Session 1: Overview of NEPA Air Quality Analysis for Highway Projects

NEPA Law and Regulations

- National Environmental Policy Act of 1969
- Council on Environmental Quality NEPA regulations
  - 40 CFR 1500 – 1508
- FHWA/FTA joint NEPA and Environmental Impact regulations
  - 23 CFR 771
- All can be found on the FHWA Environmental Review Toolkit website
  - http://www.environment.fhwa.dot.gov/index.asp

FHWA's NEPA Documents are Environmental Compliance Documents

- Federal agencies must consider the environmental consequences of their actions
- FHWA uses NEPA to document compliance with all applicable environmental laws
- NEPA is the framework for interagency coordination
- NEPA is the framework for meaningful public involvement

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Key Elements of NEPA

- Purpose and Need
- Range of Reasonable Alternatives
- Impacts
- Mitigation
- Public Involvement and Interagency Coordination
- Documentation

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FHWA NEPA Process "Umbrella"

- We use the NEPA process to identify all of the applicable environmental laws and how we will comply with them; partial list:
  - Economic, Social, and Environmental Effects (23 USC 109(h)) analysis
  - Public involvement, interagency coordination
  - Tribal consultation
  - Location, design, and engineering
  - Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970
  - Noise Standards
  - Public Hearing Requirements
  - Americans with Disabilities Act
  - Endangered Species Act – Section 7
  - Civil Rights Act
  - Executive Order 12898 (Environmental Justice)
  - Section 4(f) of USDOT Act (49 USC 303) - Parks, recreation, etc.
  - **Clean Air Act**
  - Safe Water Drinking Act
  - Clean Water Act 404(b)(1)
  - Farmland Protection Policy Act
  - National Historic Preservation Act
  - Floodplains

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NEPA Air Quality Analysis

- Components (not all are completed for every project):
  - Information on the NAAQS (table)
  - Description of existing conditions (air quality, meteorology)
  - Status of State Implementation Plans for the area
  - Comparison of corridor emissions for no-action and build alternatives (qualitative or quantitative inventory analysis)
  - Microscale analysis (CO and/or PM; qualitative or quantitative)
  - Qualitative or quantitative analysis of mobile source air toxics
  - Qualitative or quantitative analysis of GHGs
  - Cumulative/indirect effects analysis
  - Mitigation

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Technical Analysis for NEPA: Applicability

- Inventory analysis (criteria pollutants: CO, PM, ozone precursors)
  - Not required by any guidance, but often completed for large projects
- Microscale analysis for CO
  - 1987 TA: CO hotspot modeling recommended for large projects
- Qualitative or quantitative analysis of mobile source air toxics
  - Required by FHWA guidance (more later)

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Technical Analysis for Conformity: Applicability

- Transportation conformity rule hot-spot requirements apply in nonattainment and maintenance areas for CO, PM10/2.5
- If the area is nonattainment/maintenance for multiple pollutants, multiple analyses may be needed
- No hot-spot or other analysis is required at the project level for ozone
- Conformity determination required prior to NEPA process completion (CatEx, FONSI, ROD)

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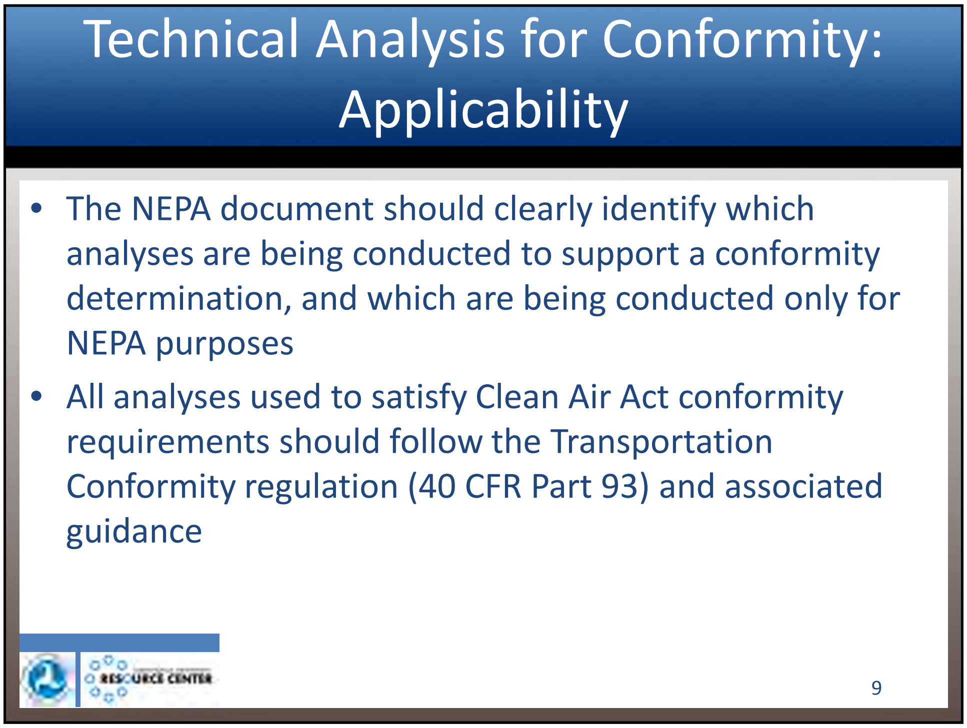
Technical Analysis for Conformity: Applicability
• The NEPA document should clearly identify which analyses are being conducted to support a conformity determination, and which are being conducted only for NEPA purposes
• All analyses used to satisfy Clean Air Act conformity requirements should follow the Transportation Conformity regulation (40 CFR Part 93) and associated guidance
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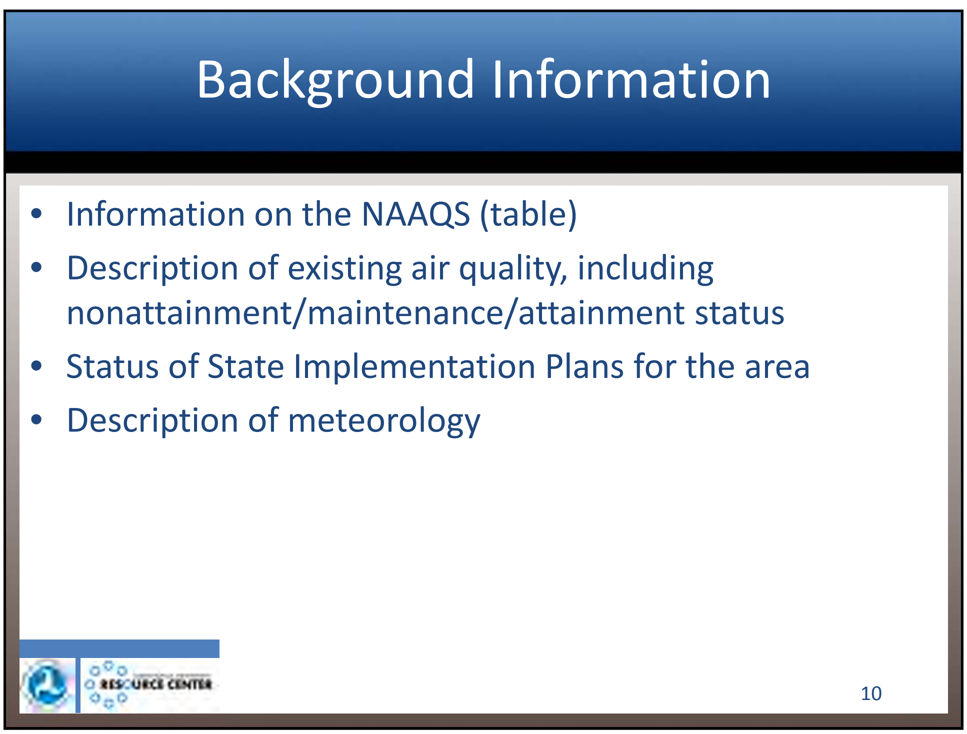
Background Information
• Information on the NAAQS (table)
• Description of existing air quality, including nonattainment/maintenance/attainment status
• Status of State Implementation Plans for the area
• Description of meteorology
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Emissions Inventory

- Many large projects include an inventory analysis in the NEPA document, which is a corridor-level emissions analysis
  - Required for MSATs for some projects, sometimes also done for criteria pollutants
- Example:

Pollutant Emissions (tons/day) Resulting from the Proposed Project

Pollutant	2012 Baseline	2017 No-Action	2017 Alt A	2017 Alt B	2037 No-Action	2037 Alt A	2037 Alt B
CO							
VOC							
NOx							
PM10							
Benzene							
Butadiene							
Acrolein							
. . .							

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Reference Materials for NEPA Air Quality Analysis

- "Discussion Paper on the Appropriate Level of Air Quality Analysis for a CE, EA/FONSI and EIS," April 7, 1986
- Air Quality section of 1987 Technical Advisory
- December 2012 Interim MSAT Guidance (update of 2006 and 2009 guidance)
- FHWA Environmental Guidebook:
  - http://environment.fhwa.dot.gov/guidebook/index.asp

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Hot-Spot Analysis for Transportation Conformity

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Project Level Conformity – General

- Project-level conformity analyses and hot-spot analysis documentation often appear in the environmental document
  - Meeting transportation conformity requirements is a very involved process which will not be covered in detail in this course
- Training on project-level conformity is available at:
  - http://www.fhwa.dot.gov/environment/air_quality/conformity/training/

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Project Level Conformity – General

- The Clean Air Act prohibits the Federal government from approving or funding any activity (including transportation projects) which does not conform to State Implementation Plan
- Conformity applies in nonattainment and maintenance areas for the transportation-related NAAQS
- These areas are designated by EPA, and listed on EPA's Green Book web site:
  - www.epa.gov/oar/oaqps/greenbk/

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General Project-Level Conformity Requirements

- The project comes from a conforming plan and TIP
  - Including any necessary written commitments for project-level emissions mitigation or control measures (any included in TIP project design concept and scope)
- The design concept and scope have not changed significantly since the conformity finding regarding the plan and TIP from which the project derived
- Analyses use latest planning assumptions and latest emissions model

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40 CFR §93.114-117

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General Project-Level Conformity Requirements

- Includes a hot-spot analysis in CO and PM nonattainment and maintenance areas, if required
- Compliance with control measures in PM SIP

40 CFR §93.114-117

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Hot-Spot Analysis for Conformity

- Required for Federal nonexempt projects in CO, PM2.5, and PM10 nonattainment and maintenance areas
  - applicability depends on type of project
- EPA quantitative hot-spot guidance
  - Guidance for use of MOVES2010b in CO hotspot analysis issued December 2010
  - PM hotspot guidance updated November 2013
  - MOVES model required for quantitative PM and CO hot-spot analyses begun after 12/20/12

www.epa.gov/otaq/stateresources/transconf/projectlevel-hotspot.htm

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What Projects are Subject to CO Hot-spot Analysis?

- Modeling required for:
  - Projects that impact a location identified in the SIP as a site of actual or possible violations
  - Projects that affect intersections that are or will be LOS D or worse
  - Projects affecting one of the 3 worst intersections in the area in terms of traffic volume or LOS
- Qualitative analysis required for all other projects

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Categorical Hot-spot Finding for CO

- Modeling conducted by U.S. DOT that shows particular category of highway or transit projects will not cause or contribute to new or worsened local violations
- Potential for project sponsor to streamline meeting the CO hot-spot requirements, since no additional quantitative hot-spot modeling would be required
  - Compare project to scenarios modeled by U.S. DOT to see if it is covered by the categorical finding
  - www.fhwa.dot.gov/environment/air_quality/conformity/policy_and_guidance/cmcf/hotspot_finding.cfm

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Categorical Hot-spot Finding for CO

- A project-level conformity determination is still required
  - A categorical hot-spot finding is not an "exemption" from conformity itself, just hot-spot modeling
- Only applies for conformity, not for NEPA CO modeling

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What Projects are Subject to PM Hot-spot Analysis?

- Projects of Air Quality Concern are . . .
  - i. New highway projects that have a significant number of diesel vehicles, or expanded highways with a significant increase in diesel vehicles;
  - ii. Projects affecting intersections at LOS D, E, or F with a significant number of diesel vehicles, or those that will change to LOS D, E, or F because of increased traffic volume from a significant number of diesel vehicles related to the project;
  - iii. New bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location;

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40 CFR §93.123(b)(1)

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What Projects are Subject to PM Hot-spot Analysis?

- Projects of Air Quality Concern are . . .
  - iv. Expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location; and
  - v. Projects in or affecting locations, areas, or categories of sites which are identified in the PM10 or PM2.5 applicable implementation plan or implementation plan submission as appropriate, as sites of violation or possible violation

40 CFR §93.123(b)(1)

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More Resources for Conformity

- FHWA conformity web site:
  - http://www.fhwa.dot.gov/environment/air_quality/conformity/
- Regulations and guidance
- On-demand training
- Examples of conformity practices
- Nonattainment area maps
- Conformity Highlights newsletter

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Mobile Source Air Toxics (MSATs)

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Mobile Source Air Toxics (MSATs)

- The 1990 Clean Air Act Amendments mandates EPA to regulate 188 hazardous air pollutants (HAPs)
- In 2001 and 2007 rulemakings, EPA identified a subset of these that come from mobile sources (MSATs)
- 7 MSATs account for most of the adverse health effects:

Benzene	Naphthalene
1,3-Butadiene	Formaldehyde
Diesel Particulate Matter	Acrolein
Polycyclic Organic Matter	

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Health Impacts of MSATs

- While the science is evolving, regulatory agencies are concerned about MSAT exposure
- The 7 major MSATs are known or suspected carcinogens, and can have other adverse health impacts as well
- Benzene (a known carcinogen) and diesel particulate matter are viewed as especially harmful
- No NAAQS for MSATs, but advisory standards for some pollutants exist

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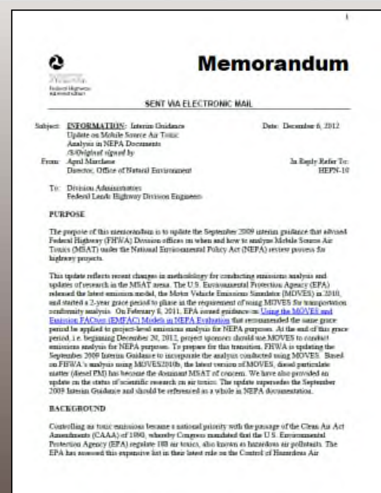
MSAT Interim Guidance Update (2012)

- http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/aqintguidmem.cfm



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MSAT Interim Guidance Update (2012)

- Guidance update to address MOVES and newer research
  - Diesel Particulate Matter dominates when MSATs modeled with MOVES
    - was benzene under MOBILE6.2
  - Research updates
  - Updates to Appendix C
    - language addressing CEQ Regulation 1502.22

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FHWA MSAT Guidance Approach

- FHWA has developed a tiered approach for analyzing MSAT emissions in NEPA documents:
  - No analysis for projects with no potential for meaningful MSAT effects;
  - Qualitative analysis for projects with low potential MSAT effects; or
  - Quantitative analysis to differentiate alternatives for projects with higher potential MSAT effects

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Exempt Projects

- No analysis is necessary
- Document in the project record that the project does not need an MSAT analysis because it qualifies as:
  - A categorical exclusion under 23 CFR §771.117(c);
  - Exempt from conformity under 40 CFR §93.126; or
  - Will have no meaningful impacts on traffic volumes or vehicle mix
- Prototype language provided in Appendix A of the Guidance

Screening Thresholds for Quantitative Analysis

- Quantitative emissions analysis is recommended for projects that
  1) Involve new or additional capacity on roadways where the traffic volume will be 140,000-150,000 AADT (or higher) in the design year, or
  2) Create or significantly alter an intermodal freight facility that generates high levels of diesel particulate emissions in a single location
- AND
  - are in proximity to populated areas, or in rural areas, in proximity to vulnerable populations (near schools, nursing homes, hospitals)

Qualitative Analysis for Projects with Low Potential MSAT Effects

- The NEPA document should include a qualitative discussion of project-specific factors that could affect MSAT emissions and exposure
- Example language for different types of projects is included in Appendix B of guidance;
  - ***This language needs to be tailored to account for the unique characteristics and impacts of each project***

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Quantitative Analysis for Projects with Higher Potential MSAT Impacts

- Emissions analysis at the study area/corridor level using MOVES
- Analyze emissions of the 7 priority MSATs for base year (current conditions) and future no-action and build alternatives
- RC and HQ staff can provide technical guidance on project-specific methodologies

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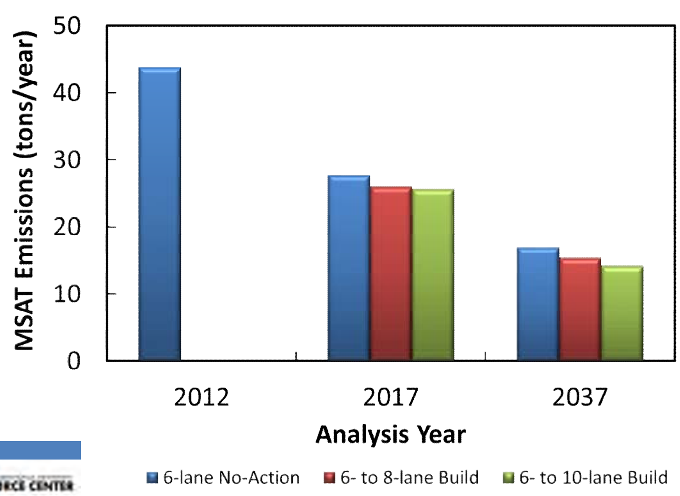
Quantitative Analysis for Projects with Higher Potential MSAT Impacts

- FHWA is developing FAQ's on quantitative MSAT analysis with MOVES, including:
  - How to set up MOVES runs
  - Necessary types and sources of input data
  - Working with MOVES output
  - Troubleshooting and data management tips
- The MSAT session in this course covers the same topics

Predicted Changes in MSAT Emissions: Example



Mitigation

- If meaningful differences in emissions identified between alternatives, evaluate and consider mitigation
- Possible mitigation options:
  - Cleaner (newer) construction equipment
  - Retrofit of construction equipment/cleaner fuels
  - Alternative fuels (propane, biodiesel)
  - School bus retrofit
  - Truck stop electrification
  - Anti-idling ordinances

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CEQ Regulation 1502.22: Incomplete or Unavailable Information

- Covers situations where an agency's ability to evaluate reasonably foreseeable significant adverse impacts is affected by incomplete or unavailable information
- Air toxics is an emerging field, and many necessary tools and data are missing or incomplete
  - In cases like this, 1502.22 requires:
    - statement that information is incomplete or unavailable
    - statement of the relevance of the information
    - summary of existing credible scientific information
    - our evaluation of impacts

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CEQ Regulation 1502.22: Incomplete or Unavailable Information

- Template language is provided for this discussion in Appendix C of the FHWA guidance
  - ***Needs to be tailored for each project***

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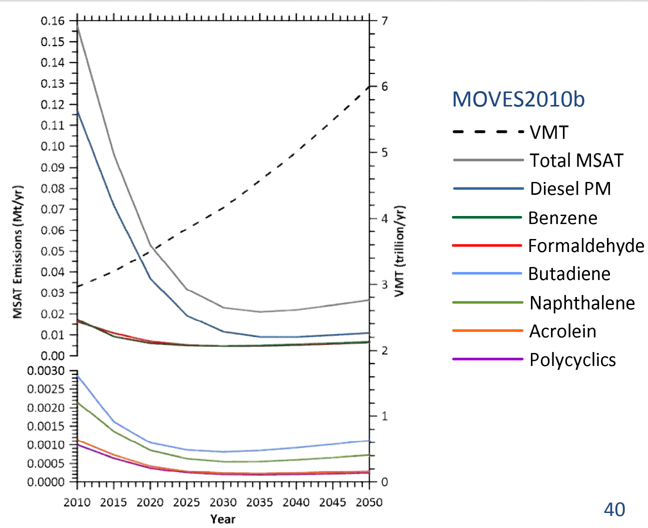
National MSAT Emission Trends for Vehicles Operating on Roadways



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Other Issues Raised in NEPA

- Health Risk Assessment/Health Impact Assessment/ Children's Health
- Climate Change/Greenhouse Gas Emissions

Air Quality Health Issues Raised in NEPA

- As part of comments on NEPA documents, FHWA often receives requests for analysis that go beyond our guidance. These include:
  - Health Risk Assessment
  - Health Impact Assessment
  - Children's Health Assessment

Air Quality Health Issues Raised in NEPA

- FHWA has not conducted more advanced forms of air quality health risk assessment for several reasons:
  1) Research available to FHWA suggests low health risk from MSATs
     - Project-specific MSAT risk assessments, NCHRP research studies, and EPA rulemaking support documents have all identified risks well below EPA's 100-in-a-million action level, and closer to EPA's 1-in-a-million "negligible" level
     - Health risk from MSATs is hundreds of times lower than health risk from injury or fatality traffic accidents

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Air Quality Health Issues Raised in NEPA

2) Health risk is declining regardless of FHWA decisions on project alternatives
   - EPA's fuel and vehicle emissions control programs are producing reductions in emissions (and health risk) that are far larger than project impacts (emissions decline regardless of which alternative is selected)
3) Congestion relief projects can provide reductions in MSAT health risk for motorists
   - Higher speeds reduce MSAT emissions rates
   - Higher speeds also reduce the amount of time motorists are on roadways in traffic, where MSAT concentrations are the highest

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Air Quality Health Issues Raised in NEPA

4) MSAT emissions analysis under FHWA's guidance provides tangible information on likely health impacts, without uncertainty of risk-based approaches
   - Limitations on toxicity information and assumptions made in risk-based assessments result in uncertainties spanning two orders of magnitude or more, far larger than the traffic and emissions changes associated with projects
5) FHWA NEPA documents also address the NAAQS, which are required by law to protect public health with an adequate margin of safety; if analyses demonstrate no violations of the NAAQS, health impacts would not be expected from those pollutants

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Air Quality Health Issues Raised in NEPA

6) CEQ regulations regarding the content of NEPA documents suggests that risk assessments are not appropriate for NEPA
   - "High quality information, accurate scientific analysis": MSAT HRA approaches involve large assumptions and uncertainties that overwhelm the influence of projects
   - "Concentrate on issues significant to the action in question, avoid amassing needless detail": MSAT emissions (and health risk) are declining regardless of which alternative is chosen
   - "Documents should be analytic rather than encyclopedic, no longer than absolutely necessary": MSAT emissions analysis provides adequate information for the public and decision-maker to see which alternative is "better" from an MSAT standpoint, without relying on more involved but more uncertain analysis approaches

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Climate Change in NEPA

- Multiple aspects:
  1) Impact of the project on climate (greenhouse gas emissions impacts of the proposed project)
  2) Impact of climate change on the proposed project
     a) Direct impacts of future climate on infrastructure
     b) Cumulative effects of the project and future climate on the affected environment

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GHG Emissions Analysis in NEPA: Current State of Affairs

- CEQ issued draft guidance (twice), never finalized
- FHWA does not have formal guidance
- Some states have state-level guidance
- Some EPA Regions have coordinated with FHWA Divisions on methods
- Case-by-case on projects in other areas

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No FHWA Requirement for a GHG Emissions Analysis

- No national standards
- No EPA thresholds
- Climate impacts are global, not measurable
- Focus on issues that are significant and meaningful for decision-making
- Best addressed at the planning and programmatic level

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Draft CEQ Climate Change in NEPA Guidance

- Issued February 18, 2010, reissued December 24, 1014
- Recommends that federal agencies address GHG emissions impacts of proposed actions where the analysis would "provide meaningful information to decision-makers"
- Recommends consideration of potential impacts of future climate change on proposed actions
- No set timeframe for final guidance

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Draft CEQ Guidance: Greenhouse Gas Analysis

- Analyze GHG emissions if agency has determined that an analysis is appropriate
- Quantify direct, indirect, and cumulative emissions over life of the project
- Use interagency consultation to determine best procedures for evaluation
- Programmatic approaches may be accommodated (FHWA's preference)

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Draft CEQ Guidance: When to Analyze GHG Emissions

- EA and EIS with direct emissions of 25,000 metric tons per year
- Roughly a VMT increase of 190,000 miles per day
  - Based on 2035 GHG running emissions rates, not including construction emissions
- Direct emissions would probably also include construction and tailpipe emissions

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When has CC been addressed in NEPA?

- When the state or local jurisdiction has a requirement
- When you've worked something out with your EPA Region
- When there is strong interest identified in scoping and/or comments

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What Might I Include?

- Documentation of a state required analysis
- Reference to an analysis done at the planning level and/or
- Qualitative analysis and discussion

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Example Framework for GHG Qualitative Analysis and Discussion

- Note that climate change is an important concern
- Include description of why GHGs from project aren't significant
- Table showing statewide and project emissions potential compared to global totals

Analysis Year	Global CO_2 Emissions (MMT)	State-wide Motor Vehicle CO_2 Emissions (MMT)	(% of Global)	Project Area VMT (% of State-wide VMT)	Percent change in State-wide VMT due to Project
Current Conditions (2012)	29,670	29.3	0.0986%	19.0%	(None)
Future Projection (2037)	42,380	37.4	0.0883%	18.6%	0.876%

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Example Framework for GHG Qualitative Analysis and Discussion

- Description of expected GHG emissions direction as a result of implementing the project, such as:
  - Federal actions to reduce transportation GHG emissions including NHTSA fuel economy/GHG emissions standards
  - State/local actions to reduce transportation GHG emissions
  - Project elements to reduce GHG emissions

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Climate Change Impacts/ Adaptation: National Policy

- DOT Sustainability Strategic Plan (not specific to NEPA), developed pursuant to EO 13514
- DOT Policy Statement on Climate Change Adaptation:
  - www.fhwa.dot.gov/environment/climate_change/adaptation/policy_and_guidance/usdot.cfm
- EO 13653, "Preparing the United States for the Impacts of Climate Change"
- No FHWA NEPA guidance or requirements at this time

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Why Consider Climate Change *Effects* During Project Development?

- **Direct impacts** on transportation infrastructure
- **Cumulative impacts** of transportation projects on an environment vulnerable to the effects of climate change

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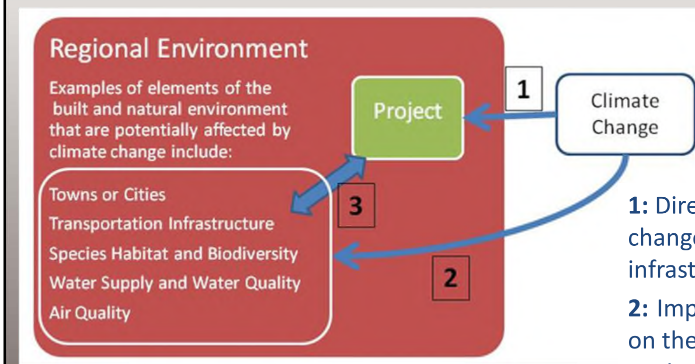
Climate Change Effects in Project Development



1: Direct impacts of climate change on transportation infrastructure

2: Impacts of climate change on the natural and built environment

3: Cumulative impacts of the project and climate change on the environment

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Resources: GHG Analysis

- FHWA HQ and Resource Center staff can provide assistance with GHG emissions analysis
- GHG analysis in both planning and NEPA:
  - SHRP2-C09 "Practitioners Handbook" available at www.trb.org/Main/Blurbs/166940.aspx
- Tailpipe emissions:
  - MOVES can be used (EPA has issued guidance, and FHWA can also provide lookup tables of emissions rates)

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Resources: GHG Analysis

- Construction emissions:
  - FHWA Infrastructure Carbon Estimator tool available at www.fhwa.dot.gov/environment/climate_change/mitigation/publications_and_tools/carbon_estimator/index.cfm

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Resources: Vulnerability Assessment/Adaptation

- FHWA HQ staff can provide assistance with climate vulnerability and adaptation considerations
- NCHRP Report 750, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Chapter 6 addresses project development
  - www.trb.org/Publications/PubsNCHRPProjectReports.aspx
- FHWA Vulnerability Assessment Framework, NEPA Adaptation Case Studies
  - www.fhwa.dot.gov/environment/climate_change/adaptation/

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Documenting NEPA Air Analysis

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Information that is Needed in the Text of the Document

- Affected environment (emphasis on "affected")
- Summary of the results of the AQ analyses
- Project-level conformity documentation (if applicable)
- MSAT 1502.22 language on incomplete or unavailable information
  - Appendix C of MSAT guidance
- Language on climate change and GHG emissions
  - if requested by reviewing attorney

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Information that Should be in an Air Quality Technical Report

- More detailed background information (if desired)
- Summary of traffic data used in analyses
  - VMT and speed by alternative
- Detail on emissions and/or dispersion modeling analyses
  - put tables of results here, not in the text of the document
- Full documentation of project-level analyses conducted for NEPA and hot-spot analyses conducted for conformity

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Electronically-Available Information

- MOVES input and output files
- Emissions calculation spreadsheets
- Dispersion model input and output files

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Session 2: Using MOVES for Quantitative MSAT Analyses

Session Outline

- Introduction to using MOVES at the County scale for quantitative project-level MSAT analysis
- Developing a County scale MOVES RunSpec
  - Building a county-scale MOVES RunSpec to produce an emissions inventory, including recommendations for each panel
- Entering data using the County Data Manager (CDM)
  - What is the CDM and how does it work?
  - Description/recommendations for each table in the MOVES input database
- Running MOVES (Executing the RunSpec)
  - Class exercise: Run MOVES for the MSAT inventory scenario

Important Disclaimer

- This session describes use of MOVES for NEPA MSAT analysis, NOT how to use MOVES for regional or project-level conformity analysis!
- For conformity applications of MOVES, refer to the applicable guidance and training materials on EPA's MOVES web site

3

General Approach for Using MOVES for NEPA Air Quality Analysis

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1) Start with a Plan

- What type(s) of analysis do I need for my NEPA document (emission inventory, hotspot for conformity, or both)?
- What pollutants am I modeling?
- What years and seasons am I modeling?
- What inputs do I need?
- What inputs vary by year? By season? By time of day? By alternative (No Action and Build)?
- What traffic and other data do I need to develop the inputs?

