scalars (high, medium, and low scenarios) to be applied to baseline burning levels for each fire type and multiple fuel types (e.g., NFDRS, NFDRS models collapsed to "grass," "brush," and "timber") for each ecoregion province (or similar subregion). The high medium and low scenarios will be based upon an analysis of the potential range of future burning emissions. Information that could factor into the

development of the projection scalars includes the relationship of climate (expressed as monthly precipitation maps) and historic fire incidence data. The effect of regulatory programs, regional scenarios of the application of ERTs, and the AEG policy (the optimal application of ERTs) will be incorporated into the projection inventories.

- Apply the table of scalars to baseline burning levels for all types of fire to arrive at the preliminary 2018 projection burning levels.
- Summarize the preliminary 2018 projection burning levels in the form of a QC Binder presented as a Strawman of the projection inventories. Tailor the data and distribute the QC Binders along jurisdictional channels (e.g., state/Tribe smoke management programs, state forestry personnel, federal land managers, private/agricultural burners, USDA – Natural Resource Conservation Service personnel). Provide feedback forms to solicit comments from recipients. The projected acres are broken down by NFDRS fuel model. Alternatively, projected acres could be broken down by explicit fuel loading values (e.g., 0-1 tons/acre, 1-2.5 tons per acre, 2.5-5 tons per acre, etc.).
- Like the Phase II QC Binder process, Air Sciences will design the display formats to display the data effectively and will provide a BETA version of the QC Binders for review by a small group of reviewers (including at least one representative from each of the following: state smoke management program, tribal smoke management program or NTEC, state forestry department, federal land manager, private/agricultural burners, USDA – NRCS). The design of the QC Binder will reflect the importance of the different projection inventories in the regional haze planning process (i.e., emphasis will be placed on the controllable portion of anthropogenic sources.) Announce upcoming one-day technical session to review and finalize (as necessary) the table of scalars and projection burning levels.
- In the Phase II QC Binder process, Air Sciences accommodated feedback from responding jurisdictions by integrating feedback on a customized, case-by-case basis. For this project, a different approach will be used. Responses from recipients of QC Binders will be compiled in preparation for a one-and-a-half-day technical workshop (scheduled for October 2005). The workshop will likely include work done in breakout groups (organized by fire type [prescribed, agricultural, non-federal rangeland] or entities likely to require interagency coordination of smoke management programs). The agenda of the technical workshop will include:

    - Review of the compiled results of the QC Binder process.

        - Objective: Agree to a method to accommodate input of QC Binder responses (e.g., strict application of "global" rules, data/feedback hierarchy, case-by-case data integration).

- Review (and potentially revise) the table of projection scalars and the application of regional scenarios of ERTs.
    - Objective: Either accept or revise the table of projection scalars and the application rules for regional scenarios of ERTs.
- Roll-out of fire projection calculation tool.
    - Objective: Introduce likely users of the calculation tool to the software's features and outputs.

- Use the results of the October 2005 technical session to apply the final table of scalars and application of regional scenarios of ERTs to the baseline burning levels to generate the projection burning levels.
- Use the projection burning levels to generate the projected event-level emission inventories.

Allocation Scheme for Creating Event-Based Inventories from Projection Burning Levels

In general, the allocation scheme for creating event-based inventories from projection burning levels will be identical as the scheme implemented for the baseline inventories. To produce the projection inventories, the "high" estimate will be allocated first. Allocation will be parameterized by fire size distribution and annual profile and result in a spatio-temporal EI with realistically sized events in appropriate locations. To arrive at the "baseline" then "low" scenarios with less activity, events will be subsequently removed from the scenarios (similar to how the 2018 agricultural burning inventories for different control scenarios were created). In this way, the lower activity scenarios will be strict sub-sets of events in the greater scenarios. This progressive emission inventory allocation technique will control for location and timing of emissions while focusing the differences between scenarios on occurrence and size of events. If necessary, the temporal occurrence curve could be reshaped within a jurisdiction to arrive at a different temporal scenario.

Calculation Tool for Estimating Projected Emissions

A goal of this project is to create and distribute to smoke management program managers of WRAP states and Tribes a software application tool that will generate an event-level prescribed burning emission inventory given estimates of future levels of burning. The calculation tool will be designed for use by experts in fire and smoke management.

The emission inventory calculation and allocation tool will automate many but not all of the methods described already in this section. The tool will provide a straightforward method to input levels of prescribed burning by fuel class, to characterize the application of ERTs, and to estimate anthropogenic and controllable emissions due to fire sources in a particular smoke

management program administrative unit. While burning levels entered into the tool can be specific to an administrative unit, the scale and precision of the output is intended for regional modeling. Therefore, the complexity of the user interface and the scope of engineering the tool will be constrained. Furthermore, we expect the tool to be most widely used if it provides a relatively simple medium to create event-level emission inventories for planning purposes given only coarse estimates of burning levels.

The tool will be implemented as software in Microsoft Excel 2003. A Microsoft Excel workbook with a streamlined user interface and macro-driven calculations is an excellent software platform for this tool given its capability, portability, ease of use, cost, and transparency of the inner workings. The budget for this project is based upon the calculation tool being a "Proof of Concept" tool (alpha version) that is functional but not rigorously tested.

The proposed tool will have two major components: emission calculation and event-level allocation. The prescribed fire emission calculator will be based on the current documented WRAP state-of-the-science and will have the following elements:

- The fundamental calculation formula as an extension to the WRAP 2002 Phase II method: *Area burned x Fuel loading x Percent reductions x Emission factor*
- Fuel loading in ton per acre will be looked up (based on fuel model) from the existing Phase II prescribed fire, agricultural burning, and rangeland burning fuel loading look-up tables.
- Emission factors in pound per ton will be looked up (based on pile or broadcast burning) from the existing Phase II emission factor look-up tables. Emission factors will be VOC, NO_x, SO_2, PM_{10}, $PM_{2.5}$, EC, OC, CO, and NH_3.
- Non-burning technique information (if applicable to this emission calculation tool) as a percent of total area treated and fuel consumption as a percent of fuel loading may be input and will be applied to the corresponding activity value. If no value is included, a default of 0 percent reduction will be assumed.
- A look-up table of ERTs will be acquired from the ERTs Task Team of the FEJF. These values will be percent emissions eliminated by ERTs. ERTs will be credited to the tonnages estimated by the emission calculator. Most ERTs will be included, but some may not correspond with this tool that manipulates coarse estimates of burning and will therefore not be available.

The event-level allocation component of the tool will break the emission calculator output into events. The primary function of the tool will be to allocate estimates of levels of burning to nominally sized events, time them to reasonable times of the year, and distribute them to appropriate locations on the landscape.

- The suite of nominal fire sizes utilized in the 2002 baseline and 2018 projections will be loaded into the tool.
- Fire size class distributions and annual activity profiles utilized for the 2018 projections and based on the baseline emission inventories will be loaded into the tool.
- A simple user interface will guide the entry of projected levels of burning by fuel classification and ERTs application. The interface will also allow natural/anthropogenic and controllable/non-controllable designation directly by the user.
- The tool will apply the nominal fire size suite, size class distribution, and annual activity profile to the emission projections and export a database of fire events. The database will include fire size, fuel consumed, emissions, date and location, natural/anthropogenic categorization, controllable/non-controllable categorizations, and the emission reductions due to application of ERTs.
- A GIS will be used off-line to combine maps of agency, land cover, and the WRAP 12-km modeling grid into a regional-scale allocation grid. The coordinates and attributes of this grid will be loaded into the allocation tool. The tool will allocate the events it creates to cells in the grid that match the attributes of the coarse data. The resolution of the grid and intricacy of its attributes will be kept simple enough as to not burden the tool with excess data or computational requirements.
- The tool's allocation routine will be deterministic in that a given set of burning level inputs will always be allocated to the same event-level emission inventory. In this way, emission inventories generated from similar inputs will have similar event-level outputs to facilitate comparison in dispersion modeling analyses and the Regional Haze SIP process.
- The precise level of "administrative unit" to be used in the calculation tool will be chosen in discussion with the Task Team subsequent to consultation with fire experts assembled for the August 2005 "One-Day Technical Session." The level of the administrative unit must be detailed enough to be useful for emission inventory preparation but broad-scaled enough given the multi-agency user base as well as software constraints.