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2) Get organized

Framework for Hwy XX emissions analysis	
Pollutants:	MSATs (the 7 listed in guidance) GHGs (CO_2, CH_4, N_2O)
Analysis years:	2015 base year, 2018 first year of operation, 2038 design year for No Action and Build alternatives
Seasons:	All 12 months
Note: This is just an illustrative example; for a real project, these parameters are decided, in part, through discussions with the project team	

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2) Get organized

Inputs needed for Hwy XX emissions analysis		
Input*	**Aspect**	**Source**
Age distribution	Same for all runs	MPO
Meteorology	Same for all runs	State Air Agency
I/M, fuels	Same for all alternatives, differ by year, fuels vary by season	State Air Agency
VMT, speed, road type distribution, ramp fraction	Unique for each run	Project traffic modeling
Day and month VMT fractions	Same for all runs	State DOT
Hour VMT fractions	Same for all runs	MPO
*Inputs explained in detail later		

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3) Develop master checklist of inputs for each run

2018-NoAction-Winter emissions analysis run	
Input	**Spreadsheet file**
Age distribution	Age_allruns.xls
Meteorology	Met_fullyear_allruns.xls
I/M	IM_2018.xls
Fuel supply	Fuel_2018_winter.xls
VMT	VMT_2018_NoAction.xls
Speed	Speed_2018_NoAction.xls
Road type distribution	Roadtypedist_2018_NA.xls
Ramp fraction	Ramps_2018_NA.xls
Month VMT fractions	MonthVMT_allruns.xls
Day VMT fractions	DayVMT_allruns.xls
Hour VMT fractions	HourVMT_2018.xls

4) Check with the project team and get feedback on the approach

- Does it address the concepts that were discussed in the original project team meeting?
- Will it satisfy applicable requirements for NEPA and MSAT analysis?
- Do the proposed MOVES inputs adequately characterize the effects of the project alternatives on travel?
- It's always better to answer these questions before a lot of MOVES work is completed, instead of redoing work later
- Can also use this opportunity to request and define necessary input data from project team members

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5) Develop and QA input spreadsheets

- Develop a set of spreadsheet inputs for one MOVES run
- Create the necessary RunSpec, and import the inputs using the County Data Manager for emissions analysis
  - Label run as a Test run to avoid later confusion
- Find and resolve any error messages from the CDM
- Execute the RunSpec and QA the output
- For this run, specify extra detail in Output Emissions Detail
  - getting output by process, sourcetype, fueltype, roadtype can help in troubleshooting problems

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5) Develop and QA input spreadsheets

- Are all pollutants, processes, road types, etc. that you requested in the RunSpec included in the output?
  - Get "0" for any emissions?
  - Distance outputs agree with VMT inputs?
- If everything looks OK, then develop the spreadsheet inputs for the remainder of the runs

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5) Develop and QA input spreadsheets

- Reality check on spreadsheets and raw data:
  - Related spreadsheets should each have the same number of rows and file size
  - Check that distributions that should sum to one, do sum to one
  - Does VMT really triple between No Action and Build
  - Is Build lower than No Action even though you're adding lanes?
  - Is 30% of traffic really moving at 2.5 mph?
  - Do we really have motorcycle VMT in the winter, or twice as much truck VMT as car VMT?

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6) QA and interpret output

- Check file size and # of rows in output—related runs should have the same size output
- Check for and investigate cases where emissions = 0
- Emissions trends make sense? Any obvious outliers?
- Can you explain why emissions between alternatives are different?
  - You'll probably be asked, especially if the build alternatives are much lower than No Action

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Working with output

- Test runs should have a lot of detail for troubleshooting
- Actual runs should distinguish emissions by road type; additional detail may be useful for troubleshooting or interpreting results, but add to the size of output:
  - Emissions Process—increases output by a factor of 2+
  - Sourcetype—factor of 13
  - Fueltype—factor of 2 or 3
  - Model year—factor of 31
- Can use Summary Reporter to condense detailed output, or use MySQL Query Browser and export to Excel

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Use the latest version of MOVES

- Update to the newest version posted on EPA's web site before starting the analysis
- Usually, RunSpecs and input databases prepared with older versions of the model are not fully compatible with the latest version
- Reviewing agencies will have the newest version installed, and may not be able to check your work or provide troubleshooting assistance if your runs are based on an older version

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MOVES Updates/Grace Period

- When EPA releases a major revision to MOVES, a grace period is typically established
  - Grace period for MOVES2014 transition is two years
  - Analyses started with a previous version of MOVES (MOVES2010/a/b) can be completed with that version, within certain constraints
- If you plan to complete an ongoing analysis with an older version of MOVES, ensure that reviewing agencies are aware of this and maintain capability to conduct reviews and provide assistance based on the older version

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Using MOVES at the County Scale: Introduction

- "County scale" does not refer to a geographic scale, but a method of operating MOVES
  - "National" scale—MOVES uses national default input data
  - "Project" scale—MOVES requires link-level input data
- Area-specific data must be entered when the County scale is selected
- Local data should be used for most inputs; access to default data is limited at the County scale
- Data can be exported or imported with the County Data Manager (CDM)

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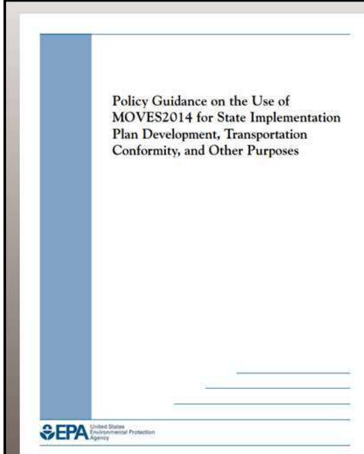
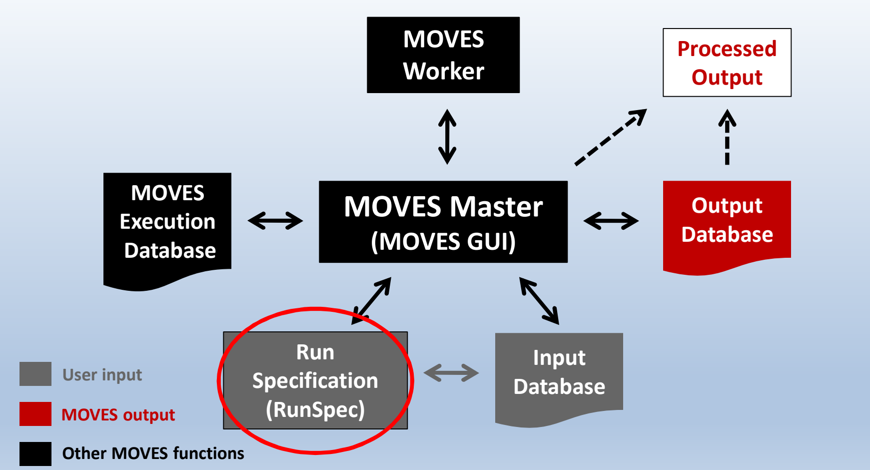
MOVES Technical Guidance


Policy Guidance on the Use of MOVES2014 for State Implementation Plan Development, Transportation Conformity, and Other Purposes

- Key source of guidance on use of local inputs and defaults
- Some input advice is presented in this course, but refer to Technical Guidance for more detail
- Posted on EPA's MOVES web site: www.epa.gov/otaq/models/moves/index.htm
- Section 2.3.3 of the MOVES User Guide is a basic reference for use of the County Data Manager

Building a County-scale Inventory RunSpec

MOVES Structure: RunSpec



Exercise Objectives

- Hands-on practice building a RunSpec and entering data for a county-scale MSAT emissions inventory run
- Exercise scenario is intentionally simplified to facilitate learning, limit complexity, and reduce MOVES run time
  - Pollutants, timeframes and vehicle types are limited compared to a real-world MSAT analysis
  - Should not be used as a complete template for a County scale run using MOVES for MSAT analysis

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Scenario Description

- Modeling one county: Cobb County, Georgia
- Typical day in 2035
  - Will select month of July and model only "weekday" days, all hours to represent this typical day
  - Normally, the entire year would be covered by the modeling
- Subset of vehicle types
  - Diesel fuel and gasoline passenger cars and passenger trucks
  - Diesel fuel combination long-haul trucks
  - Normally, all vehicle types would be selected

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Scenario Description (cont’d)

- All road types
  - Urban restricted and unrestricted
  - Rural restricted and unrestricted
- Benzene
  - Running Exhaust and Crankcase Running Exhaust
  - One MSAT (benzene) plus the required pollutant chains (VOC, NMH, THC) selected for training purposes
  - More pollutants would need to be modeled for a quantitative MSAT analysis

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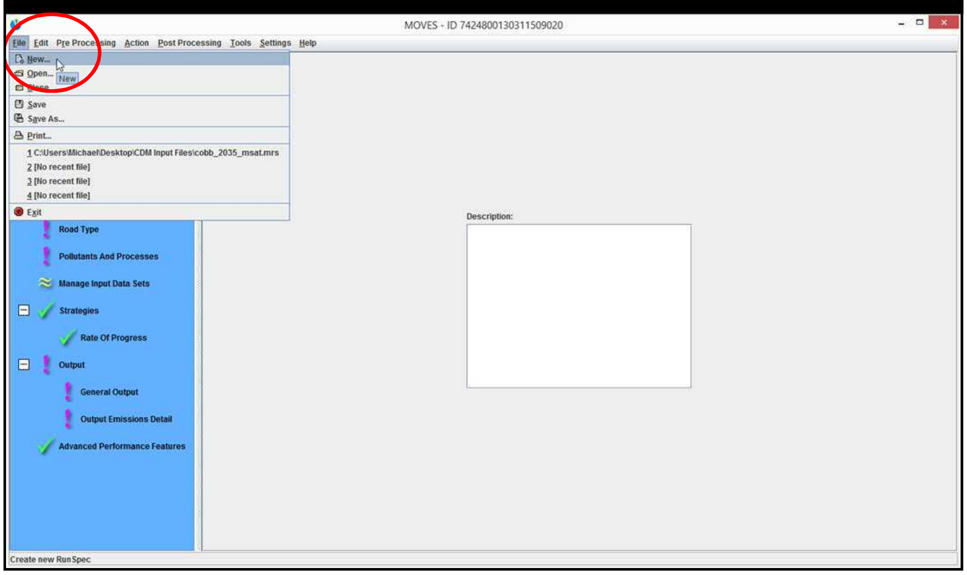
Starting MOVES: File, New RunSpec



Developing a RunSpec: County-scale Specifics

- Set up the entire RunSpec file first before the county inputs are added
  - This enables the County Data Manager (CDM) to filter the default database for relevant information
  - CDM also conducts error-checks on imported data based on selections made in the RunSpec
  - Output database must be identified to store the results
- The RunSpec can only have
  - A single county (or custom domain) selected
  - A single calendar year selected

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Developing a RunSpec: County-scale Specifics

- A County input database with local inputs must be provided
  - Can be created/populated with CDM – more later

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Description Panel

- The Description Panel allows the user to detail what the RunSpec being constructed will model
  - Up to 5,000 characters of text, but no quote, ampersand or backslash characters allowed
- IMPORTANT: Use the Description panel to describe the scenario being modeled, so you know later what that run represents!!
  - The Description entered will appear in the MOVESRun table of the output database
- Instructions: Type “Cobb County – MSAT Training RunSpec”

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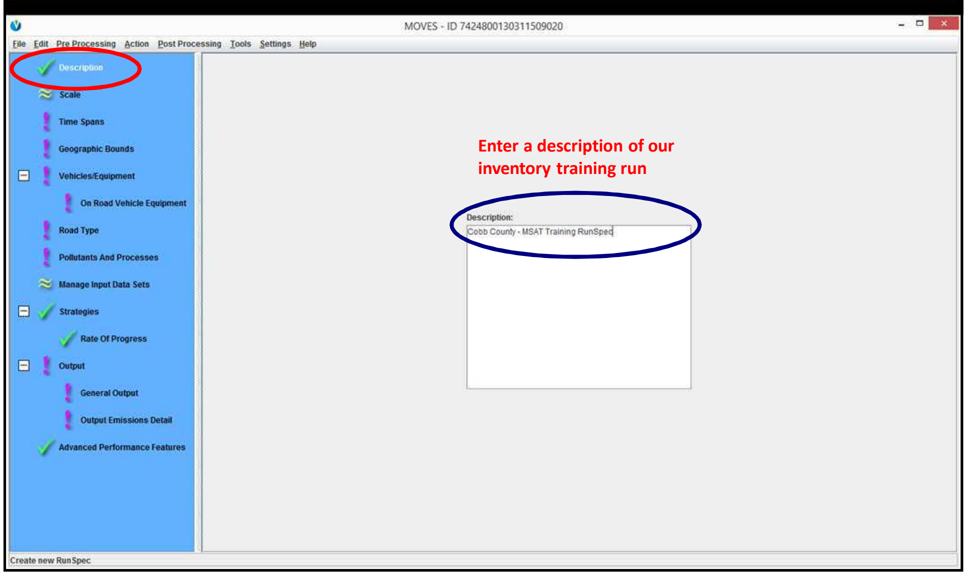
Description Panel



Selecting Scale

- MOVES2014 can model both Onroad and Nonroad sources; FHWA MSAT analyses include only Onroad emissions
- County scale must be used for SIPs or transportation conformity analyses; FHWA recommends it for MSAT analysis
  - National scale relies on national defaults and allocation factors that are not appropriate for regulatory purposes, and may not be valid for the project
  - National scale can be used for GHG analysis
- Instructions: Select Onroad, County

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Calculation Type

- Either Inventory or Emission Rates options may be used for MSAT analyses
  - Pros and cons of Rates approach discussed later in this course
  - Best to use the same approach when comparing two or more cases
    - Base year and design year
    - Different project alternatives
- Instructions: Select Inventory

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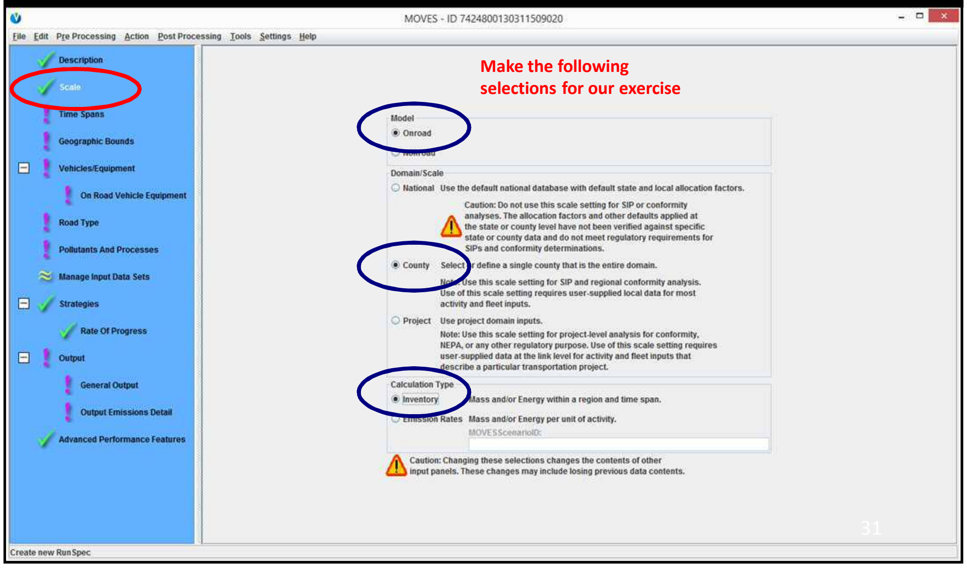
Scale Panel



Time Spans Panel

- MSAT analyses need to reflect long-term exposure
- Selections:
  - Time Aggregation Level should be set to Hour
  - All months, days, hours should be selected
    - As an option, can model 4 months to represent the seasons, instead of all 12; still need all days and hours
    - Will require post-processing to get annual emissions
  - Only one calendar year can be selected per run
    - Baseline/existing year
    - Design year
    - First year of operation (recommended)

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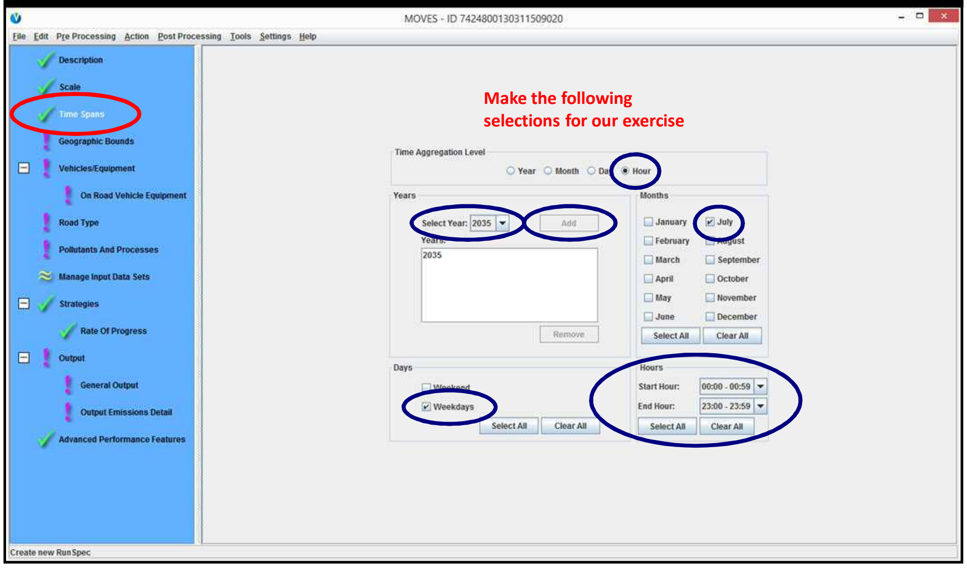
Time Spans Panel



Geographic Bounds Panel

- Select the county where the project is located
  - If the project spans more than one county, choose the most representative one, or construct a Custom Domain
- Choosing a county allows access to the available default data stored for that county
- The Enter/Edit Data button in the Domain Input Database portion of the panel opens the County Data Manager
  - A County database must be created or selected to store the county specific data (done later)
- Will show ✓ after County database has been provided

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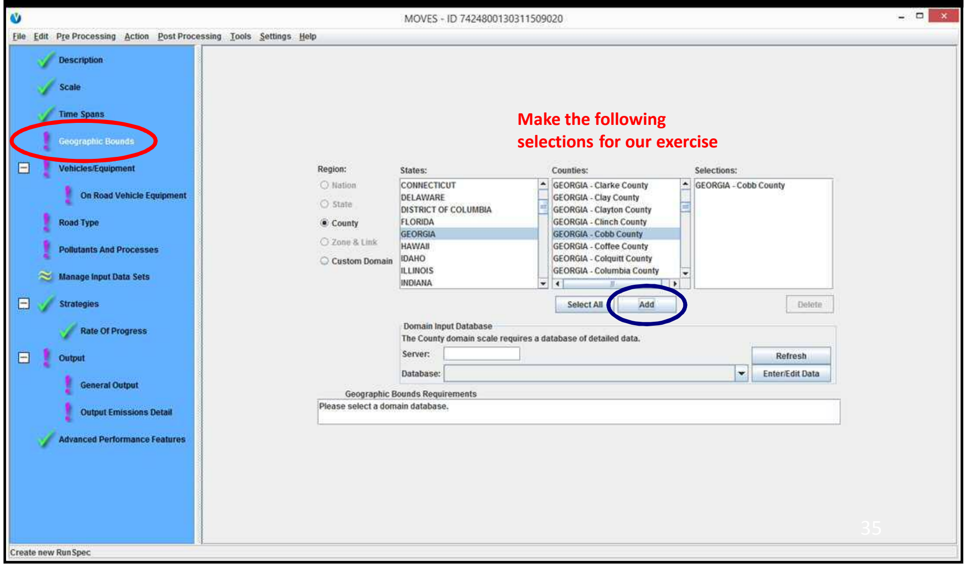
Geographic Bounds Panel



On Road Vehicle Equipment Panel

- Select all valid fuel/vehicle type combinations
  - Invalid combinations include: diesel motorcycle, gasoline long-haul combination truck, gasoline intercity bus, and numerous CNG, electricity, and LPG vehicle combinations
  - Both Gasoline and E-85 should be selected when modeling gasoline vehicles
  - If using MOVES2010b and earlier, don’t select “placeholder” fuel type — can cause errors

On Road Vehicle Equipment Panel

- For our class exercise, we will only model a subset of vehicle/fuel combinations to keep model runtime short
  - Diesel Fuel/Combination Long-Haul Truck, Passenger Car, Passenger Truck
  - Gasoline/ Passenger Car, Passenger Truck
  - E-85/ Passenger Car, Passenger Truck

On Road Vehicle Equipment Panel: Default Fuel Usage Assumptions

- By default, MOVES assigns some VMT to Compressed Natural Gas (CNG) (for transit buses) and E85 (passenger cars and passenger trucks)
  - Therefore, users should either select the CNG transit bus vehicle combination, and E85 passenger car and passenger truck; or
  - Edit the Fuel inputs in the CDM so that no VMT is allocated to CNG and E85 for the affected vehicle types
  - If one of these approaches is not used, some VMT assigned to these vehicle types will be “lost” (disregarded by MOVES)
  - We will cover this more when discussing the CDM

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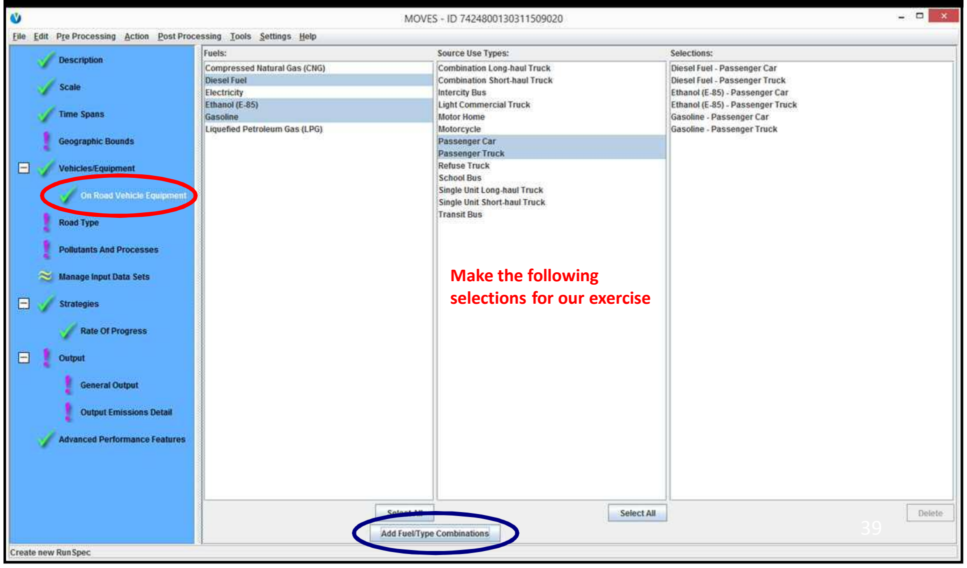
On Road Vehicle Equipment Panel



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Road Type Panel

- Select all road types in the affected network
  - RoadTypeDistribution table in CDM is used to allocate VMT to the various road types
- Don't select "off-network" road type
  - Captures start, extended idle, and resting evaporative emissions; these emissions aren't included in NEPA MSAT analysis
- Notes on ramps:
  - "Provide separate ramp output" check box instructs MOVES to report ramp and mainline emissions inventory separately for restricted access road types (not needed for our exercise)
  - A restricted road type must be selected for the Ramp Fraction tab to appear in the CDM

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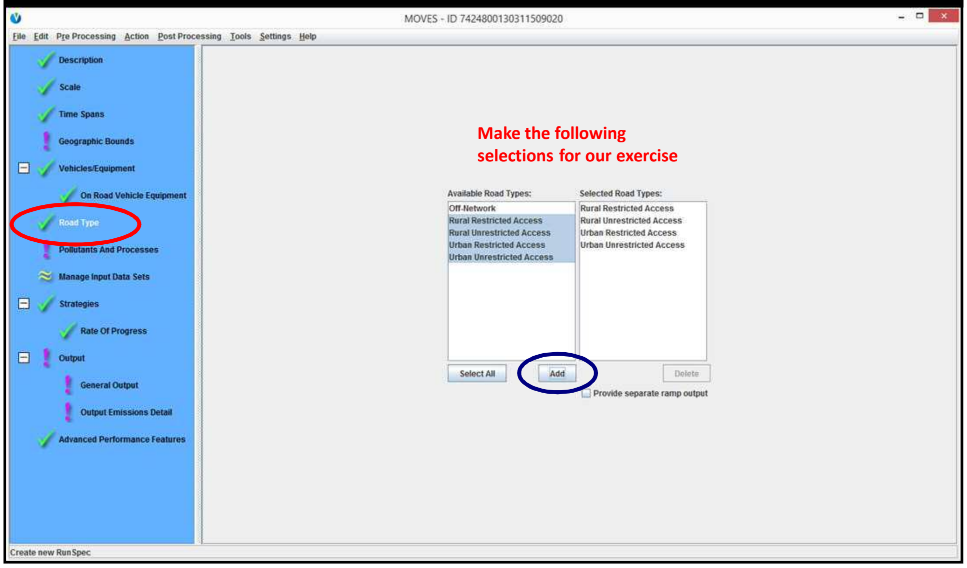
Road Type Panel



Pollutants and Processes Panel

- Diesel-fueled Vehicles
  - Pollutants
    - Primary Exhaust PM10 – Total
    - Pollutant Chains
      - Primary PM10 – Organic Carbon
      - Primary PM10 – Elemental Carbon
      - Primary PM10 – Sulfate Particulate
      - Total Energy Consumption
  - Processes
    - Running Exhaust and Crankcase Running Exhaust

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Pollutants and Processes Panel

- All Selected Fuel/Type Combos
  - Pollutants
    - Benzene
    - 1,3-Butadiene
    - Formaldehyde
    - Acrolein
    - Polycyclic Aromatic Hydrocarbons
      - (Naphthalene and Polycyclic Organic Matter)
    - Pollutant Chains
      - Volatile Organic Compounds
      - Non-Methane Hydrocarbons
      - Total Gaseous Hydrocarbons
      - Primary PM2.5 - Organic Carbon

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Pollutants and Processes Panel

- All Selected Fuel/Type Combos
  - Processes
    - Running Exhaust and Crankcase Running Exhaust
    - Evap Permeation and Evap Fuel Leaks

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Polycyclic Organic Matter

Compound	Form	pollutantID	Form	pollutantID
Dibenzo(a,h)anthracene	particle	68	gas	168
Fluoranthene	particle	69	gas	169
Acenaphthene	particle	70	gas	170
Acenaphthylene	particle	71	gas	171
Anthracene	particle	72	gas	172
Benz(a)anthracene	particle	73	gas	173
Benzo(a)pyrene	particle	74	gas	174
Benzo(b)fluoranthene	particle	75	gas	175
Benzo(g,h,i)perylene	particle	76	gas	176
Benzo(k)fluoranthene	particle	77	gas	177
Chrysene	particle	78	gas	178
Fluorene	particle	81	gas	181
Indeno(1,2,3,c,d)pyrene	particle	82	gas	182
Phenanthrene	particle	83	gas	183
Pyrene	particle	84	gas	184