Task 4: Documentation and Emission Inventory Files

Timely and unambiguous documentation for this project will be prepared according to the terms and descriptions in the request for proposal. Specific documentation deliverables will include:

- Baseline Documentation (draft and final forms) including: a description of how complete, representative baseline inventories were developed; a listing of the variables considered and why; a description of the technical methods employed to prepare the

emission inventories; identification of known limitations in applying the baseline inventories for planning purposes.

- Projection Documentation (draft and final forms) including: a description of how complete, representative baseline inventories were developed; a listing of the variables considered and why; a description of the technical methods employed to prepare the emission inventories; identification of known limitations in applying the baseline inventories for planning purposes.
- Calculation Tool Users Guide (draft and final forms) including: concise and unambiguous description of the calculation tool and written instruction on the use of the documentation tool suitable for experienced smoke management program personnel.

Emission inventory digital file deliverables for this project will be formatted using the EPA's NIF3. The NIF3 is the format most widely used by state and local agencies to transfer data to the EPA's National Emission Inventory (NEI). It is also the input format being used with the Open Emissions Model now under development. EC/R used the NIF3 point source emissions format during their project with the Lake Michigan Air Directors Consortium (LADCO) to develop a Midwest fire inventory. The WRAP then extended this format for use in the Phase II emission inventory for upload to the WRAP EDMS. The most recent format is also slated to be the primary distribution format of the Inter-RPO National Wildfire Emission Inventory. The Project Team will use this same format for the Phase III and IV project.

The NIF3 point source emissions format provides the flexibility needed to organize fire emissions data that is county- or sub-county-specific and is assigned to modeling layers. Fire emissions data will be organized into seven different NIF3 files: transmittal, site, emission unit, emission release point, emission process, emission period, and emission. The NIF3 transmittal and site files provide a record of the source and vintage of the data. The emission unit file holds the fuel model of each fire, and the emission release point file contains the geographic location of each fire as well as the model layer heights. Each fire's fuel type and fuel load is kept in the emission process file, and the time duration of each fire is recorded in the emission period file. Actual fire emission values by pollutant and model layer are listed in the emission file.

SMOKE-ready emission inventory files in PT/IDA format will also be supplied as PTINV, PTDAY, and PTHOUR text files.

The detailed definition of the NIF3 and PT/IDA format and example files are not included in this document for brevity and because they are currently being refined. The most recent documentation appears in the draft final report entitled *2002 Fire Emission Inventory for the WRAP Region – Phase II*.

SECTION 3

SCHEDULE & DELIVERABLES

Table 2: WRAP Phase III & IV Timeline for Project Deliverables and Meetings

In this table major deliverables are bolded, and project meetings are shown in italics. Dates refer to year 2005.

WRAP Phase III & IV Timeline for Project Deliverables and Meetings

Major deliverables bolded, project meetings italicized. Dates are year 2005.

	Number of weeks from contract execution and due date as a Friday.																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Deliverable	6/17	6/24	7/1	7/8	7/15	7/22	7/29	8/5	8/12	8/19	8/26	9/2	9/9	9/16	9/23	9/30	10/7	10/14	10/21	10/28	11/4	11/11	11/18	11/25	12/2	12/9	12/16	12/23	12/30
Draft work plan																													
Final work plan																													
Status Conf Calls (10a Mtn)													Sep 7				Oct 5				Nov 2								
WFU baseline Strawman																													
Rx baseline Strawman																													
Rx baseline binders																													
Meet: Rx baseline evaluation								*Aug 10-11*																					
Baseline EI files																													
Baseline draft document																													
Baseline final document																													
2018 white paper																													
Scenario draft document																													
2018 QC binders																													
Meet: projection scalars																			*Oct 18*										
Calculation tool roll out																													
Draft 2018 EI files																													
Final 2018 EI files																													
2018 draft document																													
2018 final document																													

This schedule appears in the Work Plan for the project *Development of 2000-04 Baseline Period and 2018 Projection Year Emission Inventories*, prepared by Air Sciences, Inc. and EC/R, Inc. for the Western Governors' Association, Western Regional Air Partnership, Fire Emissions Joint Forum. The revision date is indicated below.