RESOURCE CENTER

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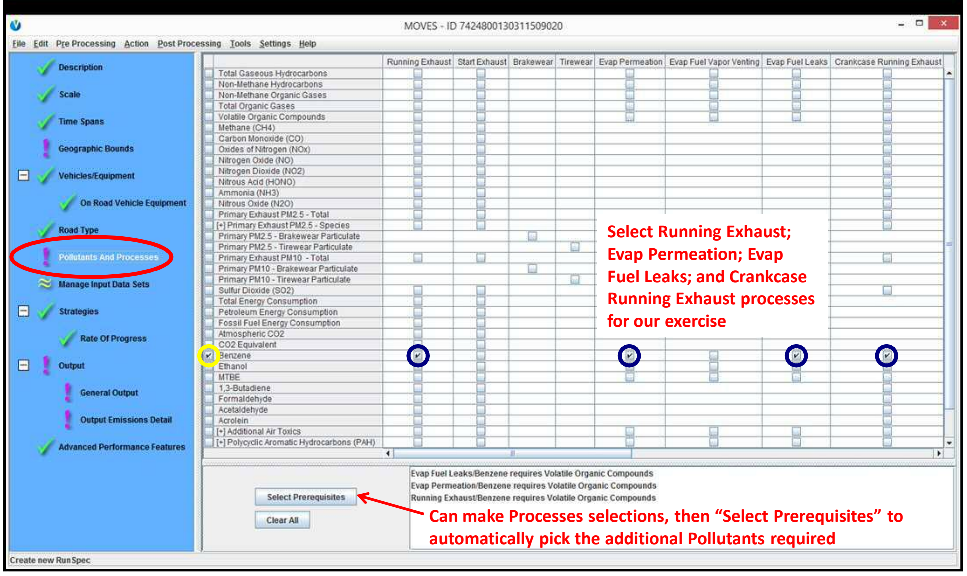
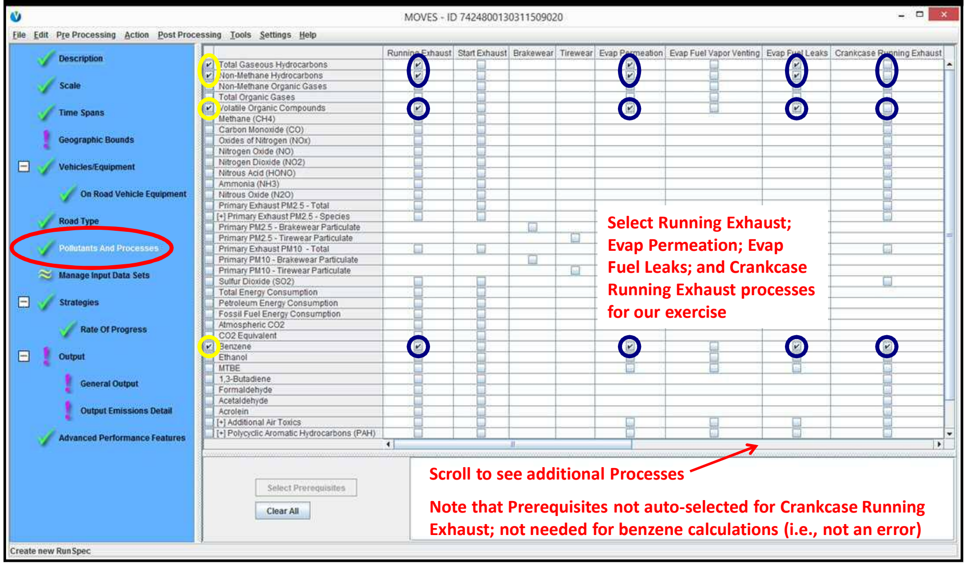
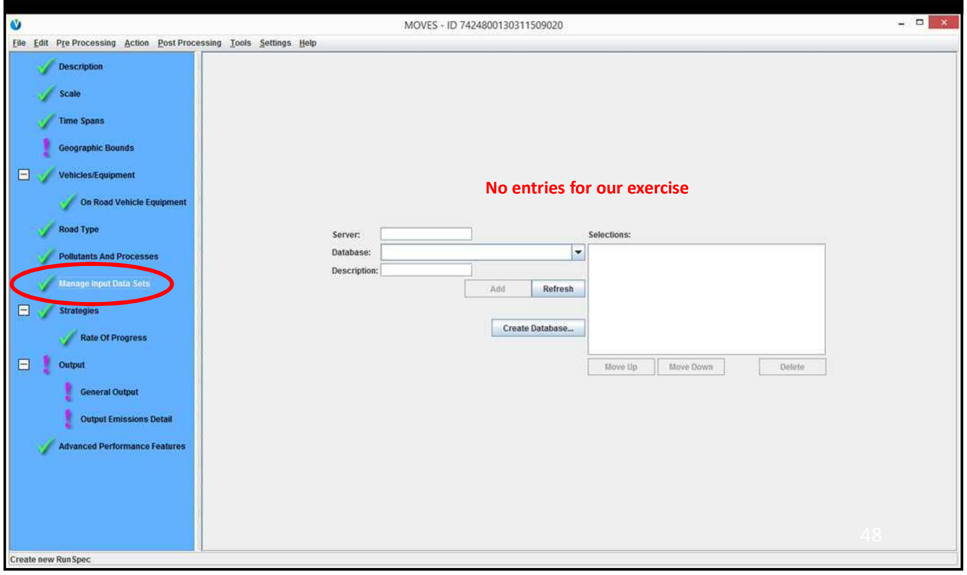
Pollutant and Processes Panel



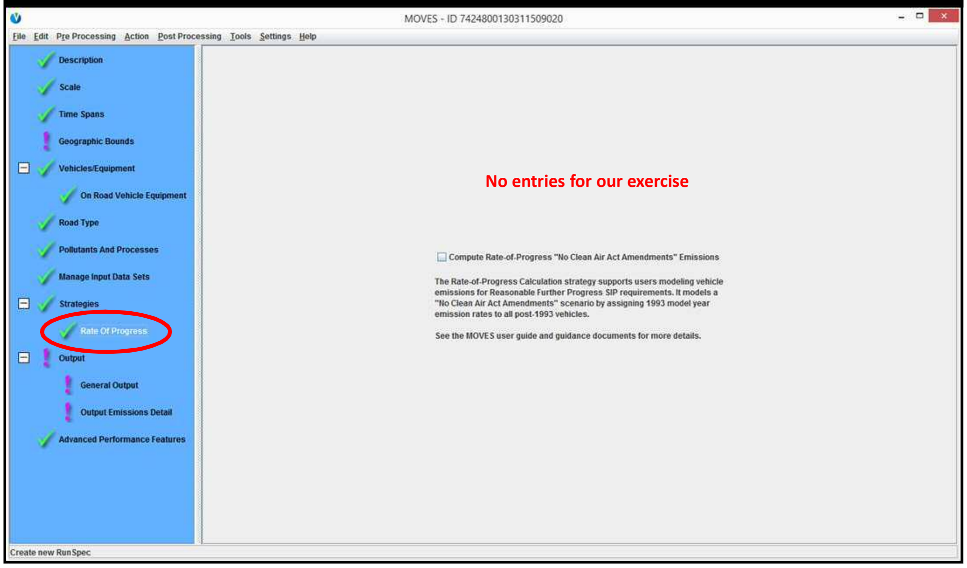
Pollutant and Processes Panel



Manage Input Data Sets Panel



Rate of Progress Panel



General Output Panel

- User must identify the output database
  - Best practice is to name output databases ending with "_out"
  - Manually create the database if it doesn't already exist
  - Multiple RunSpecs can be stored in the same database
    - Will be identified by different MOVESrunID's
    - Generally, there should be a reason to have multiple RunSpecs in the same output database (e.g., each run is a different alternative for the same year)
- Units must be selected; "grams" recommended for MSATs if results will be reported in mass/day; otherwise "pounds" or "tons" OK

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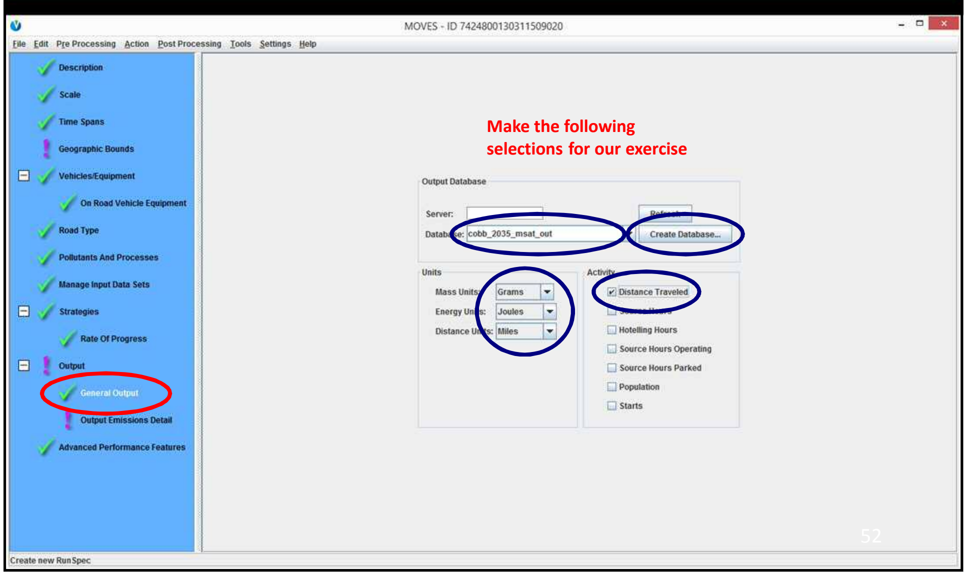
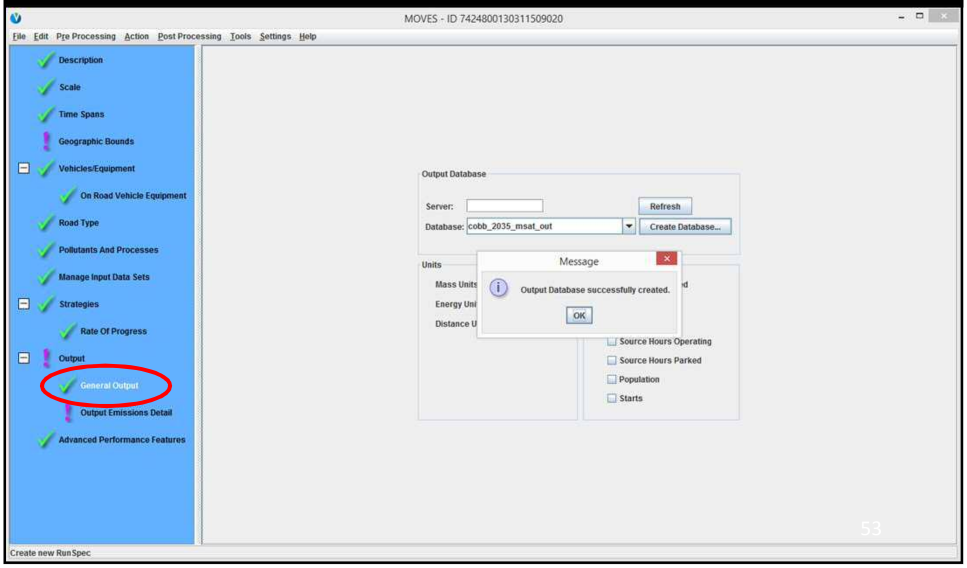
General Output Panel

- Activity output selections are optional
  - Selecting “Distance Traveled” is recommended for QA checks

General Output Panel



General Output Panel



Output Emission Detail Panel

- Aggregation of the Time level: "Year" minimizes post-processing
  - Only valid if all months, days, hours selected in Time Spans panel
- Location: County
- Fuel Type: yes
  - needed to calculate DPM, which is only from diesel vehicles
- Road Type, Source Use Type: only if you want output in that much detail
  - will need to sum outside of MOVES for presentation in NEPA document

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Output Emission Detail Panel

- SCC, Regulatory Class, Model Year, Emissions Process: never
- As noted earlier, might want to select more detail for test runs to assist in troubleshooting, e.g.,
  - if “source use type” is selected, output will be by vehicle type
  - if emissions results are zero for some vehicle types, this helps you determine where to look for erroneous inputs
  - Source Use Type, Road Type, and Month can also be useful for this purpose (don’t need to select them all at once)

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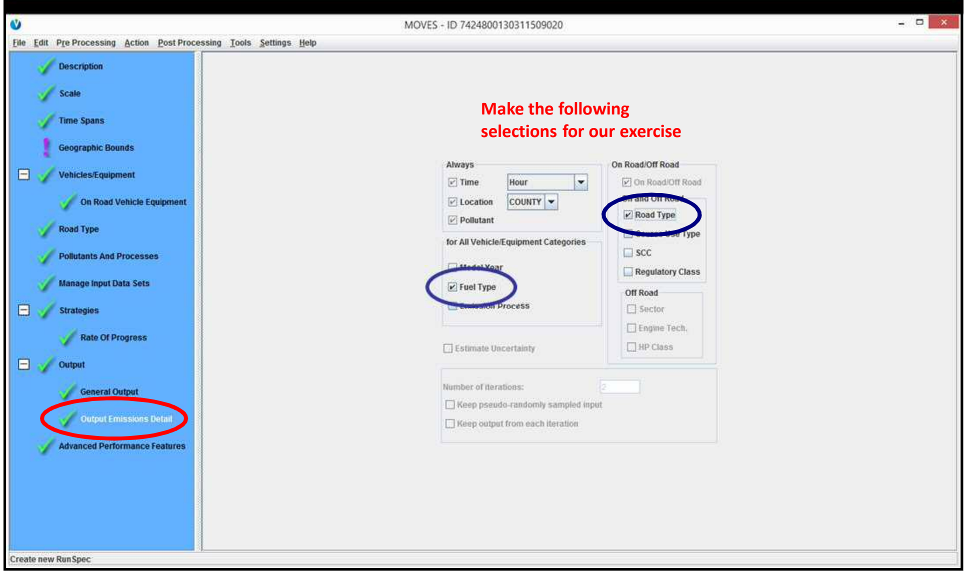
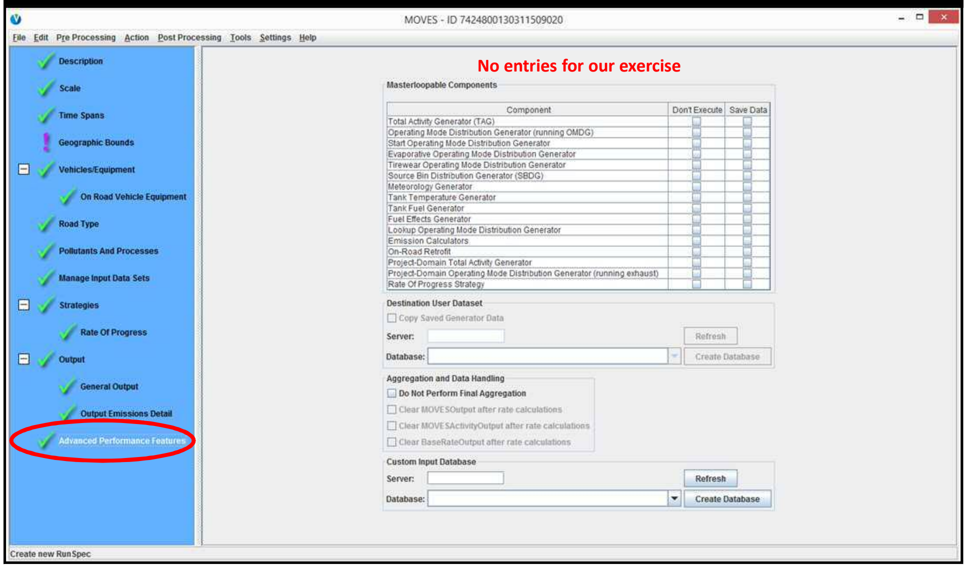
Output Emissions Detail Panel



Advanced Performance Features Panel



Saving the RunSpec

- We've completed our RunSpec selections for this run. We want to save this before proceeding with the County Data Manager
- Instructions: Save as "cobb_2035_msat.mrs" in the "CDM Input Files" folder supplied

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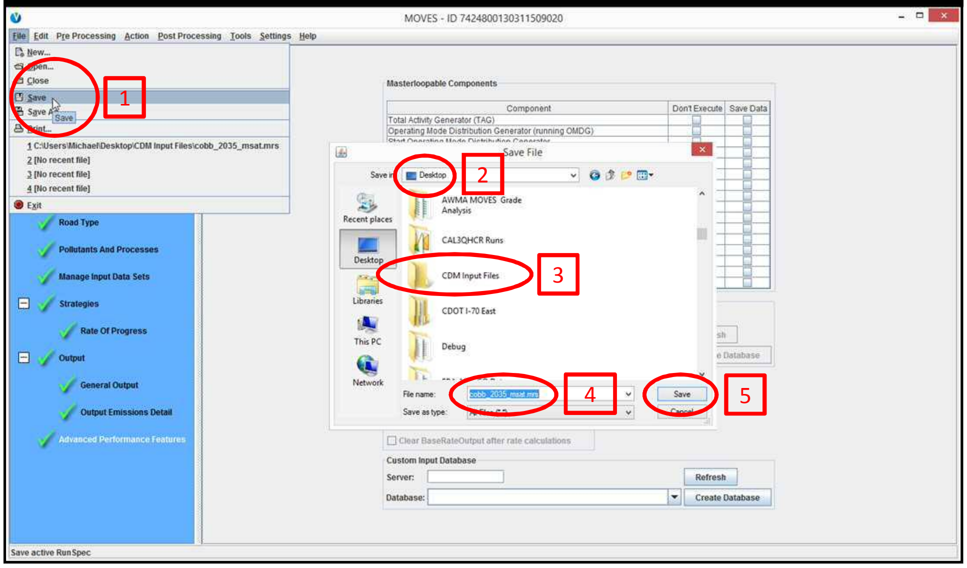
Saving the RunSpec



Using the MOVES County Data Manager (CDM) for MSAT Analysis

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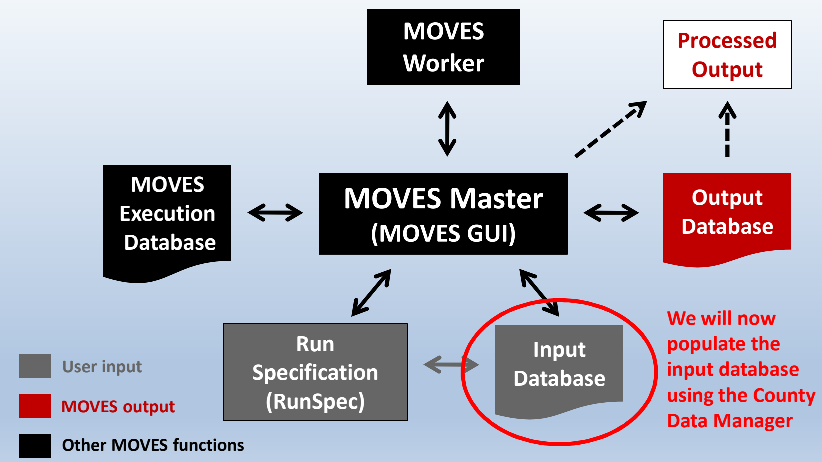
MOVES Structure: RunSpec



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What is the County Data Manager?

- The County Data Manager (CDM) is a tool that facilitates the process of entering data into a county input database
  - The data in the input database is used by MOVES when executing the run
- CDM takes the form of a separate Graphical User Interface (GUI) that is used in conjunction with the MOVES Master GUI
  - When the CDM is open, the MOVES Master GUI is frozen and no changes can be made to the RunSpec

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What is the County Data Manager?

- Data is not entered directly in the CDM
  - Users manipulate data in Excel worksheets, then "Import" worksheet into the CDM

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County Data Manager Functions

- The CDM can create templates, export default data (when available), or export previously imported data
  - The files created through the CDM provide the proper format of the input tables, which is important
- Users review CDM data for accuracy before conducting a MOVES run
  - At the County scale, MOVES process requires users to export and re-import default data so that users examine each input and the most up-to-date information can be used in modeling

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More CDM Functions

- The CDM imports (enters) the data into the county input database
  - Add descriptions of data being imported
  - Descriptions are useful for documentation of data sources
- Imported data can be cleared for each tab or the entire database can be emptied
  - Should always clear previously-imported data before importing new data for the same input; prevents execution errors

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Opening the County Data Manager

- Two ways to open the CDM:
  - "Enter/Edit Data" button on the Geographic Bounds panel; or
  - Use the "Pre Processing" pull-down menu
- If the input database you want to use already exists, it can be selected in the Domain Input Database drop-down list; otherwise, new input database can be created in CDM

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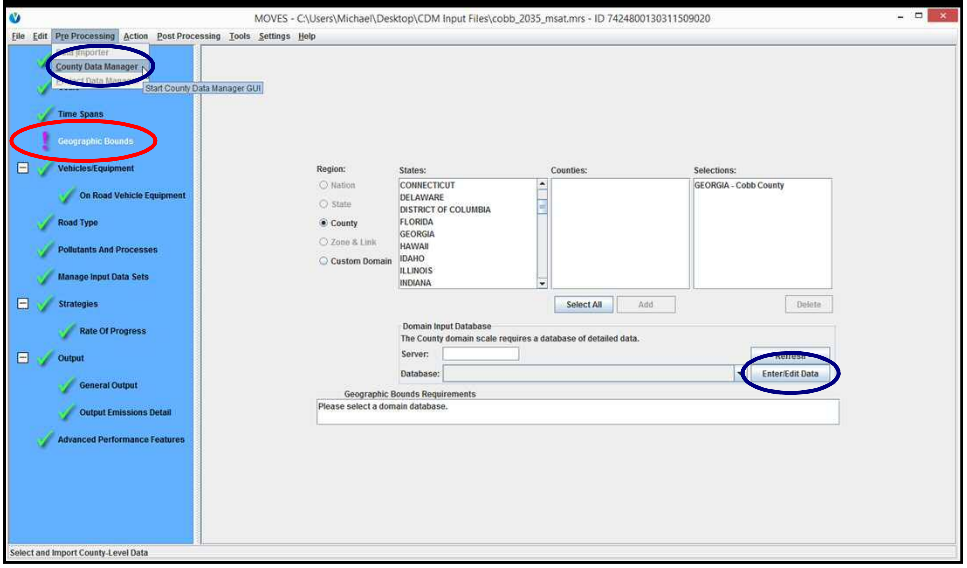
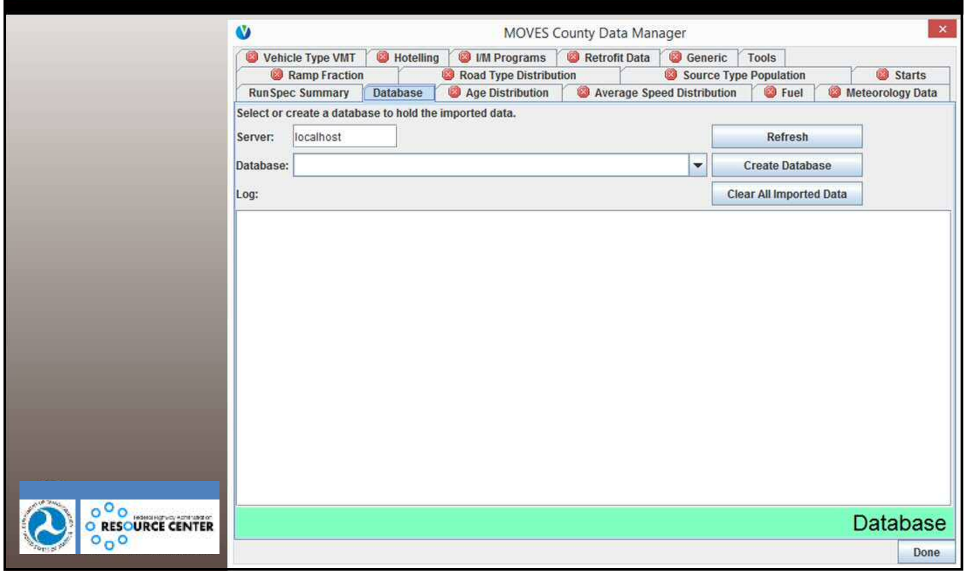
Opening the County Data Manager



A Newly Opened CDM



Using the CDM: General Info

- and symbols for each tab are determined by the relationship between the selections made in the RunSpec and the data provided by the user
  - appears when the user has provided data that is sufficient and passes error checks for all parameters in the RunSpec; note that two tabs begin with a green check (Generic and Ramp Fraction)
  - appears if the user has not provided enough information or if there is an error with the data provided
  - Nothing done in the CDM will affect the selections in the RunSpec

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Using the CDM: General Info

- “RunSpec Summary” tab restates selections made in the RunSpec
  - Helpful reference while using CDM – see next slide
- “Tools” tab (not covered in this course)
  - Used to automate data import process and for batch operation

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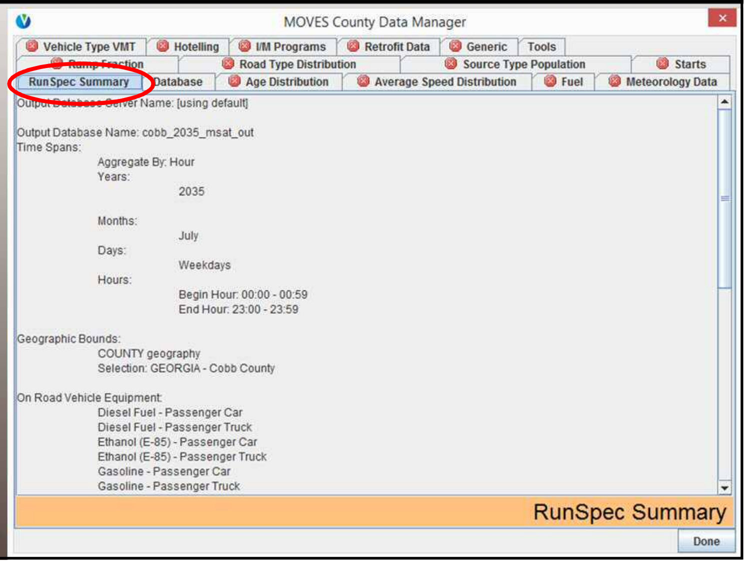
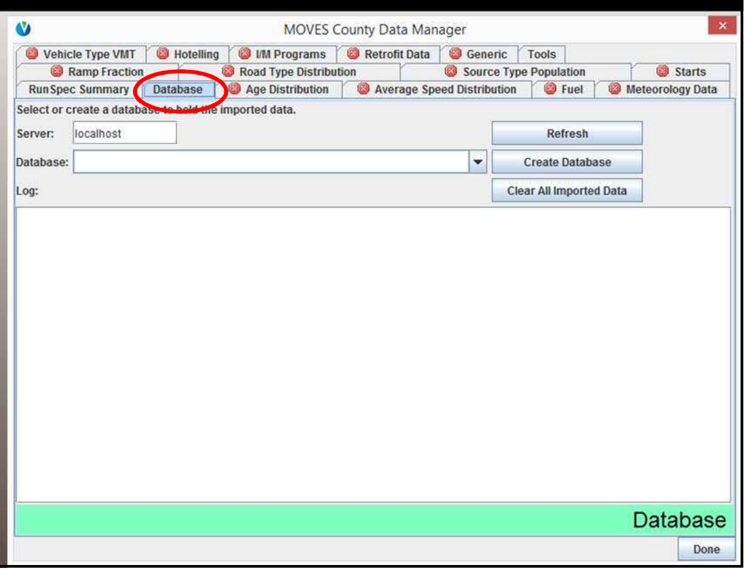
Using the CDM: RunSpec Summary Tab



Using the CDM: Database Tab



Using the CDM: Database Tab

- County input database is selected or created here
- Existing county input databases can be selected from the drop-down menu
- Once a county input database has been created or selected, the tables within it can be edited with the other CDM tabs
  - All the tables in the database can be cleared of data with the "Clear All Imported Data" button
- The tab also displays a log of changes

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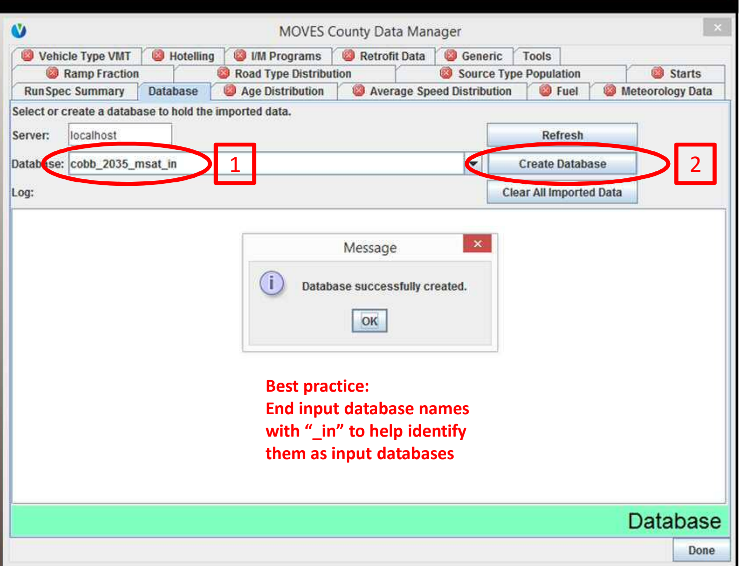
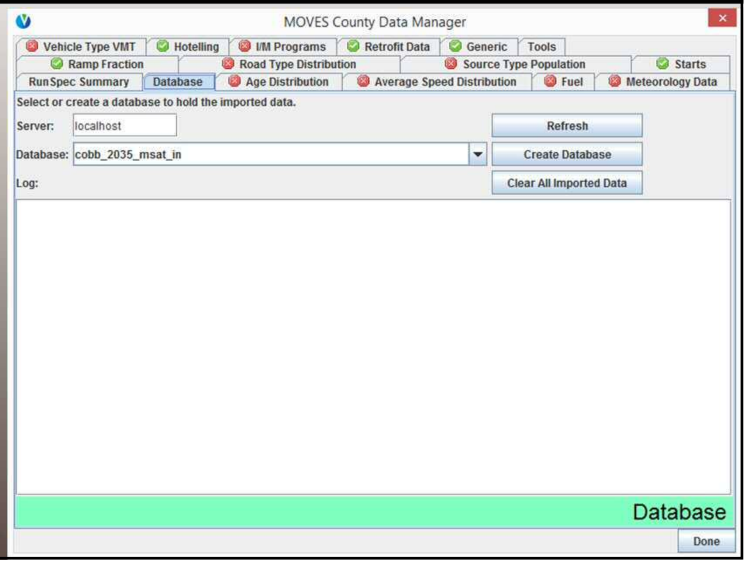
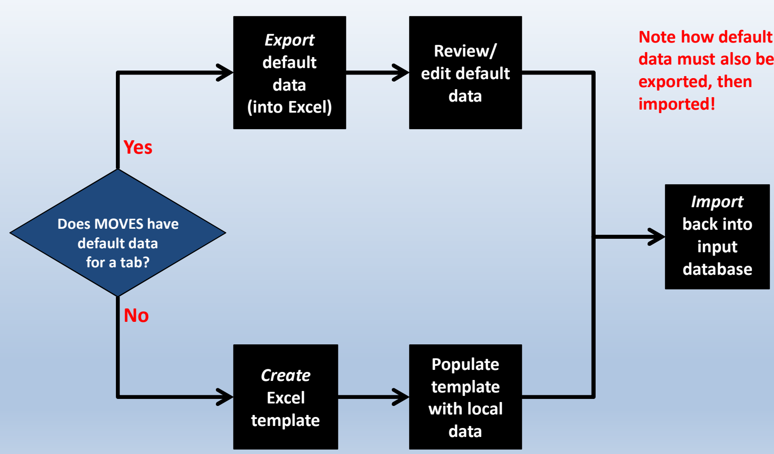
Creating a New County Input Database



Creating a New County Input Database



Using the CDM: Options for Entering Data



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Using the CDM: Creating a Template

- All tabs provide the option of creating an Excel template spreadsheet of the appropriate MOVES table
  - Save as.xls extension to get a spreadsheet format
- Templates contain the proper fields/column headings, but have blank cells for user-specified data
- The template will be pre-populated with some data based on entries made in the RunSpec
  - This is why it's recommended to complete all RunSpec panels first!
- Extra worksheets will help you decipher MOVES codes

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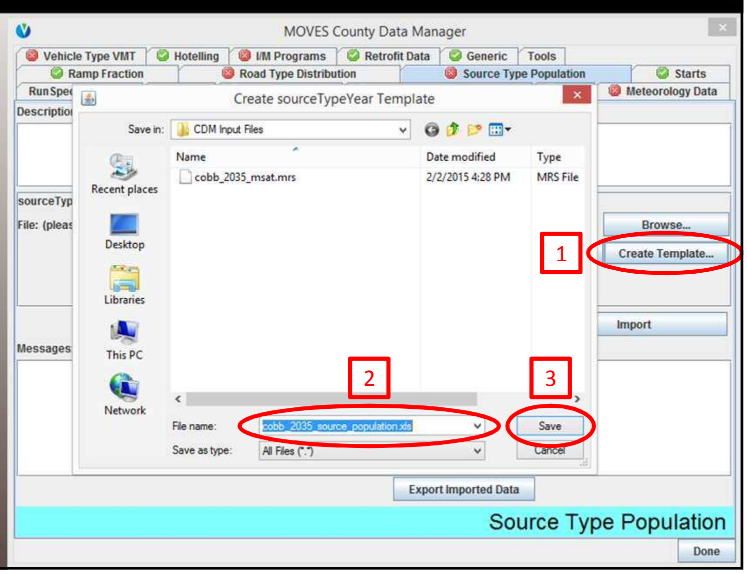
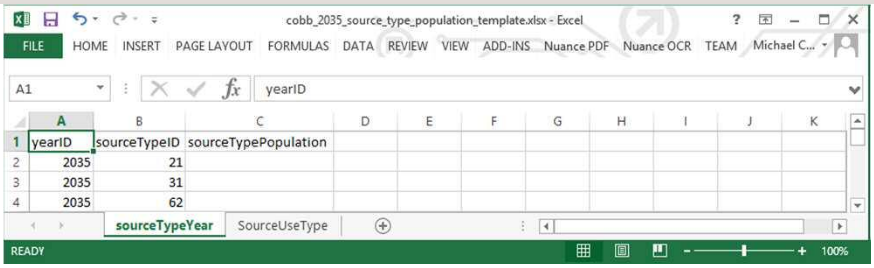
Example: Creating a Template



Example: Creating a Template



- Example template of SourceTypeYear table created from the "Source Type Population" tab of the CDM
- Note that"YearID" and "SourceTypeID" have been pre-populated based on RunSpec selections; "SourceTypePopulation" fields will need to be filled in by the user

Using the CDM: Exporting Default Data

- Some tabs have default data available:
  - Average Speed Distribution
  - Ramp Fraction
  - Fuel
  - Meteorology Data
  - Vehicle Type VMT (Month, Day, and Hour VMT Fractions)
  - I/M Programs
- Tabs with default data will have "Export Default Data" option

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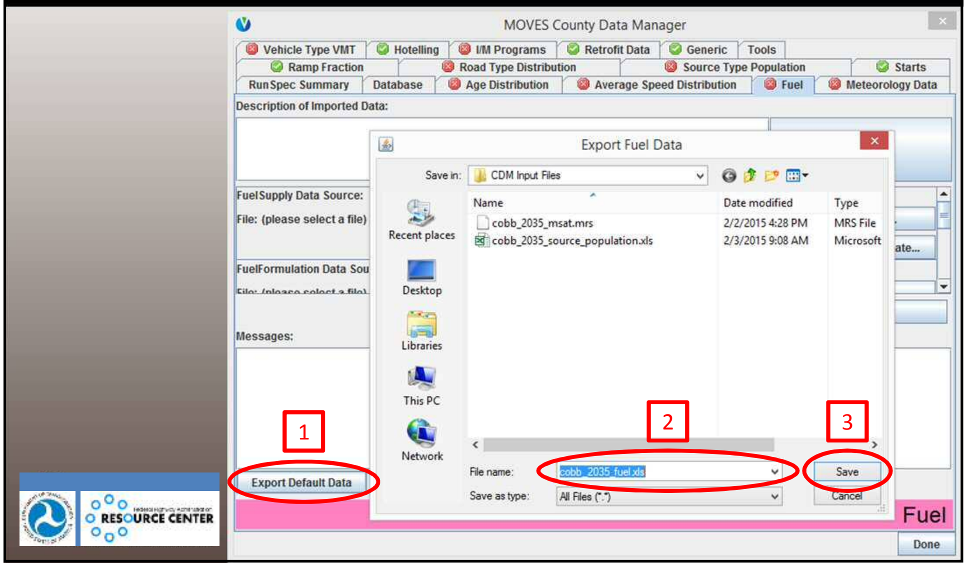
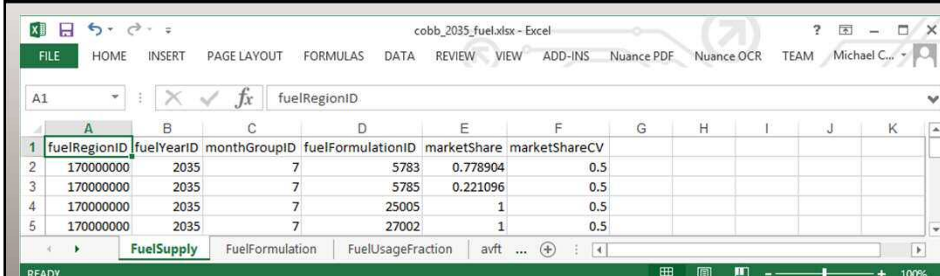
Example: Exporting Default Data



Example: Exporting Default Data



- Example of exported default data for FuelSupply table created from the "Fuel" tab of the CDM
- Per MOVES Technical Guidance, user would check default data to ensure applicability and make any changes

Using the CDM: Importing Data

- Data must be imported back into the CDM from Excel for each tab (even when using default data for a tab)
- Imported data is read from a Excel worksheet that has been properly formatted with the correct columns

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Using the CDM: Importing Data

- General steps:
  - 1) Recommended: Add a description of the data you are about to import (e.g., the file location or data source)
  - 2) Browse to find the correct Excel file
  - 3) Select the Excel file
  - 4) Select the appropriate worksheet (when using defaults, name should match Data Source in the CDM tab)
  - 5) Click the "Import" button
- Check to see if you get an "Import Complete" message

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Using the CDM: Importing Data

- When the import is successfully completed the [red X icon] will change to a [green check icon] on the County Data Manager tab
  - If message says, "Import Complete" but [red X icon] remains, that means more data is required (e.g., data was not provided for all source types selected in the RunSpec)
  - For many tables, unused data can be imported (e.g., extra months, hours, source types, etc.) with no adverse impacts; however, data for additional counties and years should NOT be imported as this can cause errors when attempting to execute the RunSpec
- The description you entered will appear in the log, which can be viewed on the Database tab

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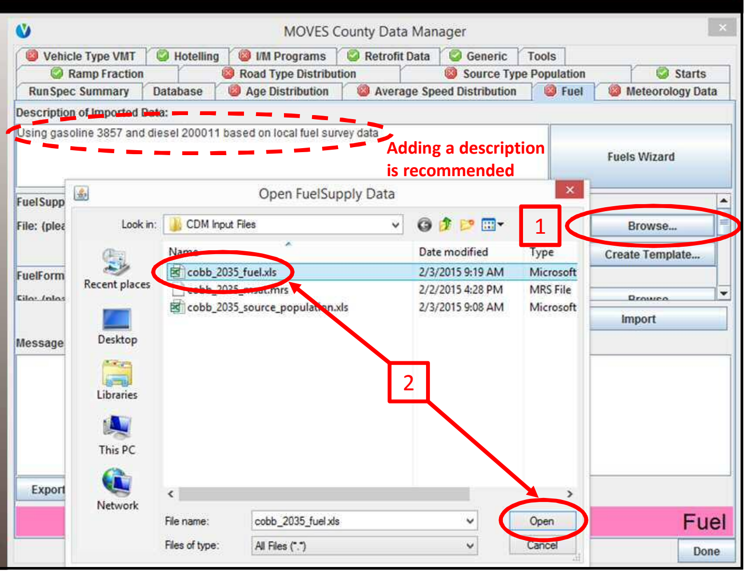
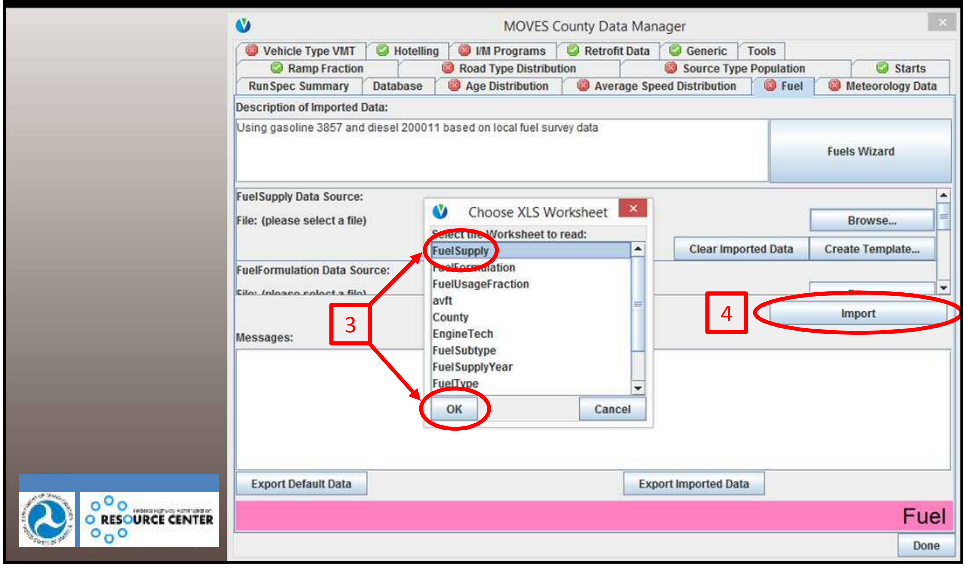
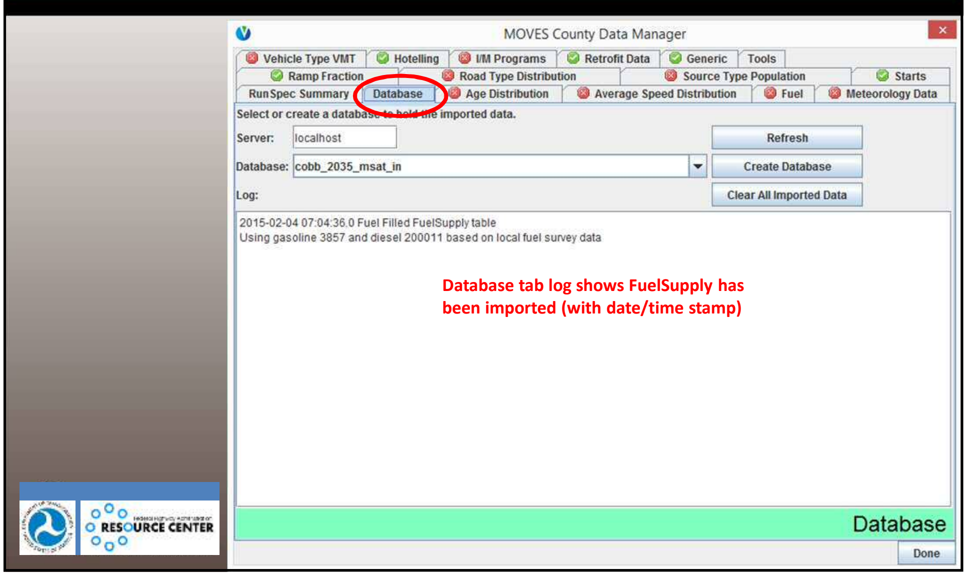
Example: Importing Data



Example: Importing Data



Example: Importing Data



Entering Local Data Using the CDM

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Overview

- We will go through each data input (MOVES table) that can be accessed through each CDM tab
- We will look at the fields in each input table and go over FHWA's recommendation for that input
- After discussing each input, we will enter the appropriate data for our MSAT inventory exercise for Cobb County
  - Exercise files can be found in the "CDM Input Files" folder

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What MOVES inputs are needed for MSAT analysis?

Possible inputs for an MSAT analysis run
Age distribution
Sourcetype population
Meteorology
I/M
Fuel parameters
VMT
Speed
Road type distribution
Ramp fraction
Month VMT fractions
Day VMT fractions
Hour VMT fractions

- Need to consider:
  - What inputs will change as a result of the project?
  - What inputs have local data available?

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Summary of Data Inputs

- Meteorology tab
  - Temperature and humidity inputs
  - MOVES table: ZoneMonthHour
- Source Type Population tab
  - Number (i.e., population) of local vehicles operating in the area
  - Important for start and evaporative emissions; these emissions are not used in MSAT analysis, but this input needed for MOVES to run
  - MOVES table: SourceTypeYear

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Summary of Data Inputs

- Age Distribution tab
  - Age fractions of fleet by age and source type
  - MOVES table: SourceTypeAgeDistribution
- Vehicle Type VMT tab
  - Total annual VMT by HPMS vehicle type
  - Also month, day and hour VMT fractions
  - MOVES table: HPMSVTypeYear (and others)

Summary of Data Inputs

- Average Speed Distribution tab
  - Speed distribution by road type, hour and source (vehicle) type
  - MOVES table: AvgSpeedDistribution
- Road Type Distribution tab
  - Fraction of source type VMT on different road types
  - MOVES table: RoadTypeDistribution
- Ramp Fraction tab
  - Fraction of freeway VHT occurring on ramps
  - MOVES table: RoadType

Summary of Data Inputs

- Fuel tab
  - Market share and composition of fuel blends
  - Travel fraction by vehicle and fuel type
  - Defaults available by fuel sales region (groups of counties)
  - MOVES tables:
    - FuelSupply
    - FuelFormulation
    - FuelUsageFraction
    - AVFT (fuel type and technology inputs)

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Summary of Data Inputs

- I/M Programs tab
  - Data on I/M program(s), if any
  - MOVES table: IMCoverage
- CDM has additional tabs for inputs not typically used in MSAT analysis
  - Retrofit
  - Hoteling
  - Starts
  - "Generic" (other possible inputs without a specific tab)

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Scope of Data Inputs for MSAT Analysis

MOVES County Data Manager

Vehicle Type VMT | Hotelling | I/M Programs | Retrofit Data | Generic | Tools
Ramp Fraction | Road Type Distribution | Source Type Population | Starts
RunSpec Summary | Database | Age Distribution | Average Speed Distribution | Fuel | Meteorology Data

Data[a]	Run Detail			Sources				
	Same for All Runs	Vary by Year	Vary by Alternative	Local MPO	State Air Agency	State DOT	MOVES Default	Project-Specific
Age Distribution	•			•	•	•		
Average Speed Distribution		•	•					•
Fuel Supply[b]		•		•	•		•	
Fuel Formulation[b]		•		•	•		•	
Fuel Usage Fraction[b]		•		•	•		•	
AVFT[b]	•			•	•		•	
Meteorology Data	•			•	•		•	
Ramp Fraction		•	•	•	•			•
Road Type Distribution		•	•					•
Source Type Population		•		•	•	•	•	
Starts	Not typically used in quantitative MSAT analysis							
HPMS Vehicle Type Year[c]		•	•					•
Month VMT Fraction[c]	•			•		•	•	
Day VMT Fraction[c]	•			•		•	•	
Hour VMT Fraction[c]	•			•		•	•	
Hoteling	Not typically used in quantitative MSAT analysis							
I/M Programs		•		•	•		•	
Retrofit	Not typically used in quantitative MSAT analysis							
Generic	Not typically used in quantitative MSAT analysis							

[a] Use data reflecting annual average conditions representing long-term MSAT exposure; e.g., data from annual PM2.5 regional conformity analyses
[b] Fuel tab
[c] Vehicle Type VMT tab

RESOURCE CENTER

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Important Disclaimer

- Some of the suggestions for input data in this course are different than those in MOVES courses oriented toward SIP and conformity analysis
- For MSAT (or GHG) analysis, we are comparing years and alternatives, not trying to calculate an exact number to compare to a target
- Inputs that would be affected by the project alternatives (e.g., speed) are important to get right; inputs that are not affected by alternatives (e.g., temperature) are not as important in MSAT analysis

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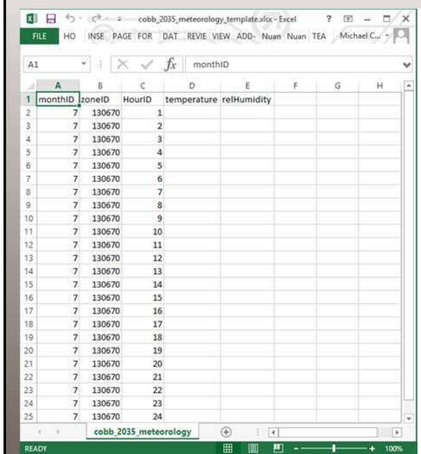
Meteorology Data



monthID	zoneID	HourID	temperature	relHumidity
7	130670	1		
7	130670	2		
7	130670	3		
7	130670	4		
7	130670	5		
7	130670	6		
7	130670	7		
7	130670	8		
7	130670	9		
7	130670	10		
7	130670	11		
7	130670	12		
7	130670	13		
7	130670	14		
7	130670	15		
7	130670	16		
7	130670	17		
7	130670	18		
7	130670	19		
7	130670	20		
7	130670	21		
7	130670	22		
7	130670	23		
7	130670	24		

- Meteorology data should be entered for every month and hour selected in the RunSpec
- Temperatures are in degrees Fahrenheit
- Relative humidity must be between 0 and 100
- ZoneID is simply the countyID + a zero

Meteorology Data: FHWA Recommendation

- Section 4.2 of MOVES Technical Guidance
- If the area conducts annual PM2.5 analysis (e.g., they are a nonattainment area for this pollutant), local temperature and humidity data for all 12 months are probably available and should be used
- If local data are not available, MOVES default data can be used

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Meteorology Data: Exercise

- Let’s enter meteorology data into the CDM for our MSAT inventory exercise
- The template has already been filled out with our met data and is available as file: cobb_2035_meteorology.xls
- ***Instructions:*** Open cobb_2035_meteorology.xls, review the data, and import the table into the Meteorology tab

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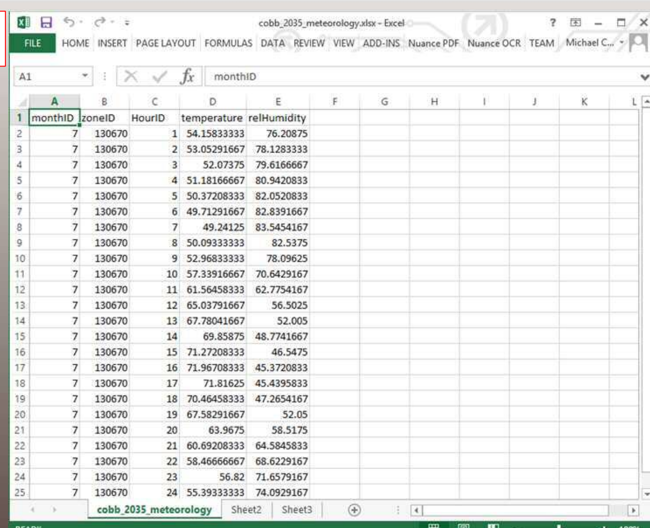
MSAT Inventory Exercise: Entering Meteorology Data

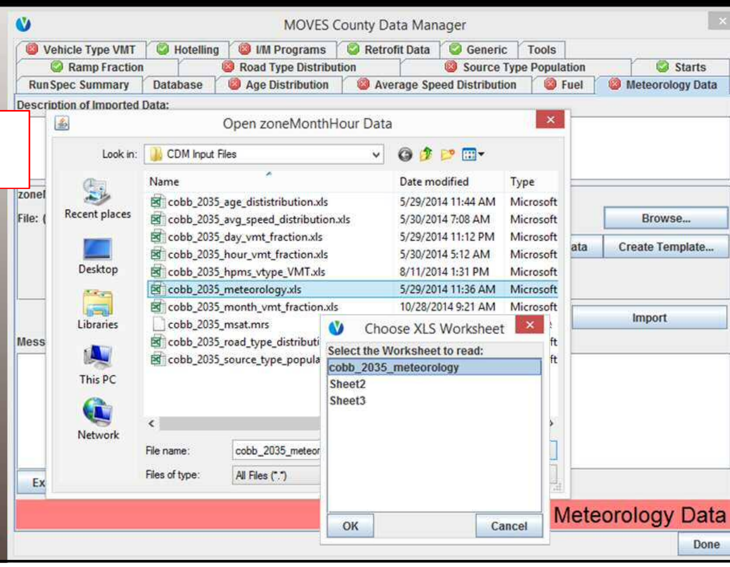
Contents of cobb_2035_meteorology.xls



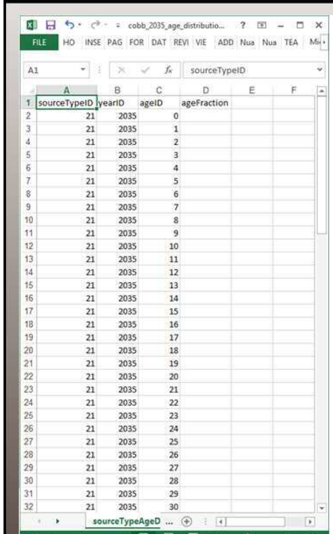
monthID	zoneID	HourID	temperature	relHumidity
7	130670	1	54.15833333	76.20875
7	130670	2	53.05291667	78.1283333
7	130670	3	52.07375	79.6166667
7	130670	4	51.18166667	80.9420833
7	130670	5	50.37208333	82.0520833
7	130670	6	49.71291667	82.8391667
7	130670	7	49.24125	83.5454167
7	130670	8	50.09333333	82.5375
7	130670	9	52.96833333	78.09625
7	130670	10	57.33916667	70.6429167
7	130670	11	61.56458333	62.7754167
7	130670	12	65.03791667	56.5025
7	130670	13	67.78041667	52.005
7	130670	14	69.85875	48.7741667
7	130670	15	71.27208333	46.5475
7	130670	16	71.96708333	45.3720833
7	130670	17	71.81625	45.4395833
7	130670	18	70.46458333	47.2654167
7	130670	19	67.58291667	52.05
7	130670	20	63.9675	58.5175
7	130670	21	60.69208333	64.5845833
7	130670	22	58.46666667	68.6229167
7	130670	23	56.82	71.6579167
7	130670	24	55.39333333	74.0929167

MSAT Inventory Exercise: Entering Meteorology Data

Browse and import the cobb_2035_meteorology worksheet



Age Distribution



- Age Distribution is entered according to MOVES source types and calendar year
  - AgeFraction must sum to “1” within these fields
- Age Distribution covers new (0) to 30+ year old vehicles
- MOVES does not vary age distribution by month
- EPA has age distribution converters on web, if needed

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Age Distribution: FHWA Recommendation

- Section 4.4 of MOVES Technical Guidance
- Emissions are sensitive to age and age distributions vary considerably by locality, but not affected by projects
  - Possible exception: transit projects that include purchase of new buses
- Use local age distribution data if available
  - varies by year, so needed for base year, first year of operation, and design year
- Otherwise, use defaults downloaded from "tools" section of MOVES web site
  - but don't use a mix of defaults and local data for different years

Age Distribution: Exercise

- Let's enter age distribution data into the CDM for our MSAT inventory exercise
- ***Instructions:*** The template has already been filled out with our local age distribution and is available as file –

  cobb_2035_age_distribution.xls

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MSAT Inventory Exercise: Entering Age Distribution Data

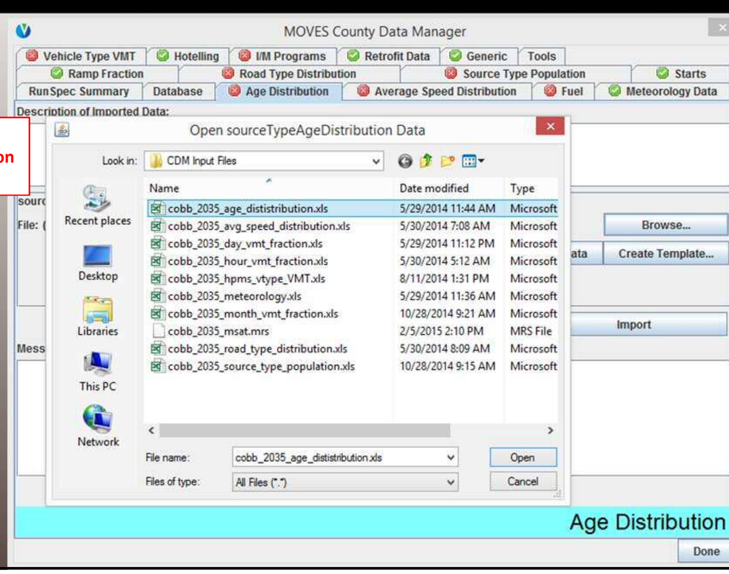
Contents of cobb_2035_age_distribution.xls

sourceTypeID	yearID	ageID	ageFraction
21	2035	0	0.023802
21	2035	1	0.071207
21	2035	2	0.068707
21	2035	3	0.077108
21	2035	4	0.072907
21	2035	5	0.067107
21	2035	6	0.068907
21	2035	7	0.065607
21	2035	8	0.076308
21	2035	9	0.061806
21	2035	10	0.055906
21	2035	11	0.046105
21	2035	12	0.039904
21	2035	13	0.037004
21	2035	14	0.032503
21	2035	15	0.026703
21	2035	16	0.021402
21	2035	17	0.016602
21	2035	18	0.012601
21	2035	19	0.008901
21	2035	20	0.005401
21	2035	21	0.0032
21	2035	22	0.0026
21	2035	23	0.0023
21	2035	24	0.002035
21	2035	25	0.0018
21	2035	26	0.001592
21	2035	27	0.001409
21	2035	28	0.001246
21	2035	29	0.001102
21	2035	30	0.026219