SECTION 4

PROJECT TEAM MEMBER RESPONSIBILITIES

The Project Team of Air Sciences and EC/R will cooperate on many technical tasks. For some tasks, one Project Team member or the other will take the primary role to complete the task (or complete the task independently). The responsibilities of the Project Team members are as follows:

Air Sciences

- Data analysis and assessment (including statistical significance tests).
- Determine and justify variation from Phase II EI's for baseline EI's.
- Inform projection EI's with forest ecosystem information and expertise on the role of fire.
- Application and calculation of ERTs.
- Application and calculation of effect of agricultural burning SMPs and rules.
- Emission inventory processing.
- Documentation.

EC/R

- Review of peer-reviewed scientific literature and gather expert opinion to inform 2018 projections.
- Gather info on state and Tribal plans for applying ERTs to agricultural burning (including ban) and prescribed fire.
- Inform projection EI's with forest ecosystem information and expertise on the role of fire.
- NIF formatting and model-ready file generation.
- Technical session coordination.
- Documentation.

APPENDIX A

Quality Assurance / Quality Control Plan

GROUP A: PROJECT MANAGEMENT

Project Organization

Overall emission inventory preparation and Quality Assurance/Quality Control (QA/QC) for the Phase III and IV project (Project) will be the responsibility of the Western Regional Air Partnership (WRAP) Technical Coordinator, Mr. Charles T. Moore. The tasks of emission inventory preparation and QA/QC have been contracted to Air Sciences Inc. of Golden, Colorado (Air Sciences). Mr. David Randall is the responsible project manager at Air Sciences. Mr. Randall will delegate project tasks to the Project Team of Air Sciences staff and EC/R Incorporated (EC/R) staff under sub-contract.

Staff at Air Sciences and EC/R will carry out all tasks of the emission inventory and perform QC. Mr. Randall will serve as both the Air Sciences Project Manager and the Project QA Manager. Several quality assurance steps will be performed by the Phase III and IV Task Team (Task Team). The Task Team and other individuals invited for ad hoc review are defined by the project manager.

Problem Definition/Background

The QA/QC plan has three primary purposes: (1) to increase the WRAP Fire Emissions Joint Forum's (FEJF) confidence in the quality and accuracy of the baseline and projected inventories, (2) to serve as a manual for the Project Team to use to implement QA/QC routines, and (3) to serve as a portion of the documentation that WRAP states and Tribes may need to provide in their Regional Haze SIP submittals to EPA. To fulfill this third purpose, the contents and organization of the QA/QC plan will be consistent with available guidance, model plans, and/or checklists developed by the U.S. EPA as part of its Quality System for Environmental Data and Technology.

This Phase III and IV project has as its starting point the preceding WRAP Phase II emission inventory. At its essence, this project manipulates the Phase II emission inventory to become "baseline" and "projection" emission inventories. This QA/ QC plan therefore focuses on ensuring that such data processing executes as intended. This project does not involve actual environmental measurements. It also does not attempt to validate existing data. Including the task of "gap filling" activity data, no ground truthing or detailed confirmation of fire activity will occur. Emission inventory content is reviewed to the extent of the expert "reality checks" delineated in this QA/QC plan. This QA/QC plan therefore takes the form of a checklist to confirm that steps prescribed in the Work Plan are implemented properly and that the outcome is reasonable.

In accordance with U.S. EPA guidance, this QA/QC plan is organized into applicable components of a Quality Assurance Project Plan (QAPP) (EPA Requirements for Quality

Assurance Project Plans, EPA QA/R-5, March 2001). Applicability of this QC Plan to U.S. EPA QAPP structure is summarized as:

- QAPP Group A: Project Management – Applicable elements are included in the QA/QC plan.
- QAPP Group B: Data Generation and Acquisition – Not applicable.
- QAPP Group C: Assessment and Oversight – Applicable elements are included in the QA/QC plan.
- QAPP Group D: Data Validation and Usability – Not applicable.