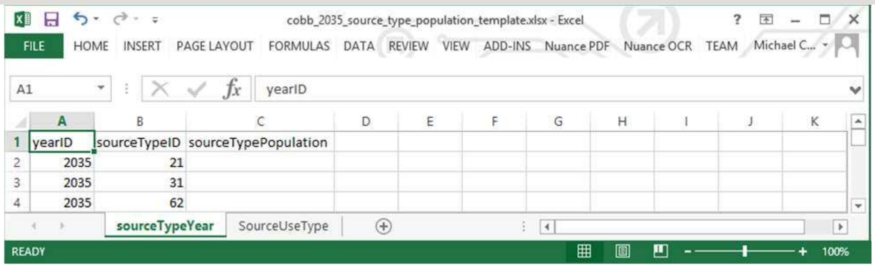
cobb_2035_age_distribution

MSAT Inventory Exercise: Entering Age Distribution Data

Browse and import the cobb_2035_age_distribution spreadsheet



Source Type Population



- Source Type Population is the actual number of vehicles of each “source type” (vehicle type) in the county being modeled

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Source Type Population: FHWA Recommendation

- Section 4.3 of MOVES Technical Guidance
- Start and evaporative emissions depend upon vehicle population
  – these emissions are not included in MSAT analysis, but population inputs still needed for MOVES to run
- Use local population data if available (needed for project analysis years); otherwise use defaults

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Source Type Population: Obtaining Defaults

- Sources of default population data
  - Can run MOVES2010b at the National scale for each of the project analysis years and get default vehicle population in the output (this approach doesn't work in MOVES2014)
    - Select off-network road type and all vehicle/fuel types in the area
    - Model start emissions for one pollutant (total energy works and is fastest)
    - Check "population" in General Output panel
  - MOVES2014: default national populations by year available in the sourcetypeyear table of the default database
    - Can allocate to counties by: 1) multiplying by the "startAllocFactor" fraction in the MOVES default zone table for your county, or 2) calculate the ratio of county VMT to national VMT, and use that ratio

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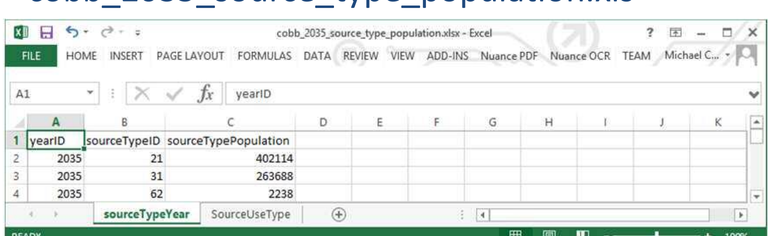
Source Type Population: Exercise

- Let's enter source type population data into the CDM for our MSAT inventory exercise
- ***Instructions:*** The template has already been filled out with our local source type population and is available as file –

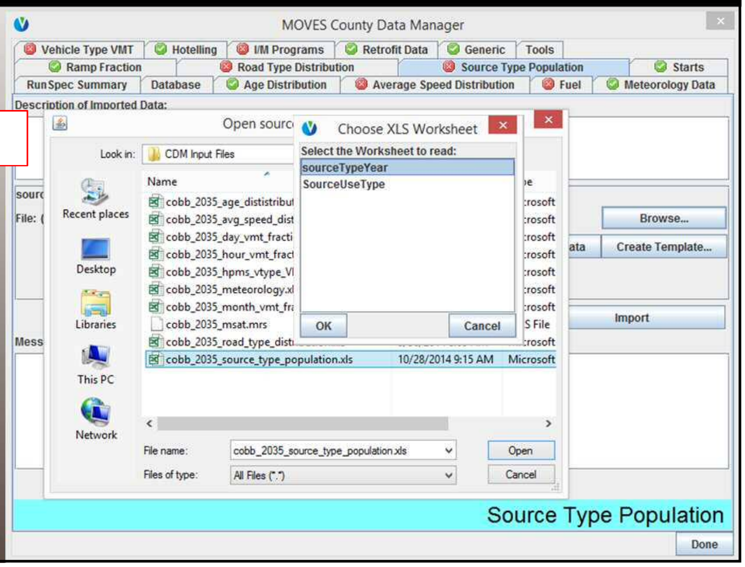
  cobb_2035_source_type_population.xls



yearID	sourceTypeID	sourceTypePopulation
2035	21	402114
2035	31	263688
2035	62	2238

MSAT Inventory Exercise: Entering Source Type Population Data

Browse and import the sourceTypeYear worksheet



Fuel

- The Fuel tab contains four data tables:
  - Fuel Supply
  - Fuel Formulation
  - Fuel Usage Fraction
  - AVFT
- Data must be selected/entered for each table
- Changes from MOVES2010b:
  - In MOVES2010b, the Fuel tab included only the first two tables were included, and AVFT data were entered under a separate tab (Fuel Type and Technologies)
  - Fuel Usage Fraction is a new input in MOVES2014

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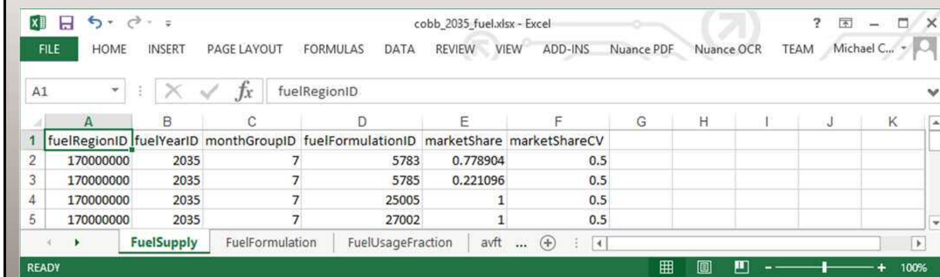
Fuel:
Fuel Supply Data



fuelRegionID	fuelYearID	monthGroupID	fuelFormulationID	marketShare	marketShareCV
170000000	2035	7	5783	0.778904	0.5
170000000	2035	7	5785	0.221096	0.5
170000000	2035	7	25005	1	0.5
170000000	2035	7	27002	1	0.5

- Fuel Supply entered by county, year, month, fuel type
  - MarketShare (column E) should sum to 1 within these fields

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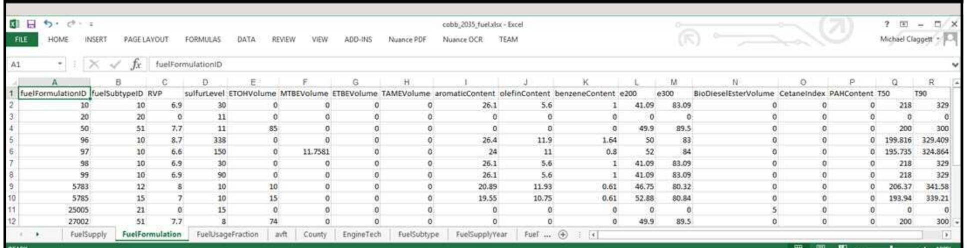
Fuel:
Fuel Formulation Data



fuelFormulationID	fuelSubtypeID	RVP	sulfurLevel	ETOHVolume	MTBEVolume	ETBEVolume	TAMEVolume	aromaticContent
10	10	6.9	30	0	0	0	0	26.1
20	20	0	11	0	0	0	0	0
50	51	7.7	11	85	0	0	0	0
96	10	8.7	338	0	0	0	0	26.4
97	10	6.6	150	0	11.7581	0	0	24
98	10	6.9	30	0	0	0	0	26.1
99	10	6.9	90	0	0	0	0	26.1
5783	12	8	10	10	0	0	0	20.89
5785	15	7	10	15	0	0	0	19.55
25005	21	0	15	0	0	0	0	0
27002	51	7.7	8	74	0	0	0	0

fuelFormulationID	olefinContent	benzeneContent	e200	e300	BioDieselEsterVolume	CetaneIndex	PAHContent	T50	T90
10	5.6	1	41.09	83.09	0	0	0	218	329
20	0	0	0	0	0	0	0	0	0
50	0	0	49.9	89.5	0	0	0	200	300
96	11.9	1.64	50	83	0	0	0	199.816	329.409
97	11	0.8	52	84	0	0	0	195.735	324.864
98	5.6	1	41.09	83.09	0	0	0	218	329
99	5.6	1	41.09	83.09	0	0	0	218	329
5783	11.93	0.61	46.75	80.32	0	0	0	206.37	341.58
5785	10.75	0.61	52.88	80.84	0	0	0	193.94	339.21
25005	0	0	0	0	5	0	0	0	0
27002	0	0	49.9	89.5	0	0	0	200	300

- Use only existing FuelFormulationID's with the proper FuelSubTypeID for the fuel properties being entered
  - However, properties can be changed for existing formulations
  - Gasoline FuelFormulationIDs are 500-9419; diesel 20011-20491
  - Consult MOVES Technical Guidance for information about the requirements for populating each field

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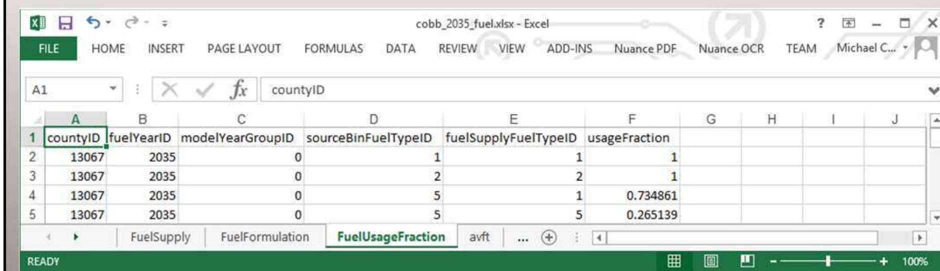
Fuel: Fuel Usage Fraction Data



countyID	fuelYearID	modelYearGroupID	sourceBinFuelTypeID	fuelSupplyFuelTypeID	usageFraction
13067	2035	0	1	1	1
13067	2035	0	2	2	1
13067	2035	0	5	1	0.734861
13067	2035	0	5	5	0.265139

- New input in MOVES2014 to accommodate E-85
  - Fraction of E-85 capable ("flex-fuel") vehicles actually operating on E-85

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Fuel: FuelType and Technologies (AVFT)

- Users can allocate VMT fractions to engine or fuel technologies
  - If fraction of VMT is not known, fraction of population can be entered
- Most common use is to change default diesel or CNG fractions
- E-85 added in MOVES2014
  - Since these vehicles can operate on E-85 or conventional gasoline, Fuel Usage Fraction is used to account for actual fuel use; AVFT would be used to modify fraction of fleet capable of using E-85

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FuelType and Technologies: CNG Transit Bus

- MOVES default assumption is that transit buses are a mix of diesel, gasoline, and CNG based on national sales data for each model year
- However, local bus fleets are likely to be different (e.g., 100% diesel or 100% CNG)
  - If the VMT fraction is not changed, MOVES will allocate bus VMT using the default VMT fractions, even if only one fuel type is selected in the RunSpec
    - MOVES will assign some VMT and emissions to diesel buses even if CNG buses only are selected in the RunSpec, unless the fuel type fraction is changed

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Fuel: FHWA Recommendation

- Section 4.9 of MOVES Technical Guidance
- Use local data if available, otherwise use defaults
  - Like other defaults, default data need to be exported from default database and imported into project run input database
- Make sure CNG bus selection in RunSpec is consistent with data in FuelType and Technologies inputs
- Input data may vary by year, should not vary by alternative

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Fuel: Exercise

- Let's enter fuel data into the CDM for our MSAT inventory exercise
- ***Instructions:*** Export the default fuel information MOVES has for Cobb County, check the values, then import into the Fuel tab

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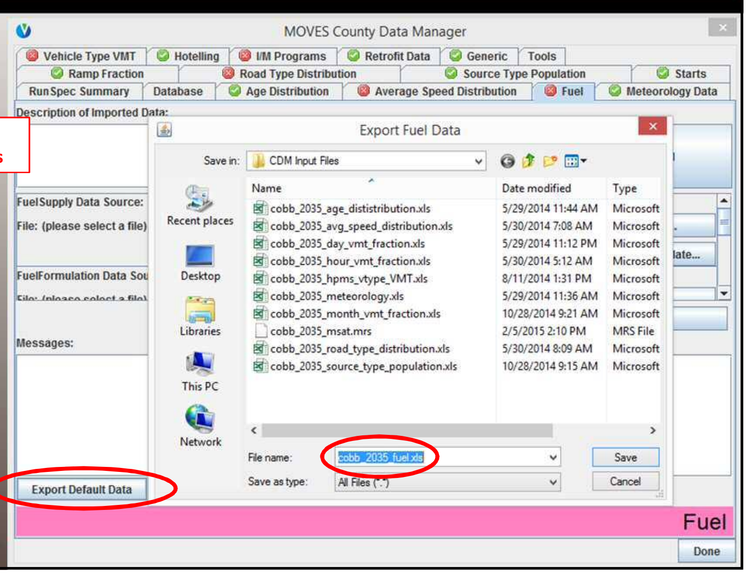
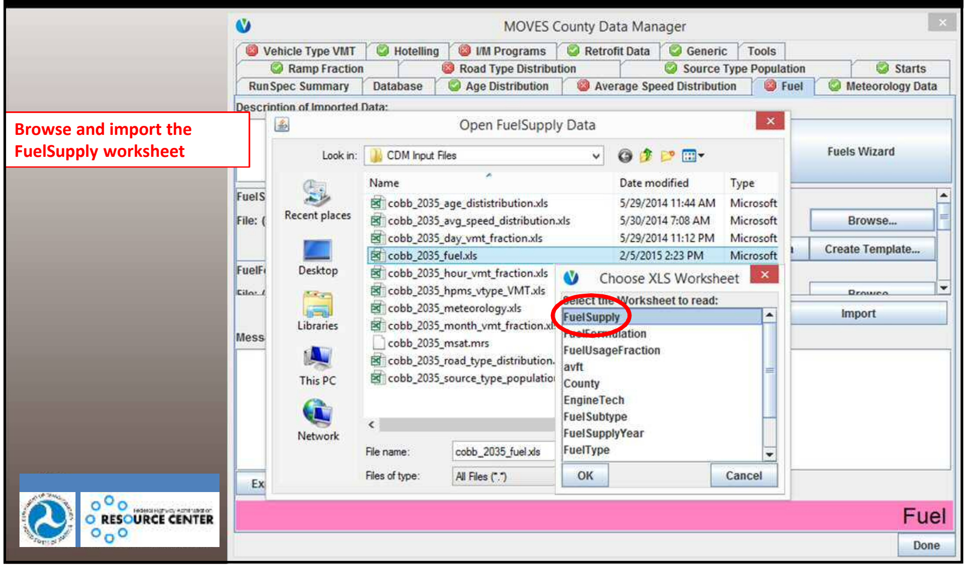
MSAT Inventory Exercise: Exporting Fuel Data

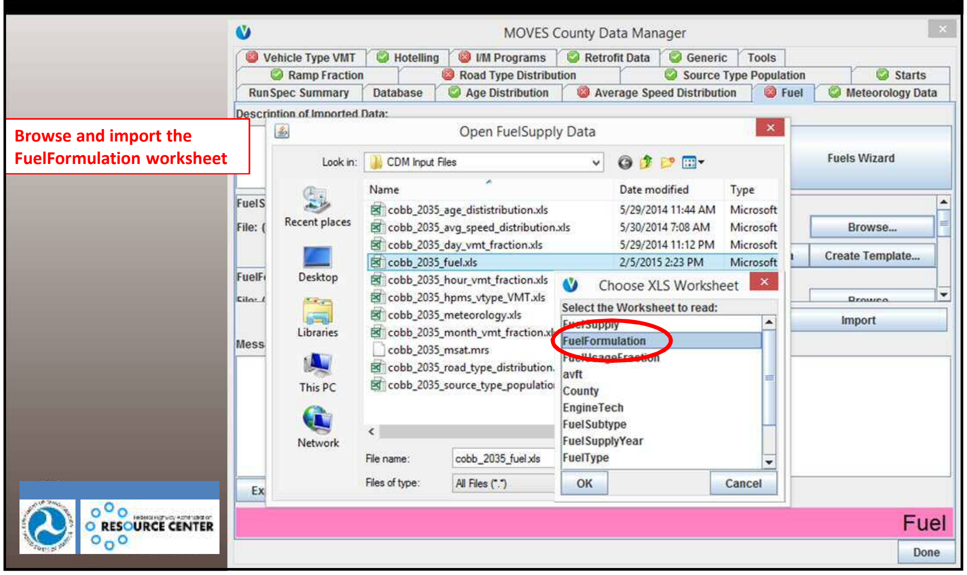
Export default data –
Save as cobb_2035_fuel.xls



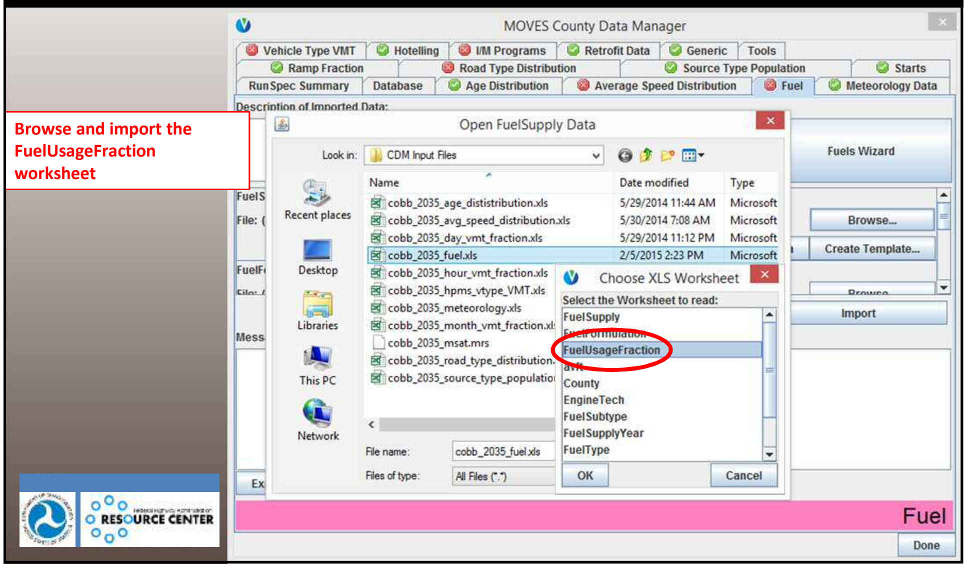
MSAT Inventory Exercise: Entering Fuel Supply Data



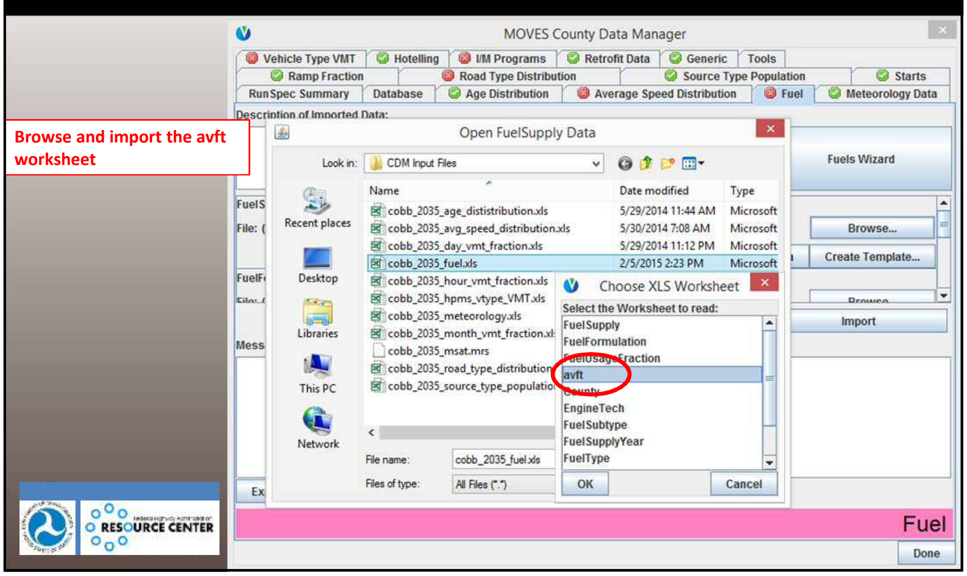
MSAT Inventory Exercise: Entering Fuel Formulation Data



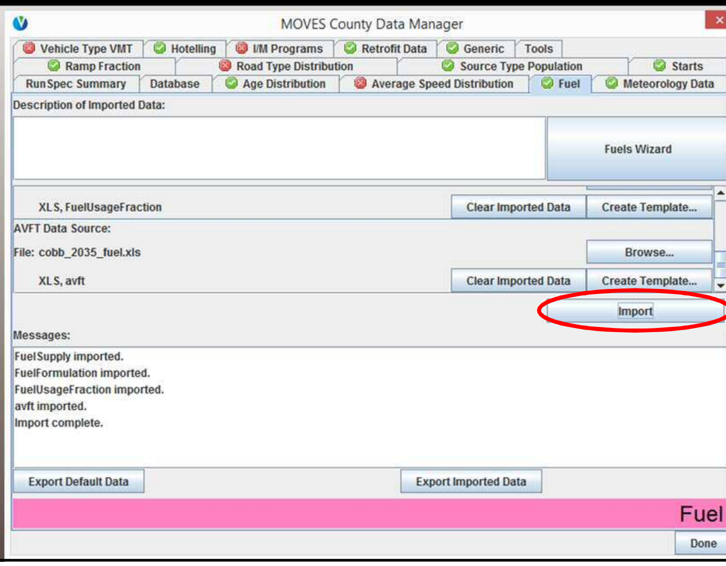
MSAT Inventory Exercise: Entering Fuel Usage Fraction Data



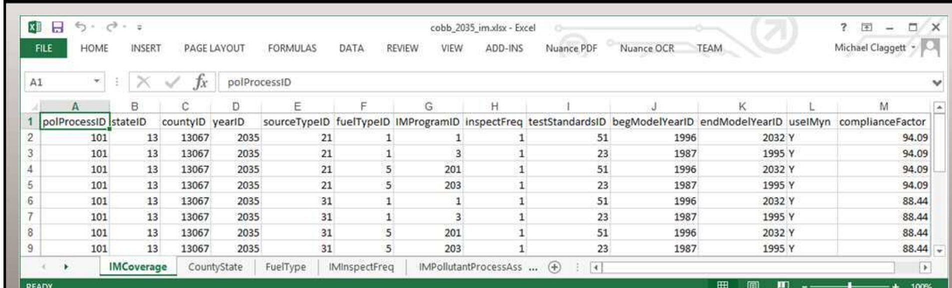
MSAT Inventory Exercise: Entering AVFT Data



MSAT Inventory Exercise: Importing Fuel Data



Inspection & Maintenance (I/M) Programs



polProcessID	stateID	countyID	yearID	sourceTypeID	fuelTypeID	IMProgramID	inspectFreq	testStandardsID	begModelYearID	endModelYearID	useIMyn	complianceFactor
101	13	13067	2035	21	1	1	1	51	1996	2032	Y	94.09
101	13	13067	2035	21	1	3	1	23	1987	1995	Y	94.09
101	13	13067	2035	21	5	201	1	51	1996	2032	Y	94.09
101	13	13067	2035	21	5	203	1	23	1987	1995	Y	94.09
101	13	13067	2035	31	1	1	1	51	1996	2032	Y	88.44
101	13	13067	2035	31	1	3	1	23	1987	1995	Y	88.44
101	13	13067	2035	31	5	201	1	51	1996	2032	Y	88.44
101	13	13067	2035	31	5	203	1	23	1987	1995	Y	88.44

- Only one I/M program can be applied to each pollutant-process, source type, fuel type, model year combination
- IMProgramID is arbitrary number but must be unique for each fuel type, inspection frequency, test standard combination

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I/M Programs: FHWA Recommendation

- Section 4.10 of MOVES Technical Guidance
- Use local input data, otherwise use defaults
  - Unique input data file needed for each analysis year; I/M program parameters may also vary by year
  - Should not vary by alternative

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I/M Programs: Exercise

- Let's enter our I/M data into the CDM for our MSAT inventory exercise
- ***Instructions:*** Export the default I/M data for Cobb County, and import the table into the I/M Programs tab

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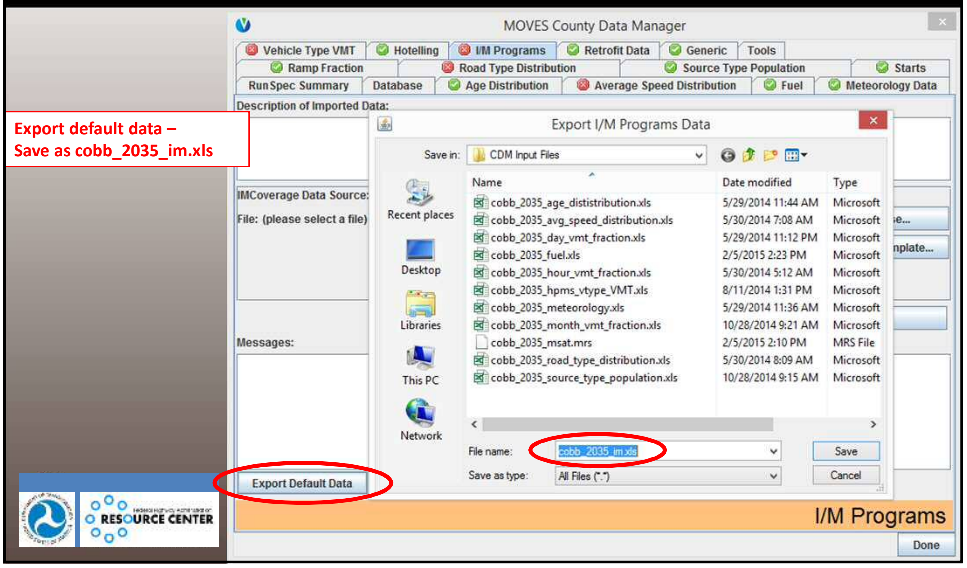
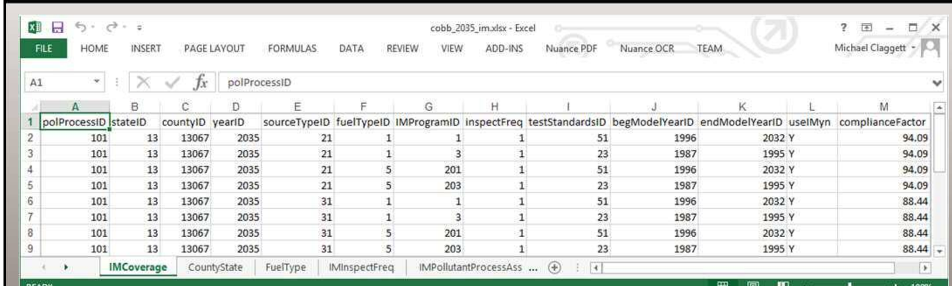
MSAT Inventory Exercise: Entering I/M Programs Data



MSAT Inventory Exercise: Entering I/M Programs Data

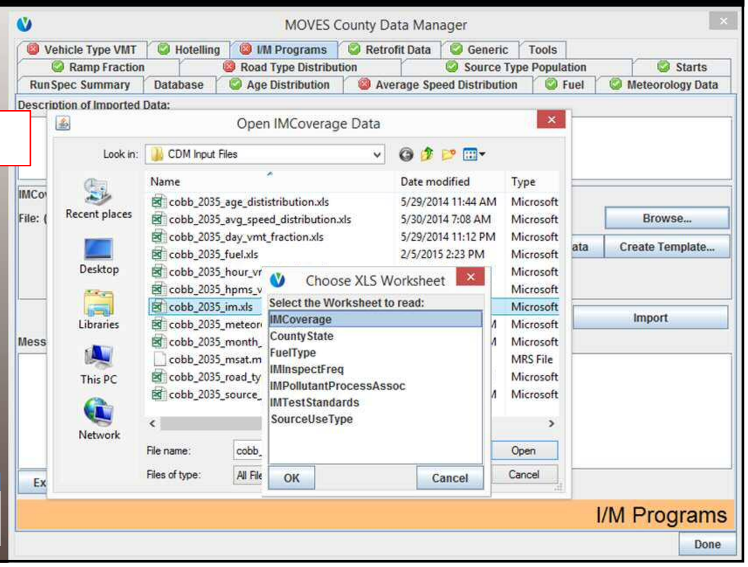


polProcessID	stateID	countyID	yearID	sourceTypeID	fuelTypeID	IMProgramID	inspectFreq	testStandardsID	begModelYearID	endModelYearID	useIMyn	complianceFactor
101	13	13067	2035	21	1	1	1	51	1996	2032	Y	94.09
101	13	13067	2035	21	1	3	1	23	1987	1995	Y	94.09
101	13	13067	2035	21	5	201	1	51	1996	2032	Y	94.09
101	13	13067	2035	21	5	203	1	23	1987	1995	Y	94.09
101	13	13067	2035	31	1	1	1	51	1996	2032	Y	88.44
101	13	13067	2035	31	1	3	1	23	1987	1995	Y	88.44
101	13	13067	2035	31	5	201	1	51	1996	2032	Y	88.44
101	13	13067	2035	31	5	203	1	23	1987	1995	Y	88.44

- cobb_2035_im_defaults.xls as exported with default data

MSAT Inventory Exercise: Entering I/M Programs Data

Browse and import the IMCoverage worksheet



Project-specific Traffic Data for MSAT Analysis

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Project-Specific Input Data from an Affected Transportation Network

- Average Speed Distribution
- Vehicle Miles Travelled
  - Annual VMT by HPMS class
  - Month, Day, Hour VMT fractions
- Road Type Distribution
- Ramp Fraction

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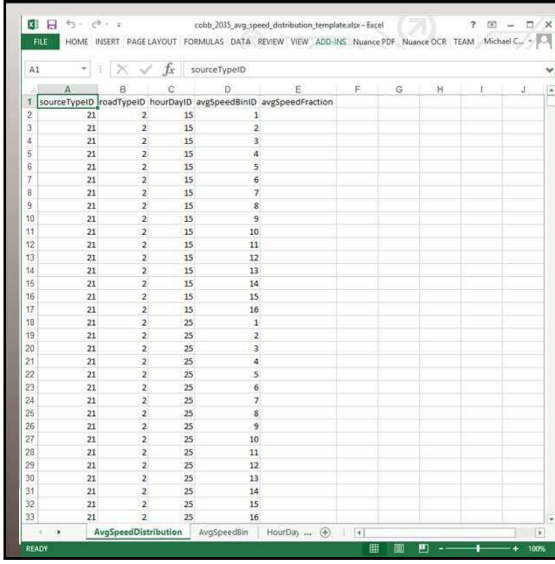
Average Speed Distribution



sourceTypeID	roadTypeID	hourDayID	avgSpeedBinID	avgSpeedFraction
21	2	15	1	
21	2	15	2	
21	2	15	3	
21	2	15	4	
21	2	15	5	
21	2	15	6	
21	2	15	7	
21	2	15	8	
21	2	15	9	
21	2	15	10	
21	2	15	11	
21	2	15	12	
21	2	15	13	
21	2	15	14	
21	2	15	15	
21	2	15	16	
21	2	25	1	
21	2	25	2	
21	2	25	3	
21	2	25	4	
21	2	25	5	
21	2	25	6	
21	2	25	7	
21	2	25	8	
21	2	25	9	
21	2	25	10	
21	2	25	11	
21	2	25	12	
21	2	25	13	
21	2	25	14	
21	2	25	15	
21	2	25	16	

- Avgerage Speed Distribution entered according to source type, road type, and hour-day
  - AvgSpeedFraction should sum to 1 within these fields
- MOVES has 16 speed bins ranging from 2.5 to 75+ mph

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Average Speed Distribution

- Average Speed Distribution is in terms of time, not distance (i.e. fraction of VHT, not VMT, in each speed bin)
- Speeds can vary by road type, hour, and vehicle type
  - Most analyses do not account for different speeds by vehicle type, but this can be a factor in some cases (e.g., lower truck speed limits)
- AvgSpeedDistribution table can be very long (~40,000+ rows) if RunSpec covers all source types, road types, day types, and hours
  - Some automation (or a lot of patience) needed to produce these files

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Average Speed Distribution: FHWA Recommendation

- Section 4.6 of MOVES Technical Guidance
- Local speed distribution data are needed, by year and alternative
  - Any project where the Purpose and Need includes congestion relief (almost all of them) needs speed inputs that vary by alternative
  - For temporal aspects, speed distribution data can be entered at the hourly level, but varying the speed distribution for peak and off-peak hours is also acceptable; however, daily average speeds will minimize the effects of congestion relief on the emissions calculations (see next slide)

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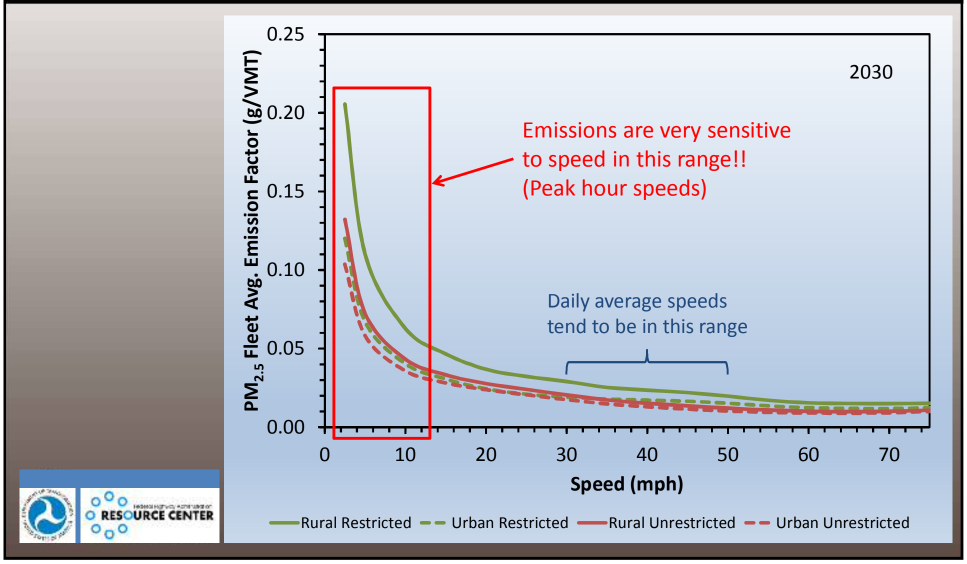
Example: $PM_{2.5}$ Trends by Vehicle Speed



Average Speed Distribution: FHWA Recommendation

- MOVES has four road types which are affected by the speed distribution
  - Urban restricted and rural restricted road types are generally interstates and highways
  - Urban unrestricted and rural unrestricted road types are generally arterials, collectors, and local roads
- If separate speed distributions are known for arterials, collectors, and local roads, calculate a weighted speed distribution that applies to all urban or rural unrestricted roads

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Average Speed Distribution: Working with Travel Model Data

- MPO travel demand forecasting (TDF) models typically produce link-level output that can be used to develop speed distributions, road type distributions and ramp fractions
- Output will need to be "mapped" to MOVES format
  - Map TDF model road types to MOVES road types
  - Map TDF model time periods to MOVES hours
  - If different vehicle types are modeled, map vehicle types to MOVES source types
  - If different geographic areas modeled (e.g., CBD, urban, suburban, etc.), map to MOVES urban and rural groups

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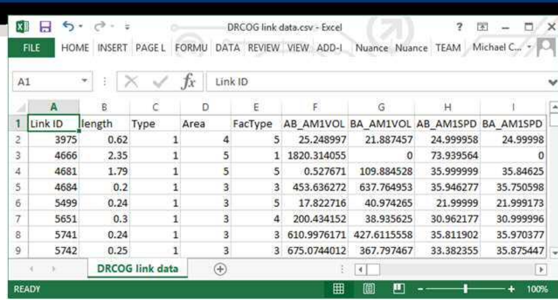
Average Speed Distribution Example Travel Model Output



Link ID	length	Type	Area	FacType	AB_AM1VOL	BA_AM1VOL	AB_AM1SPD	BA_AM1SPD
3975	0.62	1	4	5	25.248997	21.887457	24.999958	24.99998
4666	2.35	1	5	1	1820.314055	0	73.939564	0
4681	1.79	1	5	5	0.527671	109.884528	35.999999	35.84625
4684	0.2	1	3	3	453.636272	637.764953	35.946277	35.750598
5499	0.24	1	3	5	17.822716	40.974265	21.99999	21.999173
5651	0.3	1	3	4	200.434152	38.935625	30.962177	30.999996
5741	0.24	1	3	3	610.9976171	427.6115558	35.811902	35.970377
5742	0.25	1	3	3	675.0744012	367.797467	33.382355	35.875447

- Type = link type (highway, transit, etc.)
- Area = area type (CBD, urban, suburban, etc.)
- Factype = roadway type (freeway, major arterial, etc.)
- AB_AM1VOL = traffic volume in the A to B direction during the first a.m. time period
  - BA_AM1VOL = traffic volume in the B to A direction
- AB_AM1SPD = traffic speed in the A to B direction during the first a.m. time period
  - BA_AM1SPD = traffic speed in the B to A direction
- This example continues for 9 more time periods and ~ 19,000 more links

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Average Speed Distribution: Steps in Developing Speed Inputs

- Map to the four relevant MOVES road types
  - No VMT or VHT on RoadTypeID = 1 ("off-network")
  - Use only roadway links, not rail, bike, walk links
- Sort by speed bin
- Calculate VHT by speed bin and road type (link length times volume divided by speed = VHT)
  - If ramps coded separately, use only freeway mainline segments in VHT calculations, but still need to reflect ramp VMT in VMT inputs
- Sum total VHT by road type and then calculate bin fractions

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Average Speed Distribution: Steps in Developing Speed Inputs

- Repeat for each time period; map to MOVES hours
- If multiple vehicle types modeled, repeat for each vehicle group and map to MOVES source type
  - Some areas do separate traffic assignment for cars, trucks, and other classes
  - If bus transit links modeled separately, calculate speeds separately and use these speeds for the transit bus source type)
- If multiple area types, then map to rural and urban
  - Can also handle as zones in MOVES2010b

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Using Wildcards

- Wildcards allow you to populate multiple rows of a database table with identical information
  - e.g., using the same speed for all vehicle types, or both weekdays and weekends
  - See page 66 of the MOVES2010b Users Guide

The affected fields are:

Column	Wildcard
dayID	ALL
hourID	ALL
hourDayID	ALL ALL Weekday ALL 5 5* *5 ALL Weekend ALL 2 2* *2
monthID	ALL
yearID	ALL *Note: Only one year is allowed in the CDM.*
roadTypeID	ALL
sourceTypeID	ALL 1* - Applies to all motorcycles 2* - Applies to all passenger cars 3* - Applies to all passenger trucks 4* - Applies to all buses 5* - Applies to all single unit trucks 6* - Applies to all combination trucks
hpmsVTypeID	ALL
countyID	ALL *Note: Only one county is allowed in the CDM.*
zoneID	ALL

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Another Option: EPA's "MOBILE6 Converter"

- "Average Speed Converter MOBILE6", posted at www.epa.gov/otaq/models/moves/tools.htm
- Starting with project travel data, develop VMT (not VHT) fractions for the 14 MOBILE6 speed bins, and copy into the tool
  - Tool uses input format identical to the "SPEED VMT" inputs in MOBILE6
  - If rural and urban roads selected in RunSpec, both inputs needed

Another Option: EPA's "MOBILE6 Converter"

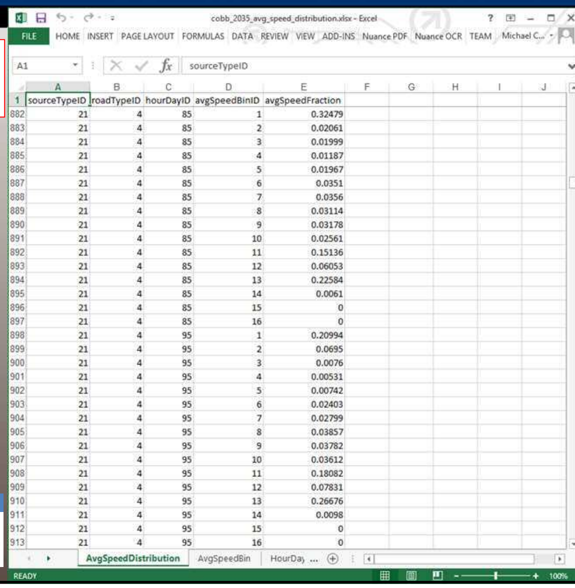
- Tool automatically creates a correctly formatted and fully populated MOVES input spreadsheet, with same speed distribution for all vehicle types and day types
- "Average Speed Converter MOBILE6", posted at www.epa.gov/otaq/models/moves/tools.htm
- Starting with project travel data, develop VMT (not VHT) fractions for the 14 MOBILE6 speed bins, and copy into the tool
  - Input format identical to the "SPEED VMT" inputs in MOBILE6
  - If rural and urban roads selected in RunSpec, both inputs are needed

Average Speed Distribution: Exercise

- ***Instructions:*** Review cobb_2035_avg_speed_distribution.xls and import into the Average Speed Distribution tab

MSAT Inventory Exercise: Entering Average Speed Distribution Data

Contents of cobb_2035_avg_speed_distribution.xls



cobb_2035_avg_speed_distribution.xlsx - Excel

	sourceTypeID	roadTypeID	hourDayID	avgSpeedBinID	avgSpeedFraction
882	21	4	85	1	0.32479
883	21	4	85	2	0.02061
884	21	4	85	3	0.01999
885	21	4	85	4	0.01187
886	21	4	85	5	0.01967
887	21	4	85	6	0.0351
888	21	4	85	7	0.0356
889	21	4	85	8	0.03114
890	21	4	85	9	0.03178
891	21	4	85	10	0.02561
892	21	4	85	11	0.15136
893	21	4	85	12	0.06053
894	21	4	85	13	0.22584
895	21	4	85	14	0.0061
896	21	4	85	15	0
897	21	4	85	16	0
898	21	4	95	1	0.20994
899	21	4	95	2	0.0695
900	21	4	95	3	0.0076
901	21	4	95	4	0.00531
902	21	4	95	5	0.00742
903	21	4	95	6	0.02403
904	21	4	95	7	0.02799
905	21	4	95	8	0.03857
906	21	4	95	9	0.03782
907	21	4	95	10	0.03612
908	21	4	95	11	0.18082
909	21	4	95	12	0.07831
910	21	4	95	13	0.26676
911	21	4	95	14	0.0098
912	21	4	95	15	0
913	21	4	95	16	0

AvgSpeedDistribution | AvgSpeedBin | HourDay ...

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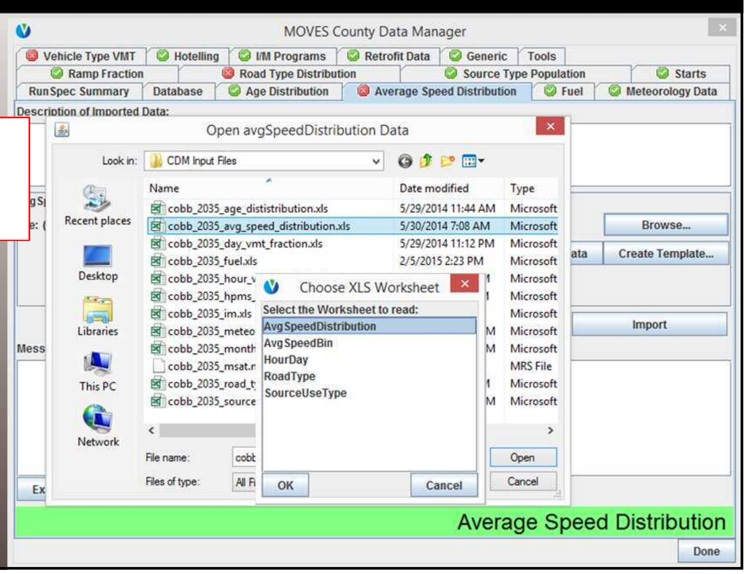
MSAT Inventory Exercise: Entering Average Speed Distribution Data

Browse and import the AvgSpeedDistribution Worksheet from cobb_2035_avg_speed_distribution.xls



Vehicle Type VMT

- MOVES requires annual VMT but also VMT fractions by month, day, and hour
- Annual VMT is entered for each HPMS vehicle class; others by MOVES source type
- Month VMT fractions
  - Fraction of annual VMT (per source type) occurring per month
- Day VMT fractions
  - Fraction of monthly VMT (per source type and road type) occurring on one of two day types (weekday or weekend)

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Vehicle Type VMT

- Hour VMT fractions
  - Fraction of daily VMT (per source type and road type and day type) occurring per hour

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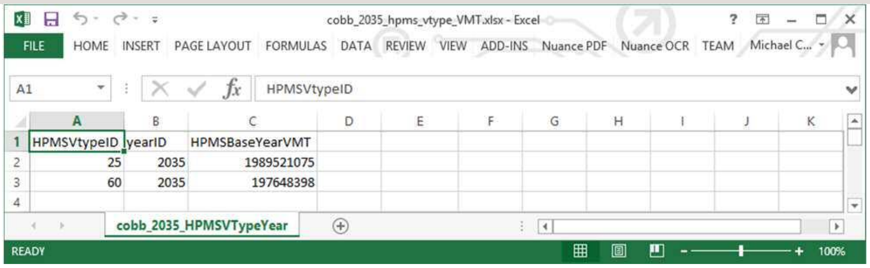
Vehicle Type VMT



HPMSVtypeID	yearID	HPMSBaseYearVMT
25	2035	1989521075
60	2035	197648398

- VMT is entered for each HPMS vehicle class
  - light-duty HPMS classes revised in MOVES2014: passenger cars and light trucks combined
- VMT will vary by year and alternative

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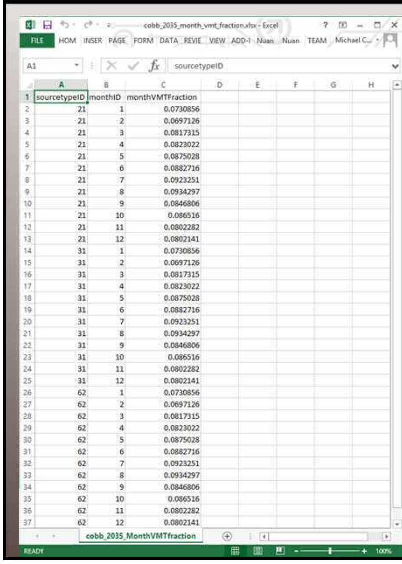
Vehicle Type VMT: Month VMT Fraction



sourcetypeID	monthID	monthVMTFraction
21	1	0.0730856
21	2	0.0697126
21	3	0.0817315
21	4	0.0823022
21	5	0.0875028
21	6	0.0882716
21	7	0.0923251
21	8	0.0934297
21	9	0.0846806
21	10	0.086516
21	11	0.0802282
21	12	0.0802141
31	1	0.0730856
31	2	0.0697126
31	3	0.0817315
31	4	0.0823022
31	5	0.0875028
31	6	0.0882716
31	7	0.0923251
31	8	0.0934297
31	9	0.0846806
31	10	0.086516
31	11	0.0802282
31	12	0.0802141
62	1	0.0730856
62	2	0.0697126
62	3	0.0817315
62	4	0.0823022
62	5	0.0875028
62	6	0.0882716
62	7	0.0923251
62	8	0.0934297
62	9	0.0846806
62	10	0.086516
62	11	0.0802282
62	12	0.0802141

- MonthVMTFraction must sum to 1 within each source type over a 12-month period
- In MOVES2010b, "isLeapYear" field (not shown here) must match year selected in the RunSpec for MOVES to run properly
  - e.g., "Y" if the RunSpec year is a leap year, "N" if not

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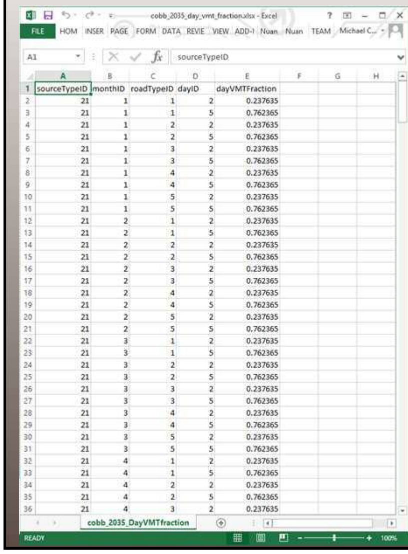
Vehicle Type VMT : Day VMT Fraction



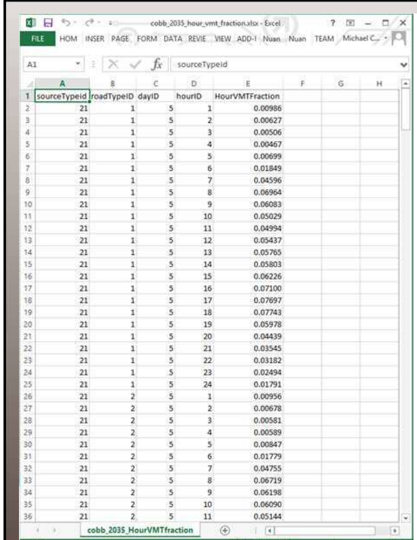
cobb_2035_day_vmt_fraction.xlsx - Excel

sourceTypeID	monthID	roadTypeID	dayID	dayVMTFraction
21	1	1	2	0.237635
21	1	1	5	0.762365
21	1	2	2	0.237635
21	1	2	5	0.762365
21	1	3	2	0.237635
21	1	3	5	0.762365
21	1	4	2	0.237635
21	1	4	5	0.762365
21	1	5	2	0.237635
21	1	5	5	0.762365
21	2	1	2	0.237635
21	2	1	5	0.762365
21	2	2	2	0.237635
21	2	2	5	0.762365
21	2	3	2	0.237635
21	2	3	5	0.762365
21	2	4	2	0.237635
21	2	4	5	0.762365
21	2	5	2	0.237635
21	2	5	5	0.762365
21	3	1	2	0.237635
21	3	1	5	0.762365
21	3	2	2	0.237635
21	3	2	5	0.762365
21	3	3	2	0.237635
21	3	3	5	0.762365
21	3	4	2	0.237635
21	3	4	5	0.762365
21	3	5	2	0.237635
21	3	5	5	0.762365
21	4	1	2	0.237635
21	4	1	5	0.762365
21	4	2	2	0.237635
21	4	2	5	0.762365
21	4	3	2	0.237635

cobb_2035_DayVMTfraction

- DayVMTFraction must sum to 1 within each source type, month, road type combination
- DayVMTFraction is in terms of the fraction of VMT on each type of day throughout the entire month
  - i.e., ~22 weekdays and 9 weekend days in a 31 day month; 22/31 = 0.71, similar to default values

Vehicle Type VMT : Hour VMT Fraction



cobb_2035_hour_vmt_fraction.xlsx - Excel

sourceTypeid	roadTypeID	dayID	hourID	HourVMTFraction
21	1	5	1	0.00986
21	1	5	2	0.00627
21	1	5	3	0.00506
21	1	5	4	0.00467
21	1	5	5	0.00699
21	1	5	6	0.01849
21	1	5	7	0.04596
21	1	5	8	0.06964
21	1	5	9	0.06083
21	1	5	10	0.05029
21	1	5	11	0.04994
21	1	5	12	0.05437
21	1	5	13	0.05765
21	1	5	14	0.05803
21	1	5	15	0.06226
21	1	5	16	0.07100
21	1	5	17	0.07697
21	1	5	18	0.07743
21	1	5	19	0.05978
21	1	5	20	0.04439
21	1	5	21	0.03545
21	1	5	22	0.03182
21	1	5	23	0.02494
21	1	5	24	0.01791
21	2	5	1	0.00956
21	2	5	2	0.00678
21	2	5	3	0.00581
21	2	5	4	0.00589
21	2	5	5	0.00847
21	2	5	6	0.01779
21	2	5	7	0.04755
21	2	5	8	0.06719
21	2	5	9	0.06198
21	2	5	10	0.06090
21	2	5	11	0.05144

cobb_2035_HourVMTfraction

- HourVMTFraction must sum to 1 within each source type, road type, type of day combination
- HourVMTFraction is applied to all months
  - If data varies for different months, you will need to run different RunSpecs for each

Annual VMT and VMT Fractions: FHWA Recommendation

- Section 4.5 of MOVES Technical Guidance
- Year- and alternative-specific annual VMT data are required
  - Required for 5 HPMS vehicle classes (6 classes in MOVES2010)
  - Total VMT for the project alternatives can be allocated to HPMS classes using count data, or the relative fractions used in any regional emissions analysis
    - e.g., for SIP inventories or conformity
  - Can also get a default split by running MOVES at the National scale and selecting Distance in the output
    - group the related sourcetypes to get VMT by HPMS class

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Annual VMT and VMT Fractions: FHWA Recommendation

- Local VMT month, day, and hour fractions should be used if data are available; otherwise, defaults are acceptable
- Troubleshooting suggestion: once you have annual VMT by HPMS class and the three different fractions (month/day/year), do a test run in MOVES to make sure that the combination of these inputs results in the correct daily VMT, and that the VMT by sourcetype looks reasonable
  - select "Distance" and "Source Use Type" in the output to see what VMT MOVES calculated based on your inputs

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Annual VMT and VMT Fractions: FHWA Recommendation

- More advice: run this test before you do all the MOVES runs for your analysis!