Quality Assurance Methods and Procedures

In general, the Project Team's approach to QA/QC will include:

- Automate QA/QC procedures (where possible).
- Apply the procedures systematically to the data set.
- Assign "flags" to data that reflect the results of the QA/QC procedures.
- Conduct record-by-record review of flagged data.
- Apply appropriate meta-data to flagged data.
- Remove, as appropriate, and retain flagged data in a companion database.
- Create exception reports for the documentation task (Task 4).

Quality Control of Baseline and Projection Inventories: Internal Processing Control

The assembly of the 2004 – 2004 baseline emission inventories and 2018 projection emission inventories will be quality-controlled as bulleted in this section. These technical methods ensure that the inventories are being calculated as specified in the Work Plan. Review of the representativeness of the actual emission estimates (quality assurance) is discussed in the next section. Internal data checks include:

- Automated routines to evaluate each record for activity data completeness will be implemented. Records flagged as containing insufficient critical temporal, spatial, and activity information will be reviewed as a sign of calculation error and removed to a companion data set if un-repairable. Critical elements are: Location as lat/lon, start date as month and day, and area burned in acres. These data checks will be implemented in MS Excel.
- The automated data completeness checks in MS Excel will be spot-checked for correct flagging. Filters will be applied to the fields being checked for completeness to confirm that the proper fields are being flagged. Also, records that are flagged as incomplete will be isolated and examined for correct flagging.

- Proper assignment of fuel loadings and consumption will be spot-checked for a selection of records for each fuel model type and for records where fuel loading was supplied explicitly.
- Emission factors will be checked for consistency by comparing the ratio between those values and ratios cited in the literature. (For instance, confirm the ratio of PM_{10} to $PM_{2.5}$ is reasonable.) Furthermore, the per-pollutant emission estimates for the entire inventory will be compared against these ratios. A selection of events will be spot-checked by following the raw data through to the end of the emission calculations (including fuel consumption) to ensure proper look-up tables are selected and that the emission calculation arithmetic and unit conversion are accurate.
- A number of GIS routines will be used to quality-control the temporally and spatially allocated fire activity data. The GIS routines will include:
    - Assign state and county Federal Information Processing Standards (FIPS) codes and time zones. Compare the summaries of the allocated data by state FIPS to state summaries of input data.
    - Summarize emissions allocated to the modeling grid cells (i.e., the WRAP Regional Modeling Center [RMC] grid system for dispersion modeling). Using GIS, map the emissions per grid cell and compare to mapped state summaries of input data.
    - Identify fires located in incongruous areas such as in water bodies, urban areas, or outside the WRAP Region.
- Checks will verify the accuracy of writing the fire event information in the database to export formats (PT files for input into the Sparse Matrix Operator Kernel Emissions [SMOKE] modeling system and National Emission Inventory 3.0 [NIF3.0]). NIF files will be checked for format accuracy using the EPA NIF QA Checker. For SMOKE files, the first page of every fixed width formatted file will be compared column for column to example files provided by the WRAP RMC. For both export formats, a custom QA script will be written to extract and summarize the number of events and $PM_{2.5}$ emissions reported. Those totals will be compared to the pollutant total in the emission inventory.

Quality Assurance of Baseline and Projection Inventories: Committee Review

The Project Team will circulate summaries of the baseline and projection inventories to the Committee for peer review. The Committee will perform "reality checks" for the representativeness and interstate consistency of the draft emission inventories. These tasks are in addition to Strawman review steps delineated in the Work Plan. Whereas technical Strawman development defines new methods to build an emission inventory, these QA techniques reality-check the resulting region-wide application. The quality assurance steps are as follows:

- Comparison and review of summary statistics (number of events, acres burned, fuel consumed, and emission estimates by state and month) of the baseline emission inventories for all fire sources.
- Review of gap-filling performed in any of the baseline emission inventories. The Project Team will circulate summary statistics (number of events, acres burned, fuel consumed, and emission estimates by state and month) of gap-filled data compared with quality-assured raw data.
- Comparison and review of summary statistics (number of events, acres burned, fuel consumed, and emission estimates by state and month) from one projection scenario to another (high, medium, and low).
- Comparison of total acres burned in the projection databases with the baseline databases to check for reasonable change in activity and emissions.
- Summarize by state the fuel loadings and emissions calculated to accommodate ERTs. Circulate these summaries to the Task Team for reasonableness.

Documentation and Records

All methodology references including citations, calculations, and assumptions will be documented in the final report. Electronic data will be maintained in clearly marked directories on project computers. The complete report and data package, consisting of report document and data spreadsheets, will be maintained on the Air Sciences' server computer with versions distributed for peer review and delivery. The Air Sciences project manager will be responsible for controlling revisions and corrections to the report and data package. Upon completion of the contract and final delivery, control of the report, emission inventory calculations, and emission inventory export files will transfer to the WRAP.

GROUP B: DATA GENERATION AND ACQUISITION

Not Applicable.

GROUP C: ASSESSMENT AND OVERSIGHT

Assessment and Response Actions

This project will be self-assessed for effectiveness of project implementation and associated QA and QC activities by the WRAP and contractor project management. Assessments of the technical systems and data quality will be made at each deliverable stage of the project including (1) Work Plan, (2) emissions inventory, and (3) final report. Corrective actions will be specified by the project managers and implemented by staff. Corrected deliverables will be subjected to another QA including peer review.

Reports to Management

See Assessment and Response Actions.

GROUP D: DATA VALIDATION AND USABILITY

Not Applicable.

APPENDIX B

Plume Profile

A plume profile tailored for fire will be assigned to each daily fire event in baseline and projection scenario emission inventories. The plume profile method in these Phase III and IV inventories will be the same as the method employed by the WRAP for the Phase II emission inventory. That method is described in this section. Figures illustrating this method are not included in this document for brevity but do appear in the draft final report entitled *2002 Fire Emission Inventory for the WRAP Region – Phase II*.

Normally, plume rise is predicted using hourly pyrotechnical and meteorological information. However, given the unique physical characteristics of wildland fire events and previous experience with dispersion models that indicated poor performance with regard to dispersing smoke plumes, the FEJF utilized expert opinion to assign plume characteristics to each fire event.

B1: Virtual Acres

Fires will be classified into size classes based on "virtual acreage." The virtual acreage is calculated by multiplying the actual fire size by the square root of the normalized pre-burn fuel loading (Equation B1). This is done in order to relate fuel loading to the characteristic "stack" diameter of the plume. Total fuel loading is normalized to 13.8 tons per acre for wildfire and 5.0 tons per acre for all other fire sources. The normalizer for wildfire is equal to the total surface loading plus a portion of the crown biomass of NFDRS fuel model U (western pines). The normalizer for all other fire sources is equal to the surface loading only of NFDRS fuel model U.

$$\text{Acreage}_{\text{virtual}} = \text{Acreage}_{\text{actual}} \cdot \sqrt{\text{Fuel Loading} \ / \ \text{Normalizer}} \qquad \textbf{Equation B1}$$

The plume profile for days added to model smoldering for the day after an original activity day is the same as for the original fire event. In the emission inventory, the smoldering events will retain the virtual acreage of the fire event they are created from, and thus the plume calculations will be identical.

B2: Diurnal Consumption

A diurnal fuel consumption table will be created to allocate daily fire emissions by hour. Table B1 shows the diurnal consumption for wildland fire (wildfire and prescribed burning, and Table B2 shows the diurnal consumption for agricultural and prescribed non-federal rangeland burning. The tables, consisting of a percent of fuel consumed for each hour of the day, summing to 100, will be submitted to the Air Quality Modeling Forum (and the WRAP's RMC). The diurnal fuel consumption tables will be implemented by the RMC within the SMOKE emissions processor to allocate daily emission estimates to hourly emissions.