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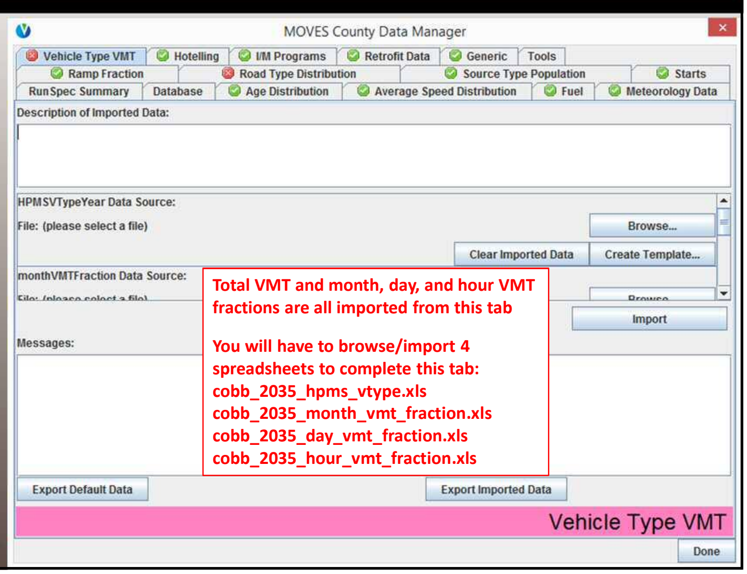
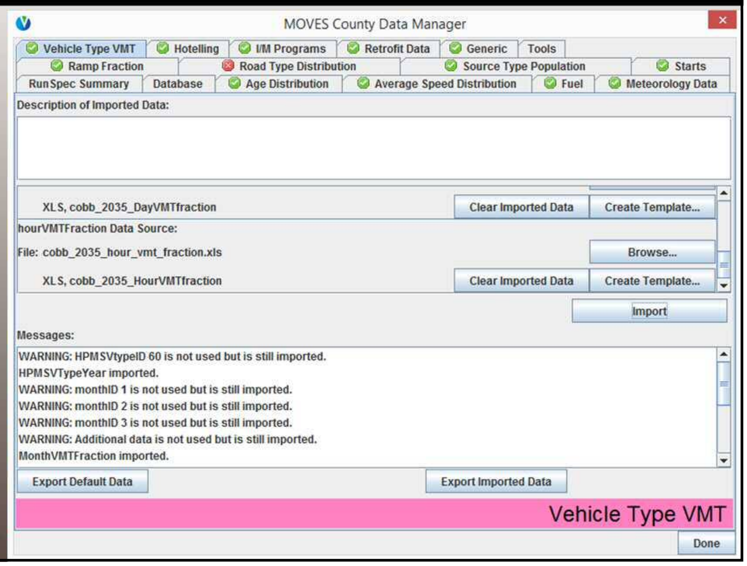
MSAT Inventory Exercise: Entering Vehicle Type VMT Data

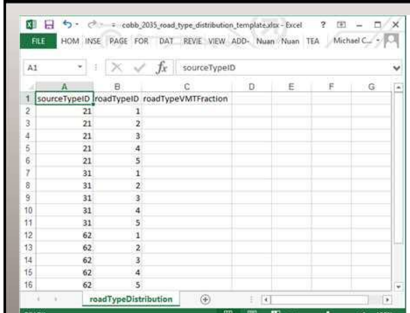


MSAT Inventory Exercise: Entering Vehicle Type VMT Data

Import Complete



Road Type Distribution



sourceTypeID	roadTypeID	roadTypeVMTFraction
21	1	
21	2	
21	3	
21	4	
21	5	
31	1	
31	2	
31	3	
31	4	
31	5	
62	1	
62	2	
62	3	
62	4	
62	5	

- RoadTypeVMTFraction is the fraction of VMT (distance, not time) on each road type by a source type

Road Type Distribution

- Fractions should sum to 1 within each source type
- A Road Type 1 (Off-network) should always have a RoadTypeVMTFraction value of zero
  - No VMT on an off-network MOVES link
  - Off-network not used in MSAT analysis
- All road types appear in the template even if they were not selected in the RunSpec
  - Any VMT assigned to a road type not selected in the RunSpec will not be accounted for in MOVES output
  - Make sure that road types reflected in road type distribution are consistent with road types selected in the RunSpec

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Road Type Distribution: FHWA Recommendation

- Section 4.7 of MOVES Technical Guidance
- Users should develop road type distribution data based on project-specific information
  - Should vary by year and alternative
  - Especially important if project shifts VMT from one road type to another (e.g., from arterial to freeway)
- If source type-specific data are not available, the same road type distribution can be used for all source types
  - However, in many cases, road type distributions vary for source types (e.g., transit bus vs. intercity bus, truck limitations), so source type- specific information is encouraged

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Road Type Distribution: Using Travel Model Outputs

- Travel model link volumes can be used to develop road type distribution fractions
  - Map to MOVES road types
    - If ramps coded separately, ramps are included as part of restricted access road If ramps coded separately, ramps are included as part of restricted access road
  - Calculate VMT by road type (length times volume)
  - Sum by link and road type across all time periods (MOVES road type distribution inputs do not vary by hour)
  - Calculate fractions that sum to one
    - If ramps coded separately, ramps are included as part of restricted access road
  - Repeat for each vehicle group, as needed

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Road Type Distribution: Exercise

- Let's enter our road type distribution data into the CDM for our MSAT inventory exercise
- The template has been filled out with our local road type distribution and is available as file –

  cobb_2035_road_type_distribution.xls
- ***Instructions:*** Review cobb_2035_road_type_distribution.xls and import into the Road Type Distribution tab

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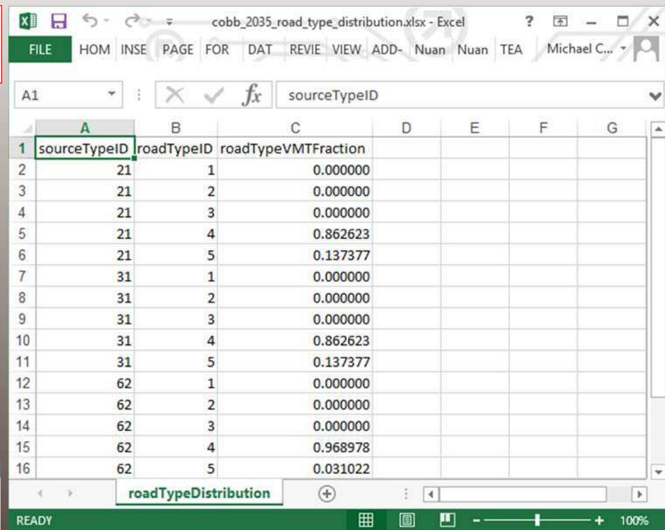
MSAT Inventory Exercise: Entering Road Type Distribution Data

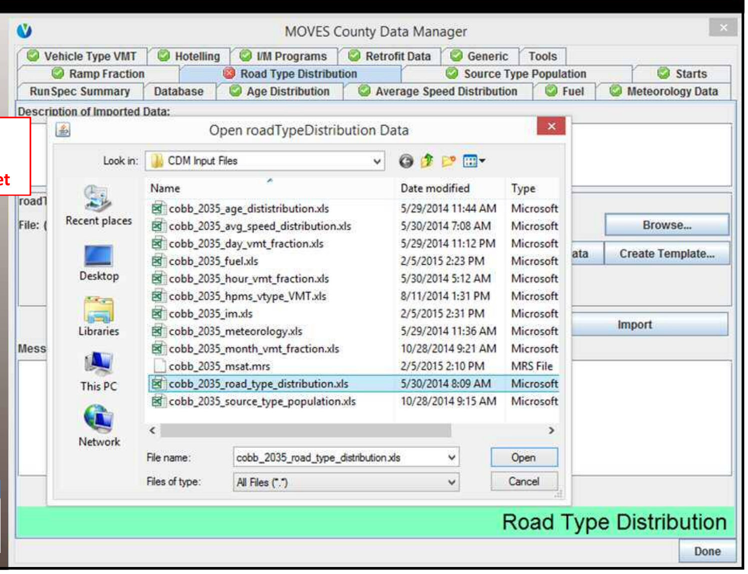
Contents of cobb_2035_road_type_distribution.xls



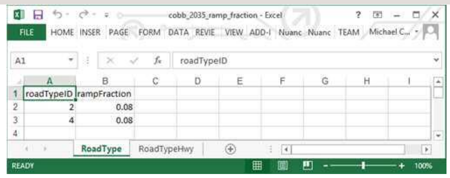
sourceTypeID	roadTypeID	roadTypeVMTFraction
21	1	0.000000
21	2	0.000000
21	3	0.000000
21	4	0.862623
21	5	0.137377
31	1	0.000000
31	2	0.000000
31	3	0.000000
31	4	0.862623
31	5	0.137377
62	1	0.000000
62	2	0.000000
62	3	0.000000
62	4	0.968978
62	5	0.031022

MSAT Inventory Exercise: Entering Road Type Distribution Data

Browse and import the cobb_2035_road_type_distribution.xls spreadsheet



Ramp Fraction



- RampFraction is the fraction of time (not distance) spent on ramps as compared to the total time on restricted roadways and ramps
  – A restricted road type must have been selected in the Road Type panel to be able to import Ramp Fraction data
- This tab starts with a green check. A default ramp fraction of 0.08 (8%) will be applied if this fraction is not changed

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Ramp Fraction: FHWA Recommendation

- Section 4.8 of MOVES Technical Guidance
- Project-specific data should be used if available, but otherwise default values of 8% are acceptable
  – May vary by alternative
    - e.g., building a new interchange probably increases ramp activity on the network
  – May vary by year

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Ramp Fraction: Using Travel Model Outputs

- If ramps coded separately, ramp fraction can be calculated from travel model link volumes
- Calculate freeway, ramp, and total freeway + ramp VHT
  - does not vary by hour or source type
- Calculate ramp fraction
- Separate calculation for urban and rural

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Ramp Fraction: Exercise

- Let's enter our ramp fraction data into the CDM for our MSAT inventory exercise
- Our local ramp fractions for rural and urban unrestricted road types are 12%
- The MOVES ramp fraction default (8%) must therefore be changed
- ***Instructions:*** Export the default data, change the fractions to 12%, and import the table into the Ramp Fraction tab

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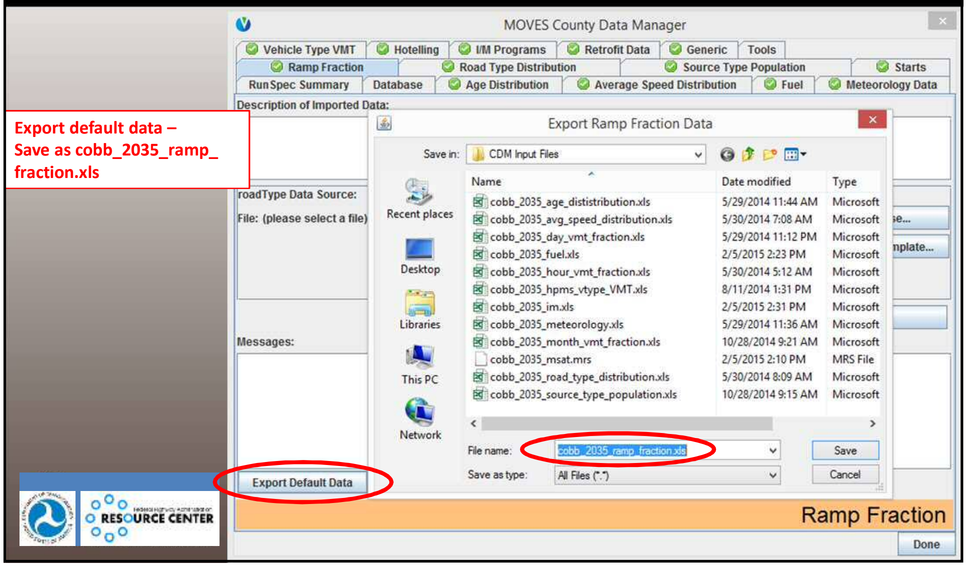
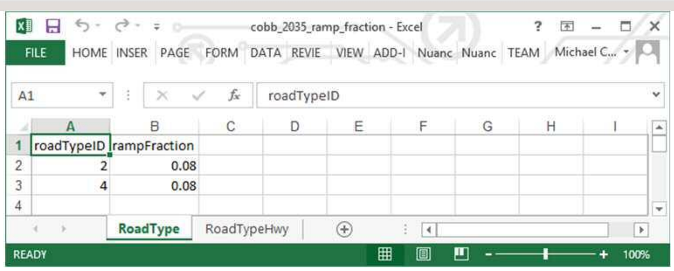
MSAT Inventory Exercise: Entering Ramp Fraction Data

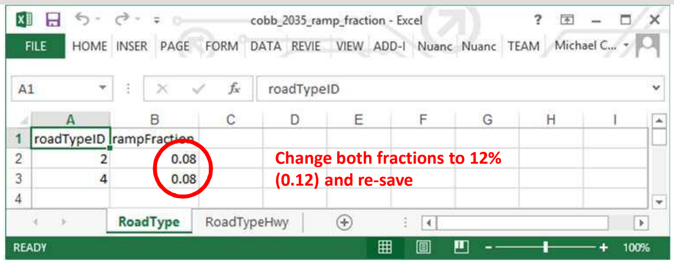


MSAT Inventory Exercise: Entering Ramp Fraction Data



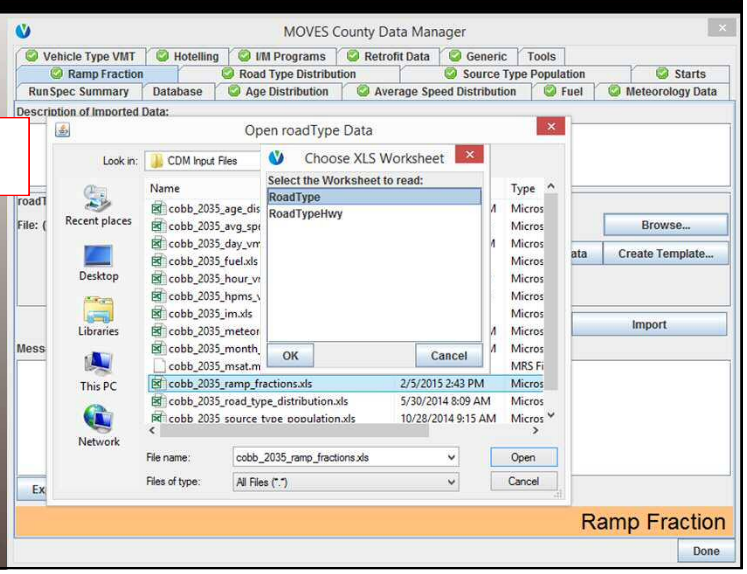
- cobb_2035_ramp_fraction.xls as exported with default data

MSAT Inventory Exercise: Entering Ramp Fraction Data



MSAT Inventory Exercise: Entering Ramp Fraction Data

Browse and import the updated RoadType worksheet



Other CDM Tabs: Generic

- The Generic tab allows advanced users to enter data into the many tables used by MOVES to complete its calculations
- In general, most users will not have a reason to enter data through this tab
- ***Instructions:*** We will not be adjusting any of the tables in this tab for our exercise

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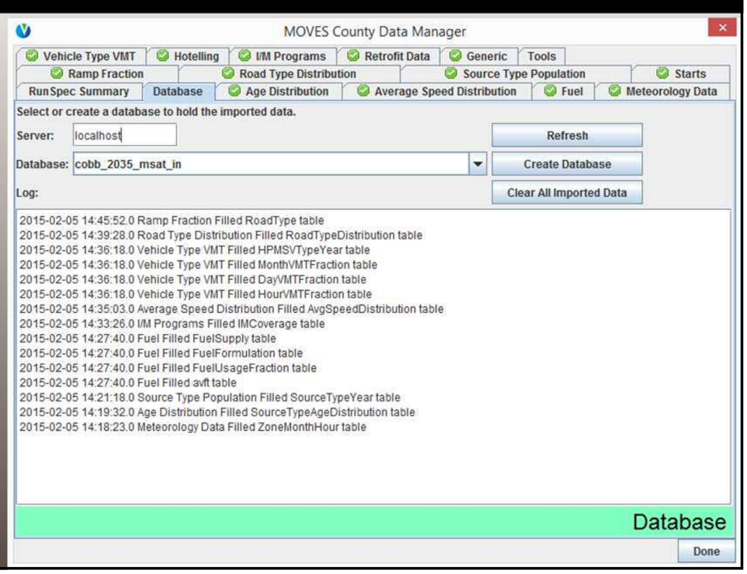
MSAT Inventory Exercise: All Data Imported



RESOURCE CENTER

Running MOVES
(Executing the RunSpec)

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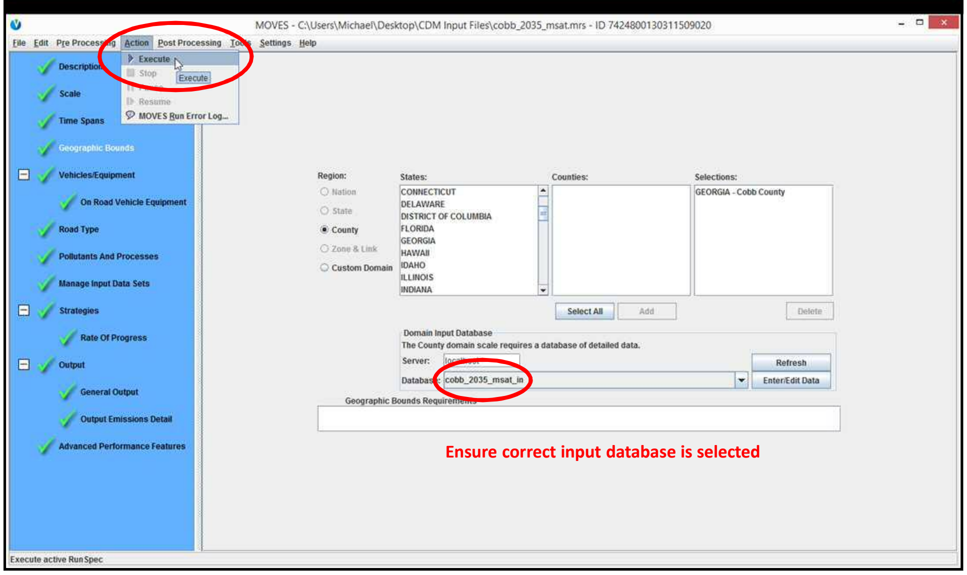
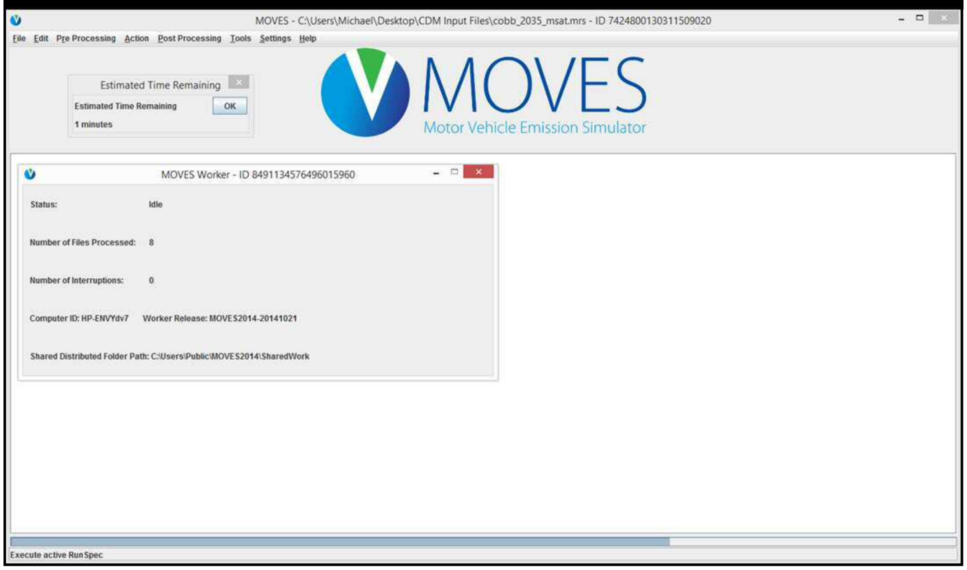
Executing the RunSpec

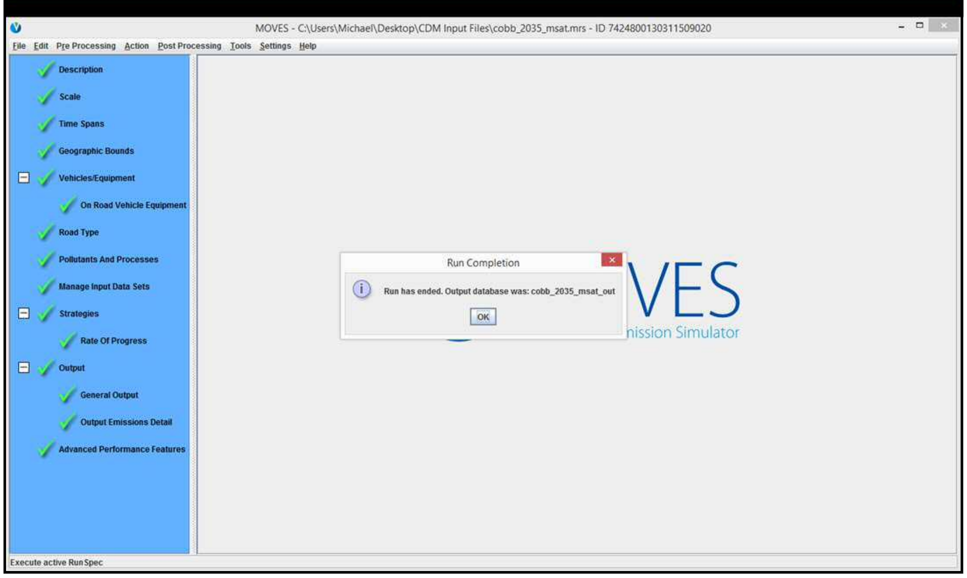


Ensure correct input database is selected

MOVES Running



Run Complete



Working with MOVES Output

MOVES Output: General

- All of the results of a MOVES run are stored in MySQL database tables
- These results can be accessed by
  - Using MOVES summary reporter
  - Using MySQL query commands and/or the MySQL Workbench (or MySQL Query Browser)
  - Using Microsoft Access with a MySQL Open Database Connectivity (ODBC)
- Any table may be exported to other applications (e.g, MS Excel) for further processing

Output Database Tables

- The MOVES output database contains numerous output tables with results, input data, and other information
- MOVESOutput table
  – Contains the quantity of emissions (by sourcetype, pollutant/process, etc., based on output detail selections made in the RunSpec)
- MOVESActivityOutput table
  – Contains the distance (useful to ensure no VMT was "lost")
- MOVESRun table
  – Information about the run (e.g., date/time of run, domain and scale, units selected)

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Output Database Tables

- Some tables are only populated when doing an Emission Rates run (not relevant to Inventory run)
  – RatePerDistance
  – RatePerVehicle
  – RatePerProfile
- Some tables are useful for diagnostic purposes
  – ActivityType
  – MOVESError
  – MOVESTablesUsed
  – MOVESWorkersUsed
  – MOVESEventLog

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Using the MOVES Post-Processing Menu

- Use this menu option only after you have completed a run
- Select an existing output database using the RunSpec used to generate the results
  - If you are interesting in doing any post-processing from the Post-Processing Menu, it's often easiest if you immediately do so upon conclusion of the run
- Options for processing output include
  - Execute any MySQL scripts that come embedded in MOVES
  - Summarize results into text files
  - Graphically represent results in a county map

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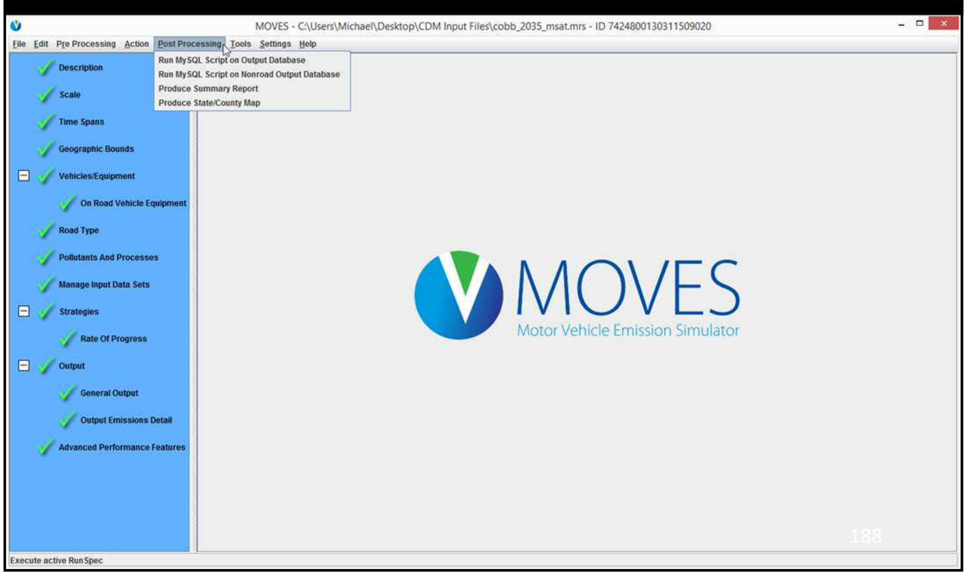
MOVES Post-Processing Menu



Post-Processing Menu: Run MySql Script on Output Database

- The scripts are applied to the current output database selected in the RunSpec
- You can select previous runs from the database using the MOVES Run Error Log window from the pull down Action menu
- There are several MySQL command scripts stored in the /database/OutputProcessingScripts folder of the MOVES application installation
- Users may write their own scripts and add them to the folder or add scripts obtained from other users

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Post-Processing Scripts

- Read the script documentation before running MOVES
  - Project-scale scripts may require that you run MOVES is a particular way
  - Scripts may require running with a specific calculation type or certain units in the output
- Send ideas for useful scripts to mobile@epa.gov

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Post-Processing Scripts in MOVES

Script Title	Description
DecodeMOVESOutput.sql	Decodes most key fields of MOVESOutput and MOVESActivityOutput tables
EmissionRates.sql	Produces an output table which reports the emission results in units of mass per distance
TabbedOutput.sql	Produces tab-delimited output suitable for reading into an EXCEL Spreadsheet from the MOVES MySQL database output tables

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Post-Processing Scripts in MOVES: Project Scale

Script Title	Description
CO_CAL3QHC_EF.sql	Produces CO emission rates for use in the CAL3QHC air quality model
CO_Grams_Per_Hour.sql	Produces CO emission rates as grams per hour for each link (project-scale runs)
CO_Grams_Per_Veh_Mile.sql	Produces CO emission rates as grams per vehicle-mile for each link (project-scale runs)
PM10_Grams_Per_Hour.sql	Produces PM10 emission rates as grams per hour for each link (project-scale runs)
PM10_Grams_Per_Veh_Mile.sql	Produces PM10 emission rates as grams per vehicle-mile for each link (project-scale runs)
PM25_Grams_Per_Hour.sql	Produces PM2.5 emission rates as grams per hour for each link (project-scale runs)
PM25_Grams_Per_Veh_Mile.sql	Produces PM2.5 emission rates as grams per vehicle-mile for each link (project-scale runs)

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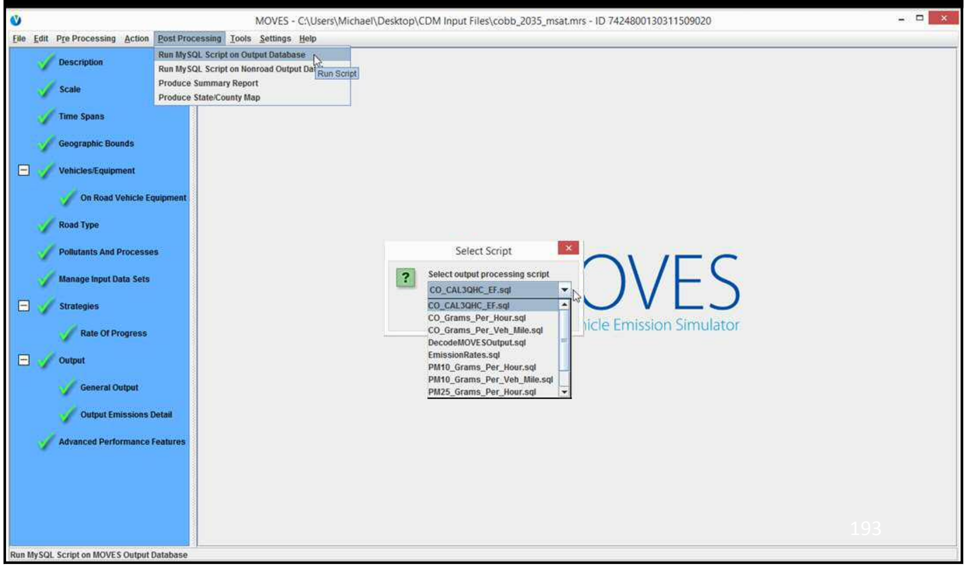
Selecting a MySQL Output Processing Script



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Use the Summary Reporter

- To minimize post-MOVES spreadsheet errors, use summary reporter in the post-processing menu to generate reports of results
- Can generate reports in multiple levels of detail (e.g., all vehicle types combined, and by individual vehicle type)

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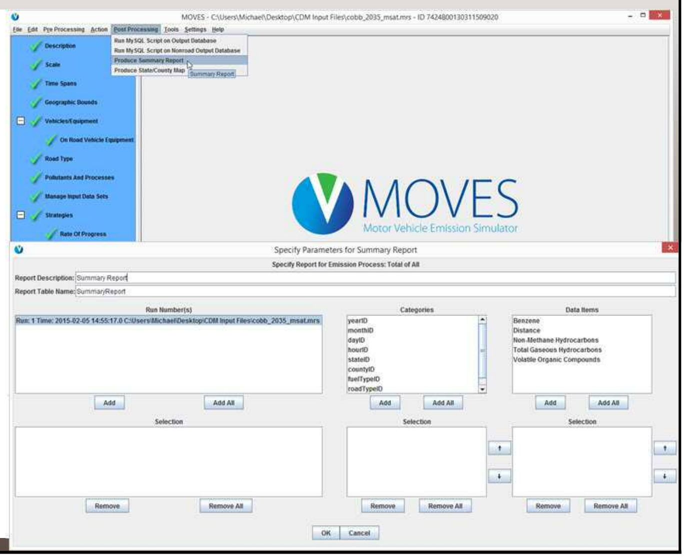
Post-Processing Menu: Summary Report

- Uses the output tables in the database referenced in the current RunSpec
- Reports output emissions and activity in varying levels of detail, based on selections by the user



Other Post-Processing Options

- Export the data using MySQL script
- Export the data using MySQL Workbench or MySQL Query Browser
  – CSV
  – MS Excel
  – PLIST
- Use the data from MS Access using the ODBC

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MySQL Workbench

- Provided with the MOVES model installation suite
- Oracle's new integrated environment for:
  - Database administration (replacing MySQL Administrator)
  - SQL development (replacing MySQL Query Browser)
- Workbench maintains the same basic functionality of Query Browser for MOVES-related database work

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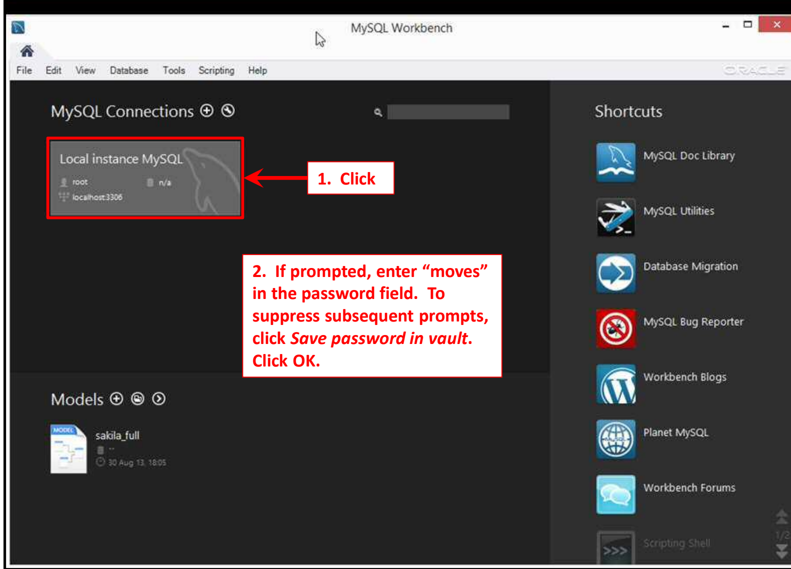
MySQL Workbench: Password