Table B1: Wildland Fire Standard Diurnal Consumption Template Used to Distribute Total Heat Production and Emissions

Hour	1	2	3	4	5	6	7	8	9	10	11	12
% Per Hour	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	2.00	4.00	7.00

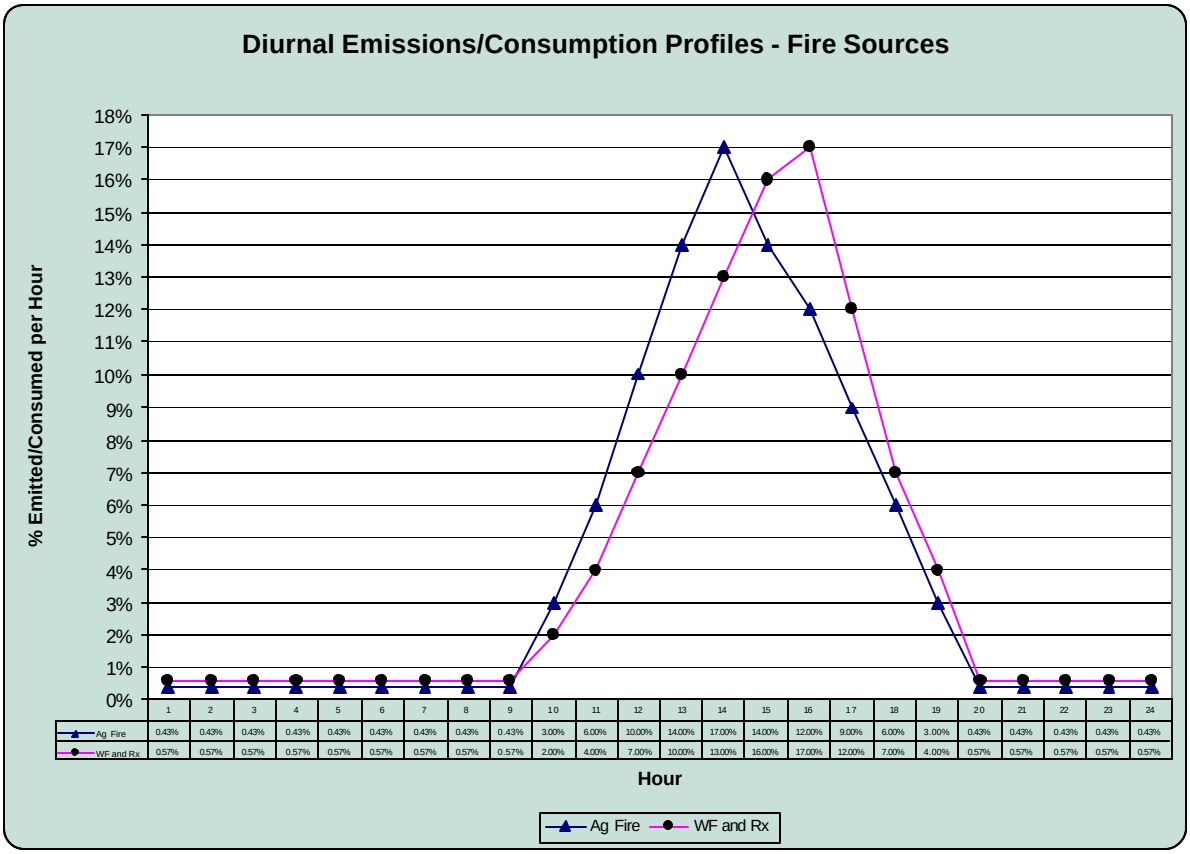
Hour	13	14	15	16	17	18	19	20	21	22	23	24
% Per Hour	10.00	13.00	16.00	17.00	12.00	7.00	4.00	0.57	0.57	0.57	0.57	0.57

Table B2: Agricultural and NFR Burning Standard Diurnal Consumption Template Used to Distribute Total Heat Production and Emissions

Hour	% Per Hour	Hour	% Per Hour
1	0.43	13	14.00
2	0.43	14	17.00
3	0.43	15	14.00
4	0.43	16	12.00
5	0.43	17	9.00
6	0.43	18	6.00
7	0.43	19	3.00
8	0.43	20	0.43
9	0.43	21	0.43
10	3.00	22	0.43
11	6.00	23	0.43
12	10.00	24	0.43

The diurnal consumption template in Table B2 varies from the template used for wildfire and prescribed fire in one important way: the daily emissions peak is moved to earlier in the day, largely due to the more consistent ignition times for agricultural fires (personal communication, Bryan Jenkins, UC Davis). The diurnal profiles for agricultural and non-federal rangeland burning and wildfire and prescribed fire are shown graphically in Figure B1.

Figure B1: Standard Diurnal Consumption Template Used to Distribute Total Heat Production and Emissions for Fire



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Ag Fire	0.43%	0.43%	0.43%	0.43%	0.43%	0.43%	0.43%	0.43%	0.43%	3.00%	6.00%	10.00%	14.00%	17.00%	14.00%	12.00%	9.00%	6.00%	3.00%	0.43%	0.43%	0.43%	0.43%	0.43%
WF and Rx	0.57%	0.57%	0.57%	0.57%	0.57%	0.57%	0.57%	0.57%	0.57%	2.00%	4.00%	7.00%	10.00%	13.00%	16.00%	17.00%	12.00%	7.00%	4.00%	0.57%	0.57%	0.57%	0.57%	0.57%

B3: Fire Size Classes and Plume Profile Calculations

Plume values include the top and bottom of the plume (Ptop and Pbot, respectively; both expressed in meters above ground elevation) and the percent of emissions entrained within the surface layer of the atmosphere (Lay1F), defined by the ETT of the FEJF as the first 38 meters above the ground. These three plume parameters are established and assigned for each of the 24 hours of each daily fire event. All of the plume values will be assigned based on the limited information available for each fire event, including fire size (fire area grown per day) and either a reported fuel loading or the NFDRS fuel model.

Five plume classes were defined with increasing potential plume heights to reflect the range of "heat release" possible in wildland fires (Table B3). Plume bottom heights and percent of the plume fumigated to the first layer of the atmosphere were also developed for the five plume classes. Using expert opinion and anecdotal evidence, a table of hourly buoyant efficiency values was derived (Table B4).

Table B3: Fire-Related Parameters as Function of Fire Size Classes

Class	1	2	3	4	5
Size (virtual acres)	0 – 10	>= 10 – 100	>= 100 – 1,000	>= 1,000 – 5,000	>= 5,000
BE_{size}	0.40	0.60	0.75	0.85	0.90
Ptop max (m)	160	2,400	6,400	7,200	8,000
Pbot max (m)	0	900	2,200	3,000	3,000

Table B4: Buoyant Efficiency as Function of Hour of Day

Hour	1	2	3	4	5	6	7	8	9	10	11	12
BE_{hour}	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.10	0.2	0.4

Hour	13	14	15	16	17	18	19	20	21	22	23	24
BE_{hour}	0.7	0.8	0.9	0.95	0.99	0.8	0.7	0.4	0.06	0.03	0.03	0.03

Equations will be used to calculate Ptop and Pbot as a function of time of day and size of the fire (expressed in terms of virtual acres). Note that the calculations will use an hourly value for buoyant efficiency (Table 4) and heat release value based on fire size, also referred to as normalized fire growth.

The hourly top of the plume will be calculated as follows:

$$\mathrm{Ptop}_{\mathrm{hour}} = \left(\mathrm{BE}_{\mathrm{hour}}\right)^2 * \left(\mathrm{BE}_{\mathrm{size}}\right)^2 * \mathrm{Ptop}_{\mathrm{max}} \qquad \textbf{Equation B2}$$

Where: BE is the buoyant efficiency looked up from the hourly or size class tables. The hourly bottom of plume will be similarly calculated as:

$$\mathrm{Pbot}_{\mathrm{hour}} = \left(\mathrm{BE}_{\mathrm{hour}}\right)^2 * \left(\mathrm{BE}_{\mathrm{size}}\right)^2 * \mathrm{Pbot}_{\mathrm{max}} \qquad \textbf{Equation B3}$$

Lastly, an equation will be used to calculate Lay1F, the proportion of emissions fumigated into the first atmospheric layer. Lay1F will be calculated as the arithmetic inverse of the hour-specific buoyant efficiency multiplied by the size-specific buoyant efficiency.

$$Lay1F_{hour} = 1 - \left(BE_{hour} * BE_{size}\right) \qquad \textbf{Equation B4}$$

Using Equations B1 through B4, the bottom and top of the atmospheric plume as well as the proportion of the plume fumigated into the first atmospheric surface layer will all be scaled to fire size, fuel loading (incorporated in virtual acres calculation), and hour of the day.