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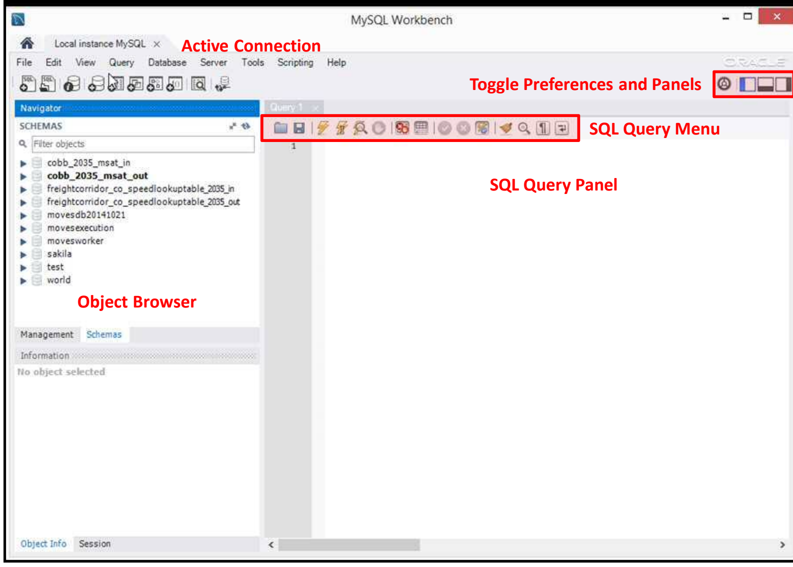
MySQL Workbench: Layout



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MySQL Workbench: SQL Query Menu

From left to right, these buttons are:

- ***Open a SQL Script File:*** Loads a saved SQL script to be ready for execution
- ***Save SQL Script to File:*** Saves the current SQL script to a specified file
- ***Execute SQL Script:*** Executes the selected portion of the query, or the entire query if nothing is selected
- ***Execute Current SQL Script:*** Execute the statement under the keyboard cursor
- ***Explain:*** Execute the EXPLAIN command on the query after the keyboard cursor
- ***Stop the Query being Executed:*** Halts execution of the currently executing SQL script
- ***Toggle Whether Execution of SQL Script should Continue after Failed Statements:*** If the red "breakpoint" circle is displayed, the script terminates on a statement that fails. If the button is depressed so that the green arrow is displayed, execution continues past the failed code, possibly generating additional results sets. In either case, any error generated from attempting to execute the faulty statement is recorded in the Output tab sheet
- ***Commit:*** Commits the current transaction*
- ***Rollback:*** Rolls back the current transaction*
- ***Toggle Auto-Commit Mode:*** If selected, each statement will be committed independently*
- ***Beautify SQL:*** Beautify/reformat the SQL script
- ***Find Panel:*** Show the Find panel for the editor
- ***Invisible Characters:*** Toggle display of invisible characters, such as new lines, tabs, or spaces
- ***Wrapping:*** Toggles the wrapping of long lines in the SQL editor window

*Note: All query tabs in the same connection share the same transactions; to have independent transactions, a new connection must be open

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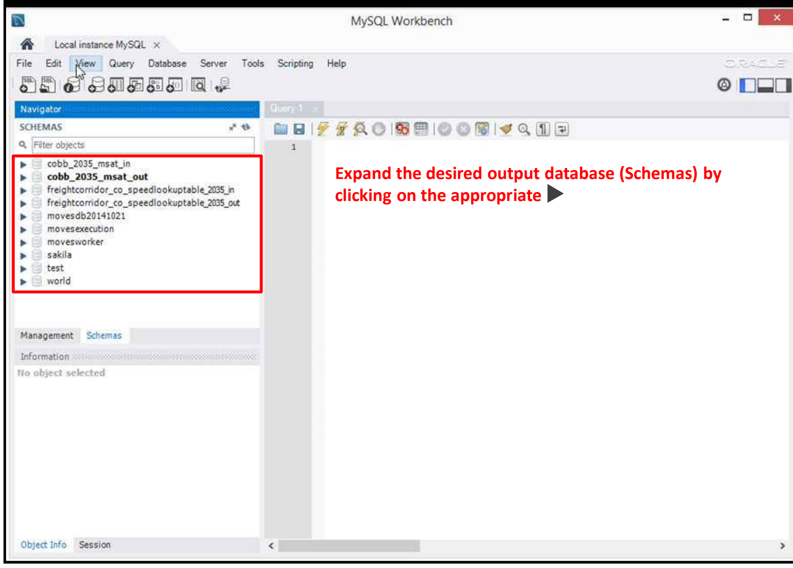
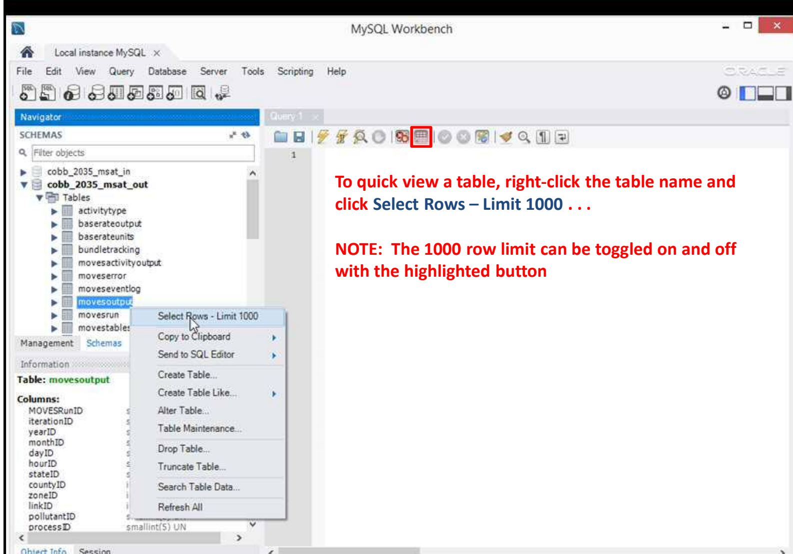
MySQL Workbench: Basics



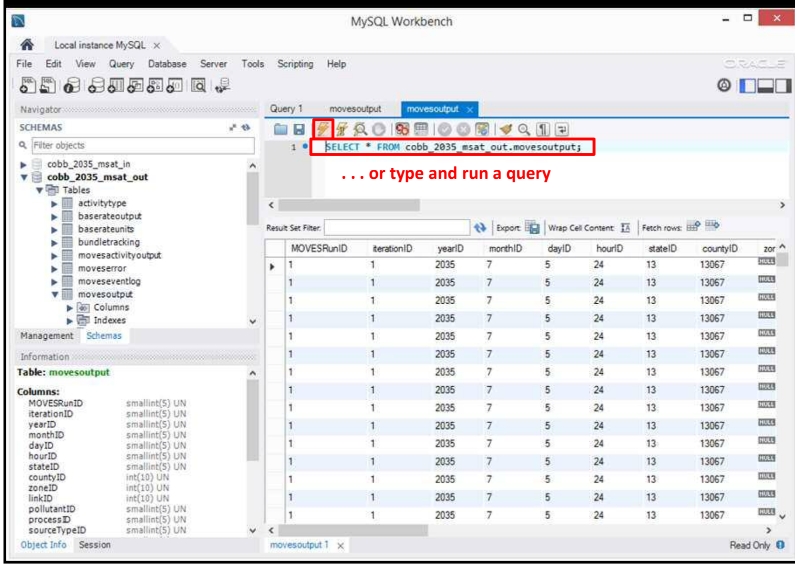
201

MySQL Workbench: Basics



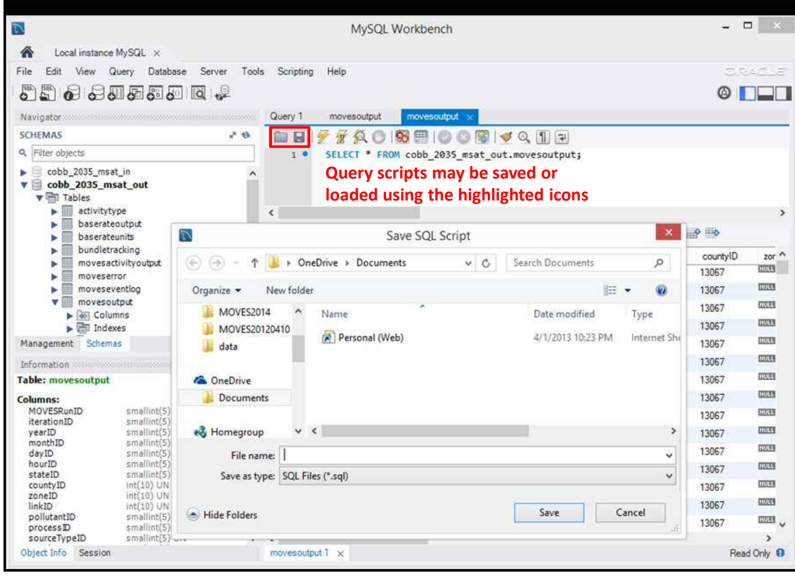
202

MySQL Workbench: Basics



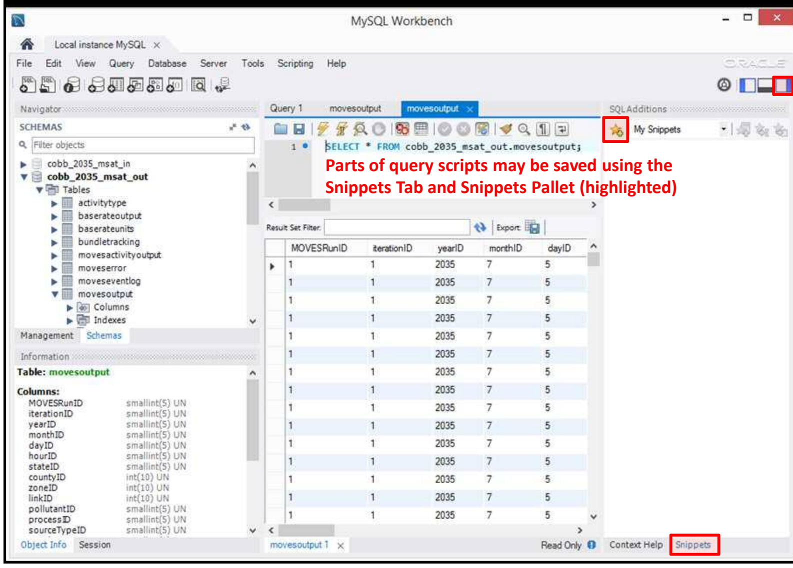
203

MySQL Workbench: Basics



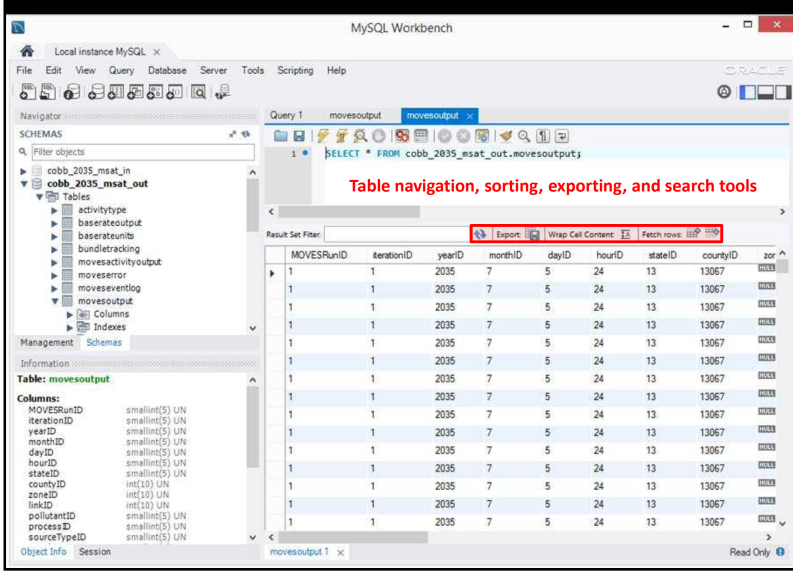
204

MySQL Workbench: Basics



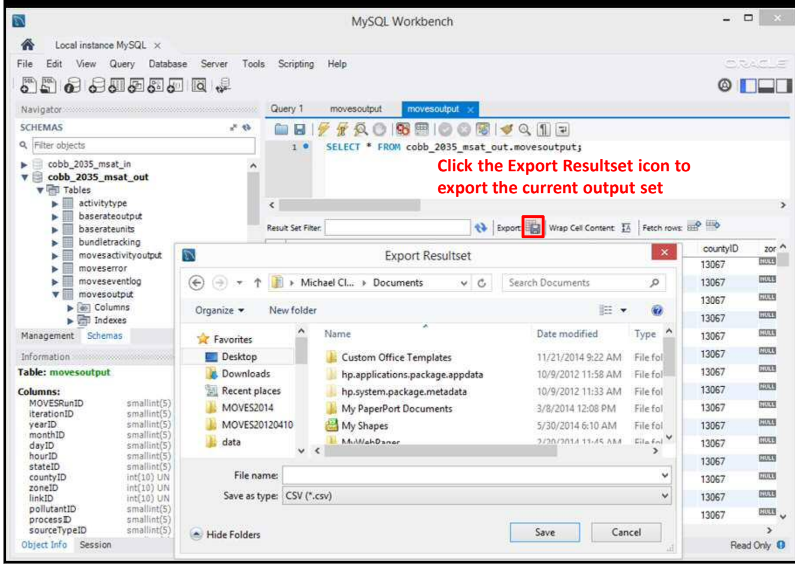
205

MySQL Workbench: Basics



206

MySQL Workbench: Basics



Note: Uncheck the Select Rows – Limit 1000 button to export the entire output set if greater than 1000 rows

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The MySQL Query Browser

- Windows tool for viewing databases, executing queries, and editing tables
- Results can be exported as .csv or MS Excel files
- Built-in Help files
- Query history recorded, so you can repeat queries without retyping them
- Tables can be edited directly, rather than using MySQL commands

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MySQL Query Browser

- No longer provided with the MOVES model suite
- Can be installed from older versions of EPA's MOVES model installation suite
- Can also be downloaded from the MySQL web site: http://downloads.mysql.com/archives/query/

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Exploring MOVES Databases with Query Browser

- ***Instructions:*** Open the MySQL Query Browser
  - Start/Programs/MySQL/MySQL Query Browser
  - Make sure "localhost" is specified (might not be after initial installation) and click "OK"
    - Click "Ignore" on warning message about schema

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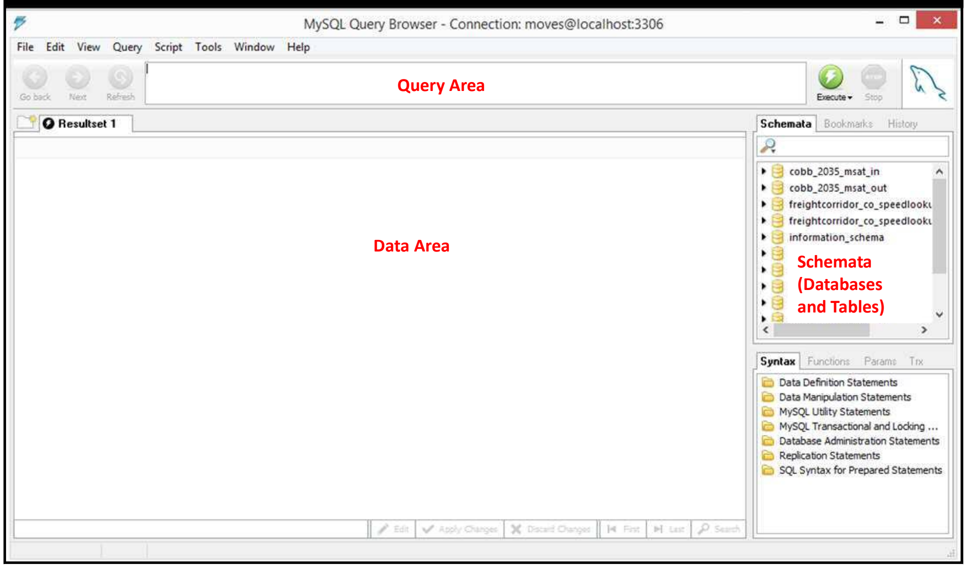
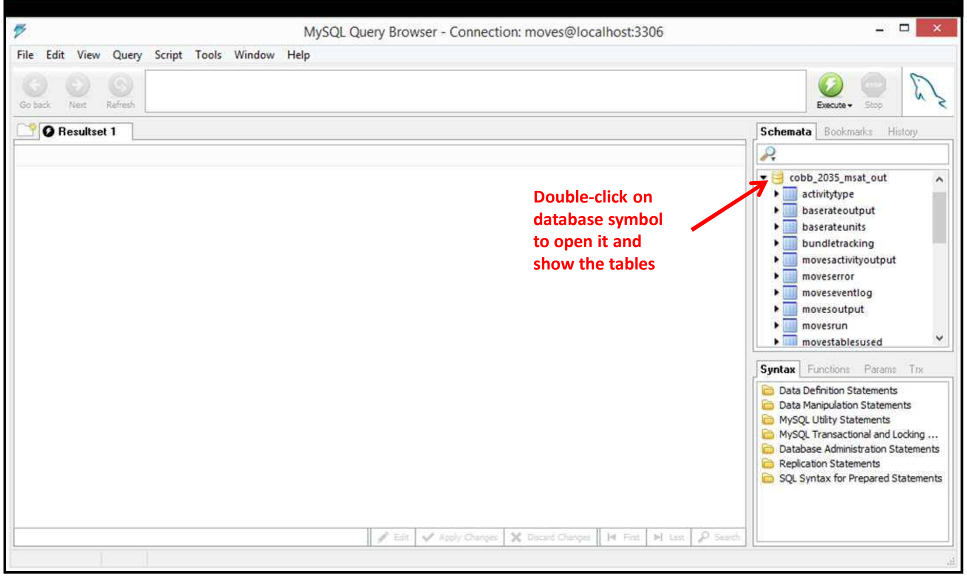
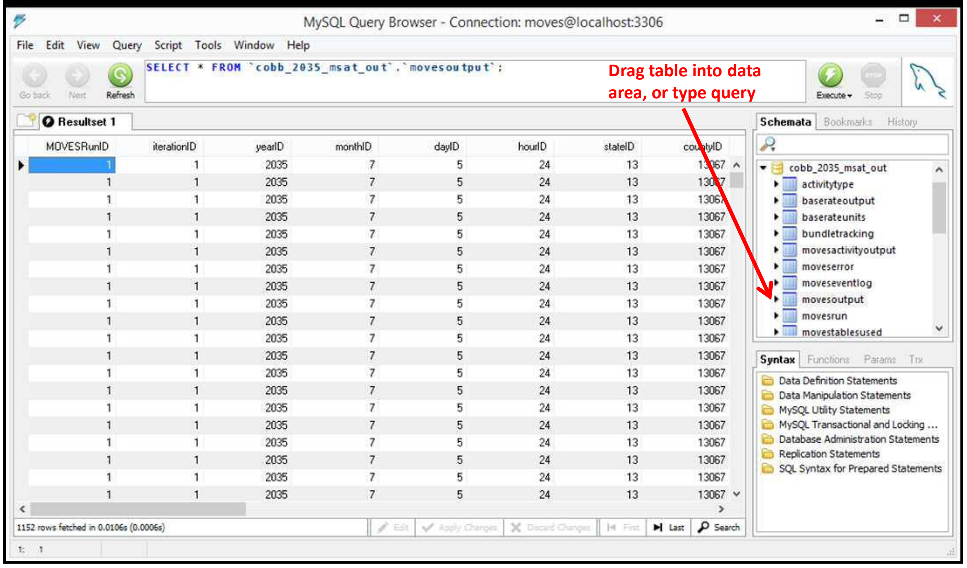
MySQL Query Browser Screen



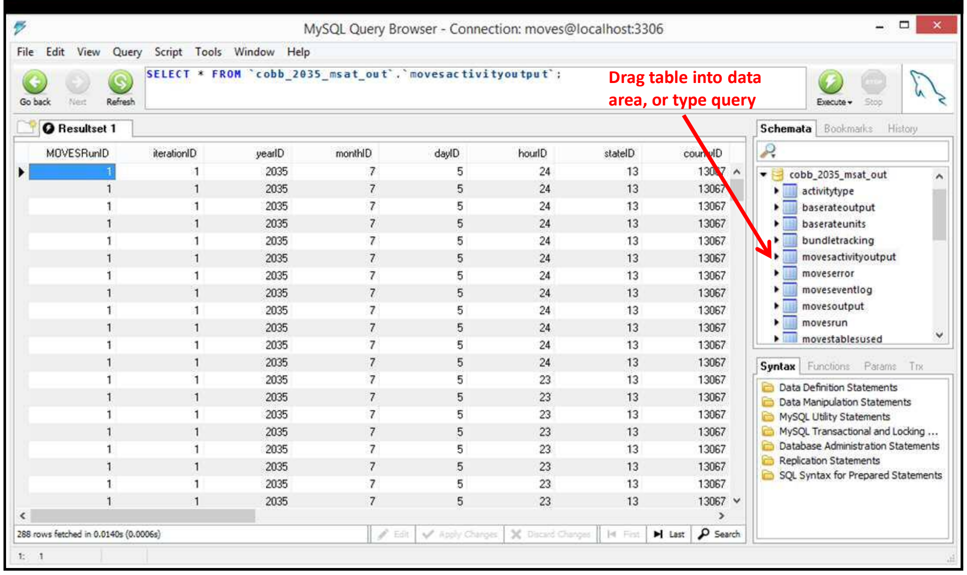
MySQL Query Browser Screen



Viewing County-scale Inventory Results: “movesoutput” table



Viewing County-scale Inventory Results: “movesactivityoutput”



Simple MySQL Queries

- Queries can be typed into the Query Area
- Queries can also be auto-generated by dragging and dropping the table name into Data area
  - Dragging to the Data Area creates and executes a “select all” query
  - This can be a useful shortcut
- Click the 

button or hit CTL/ENTER to execute queries

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Other Useful MySQL Features

- Exporting ResultSet
- Viewing history
- Bookmarking queries
- Saving queries

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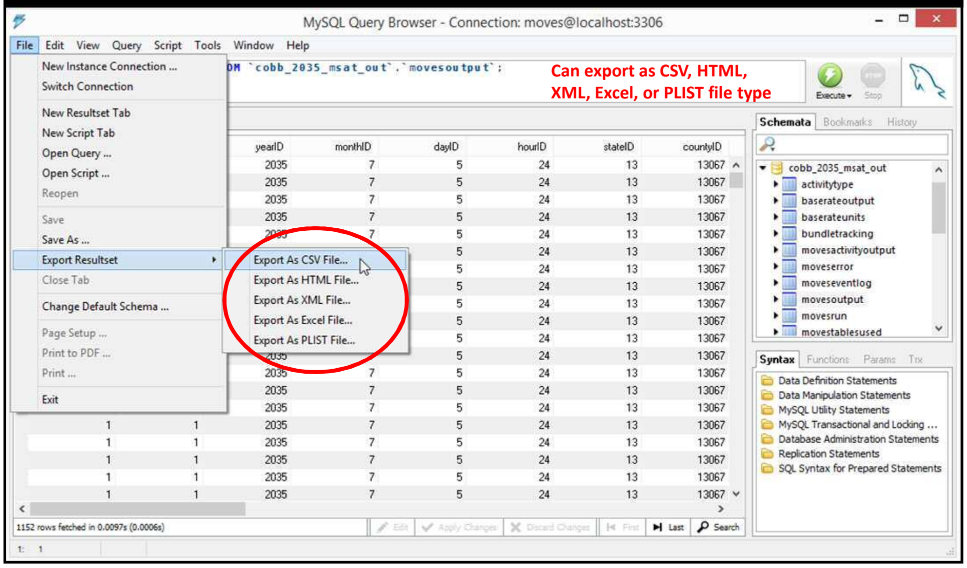
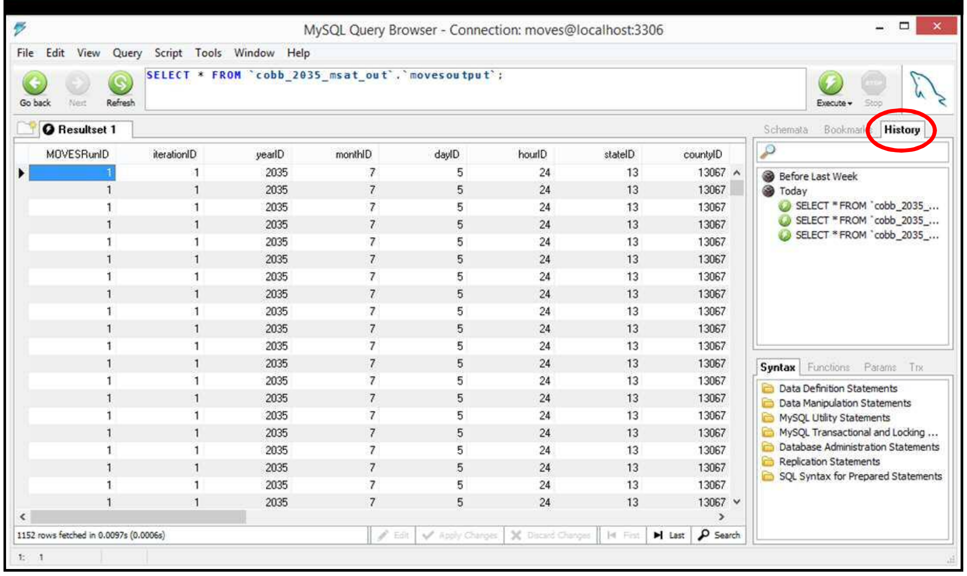
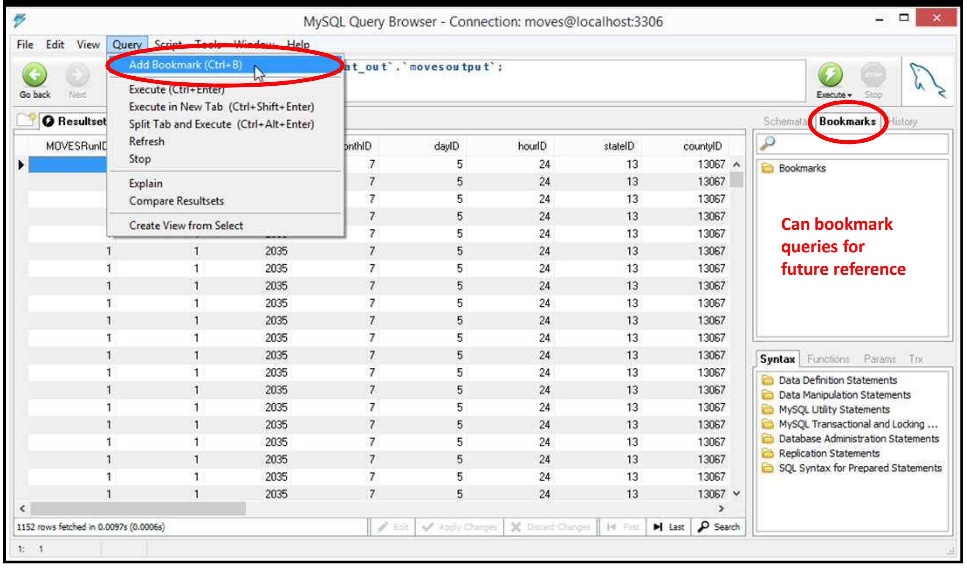
Using MySQL Query Browser: Exporting Resultsets



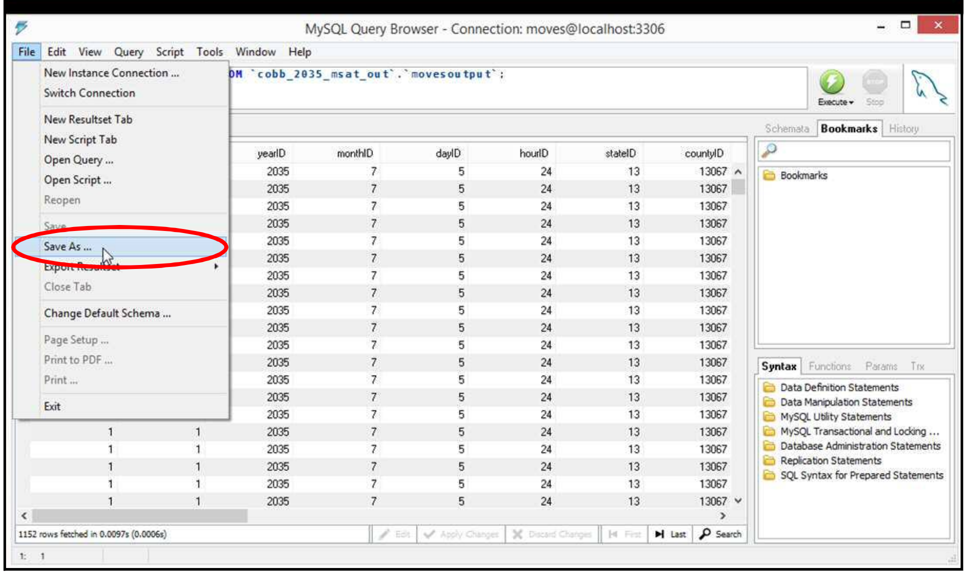
Using MySQL Query Browser: Query History



Using MySQL Query Browser: Bookmarks

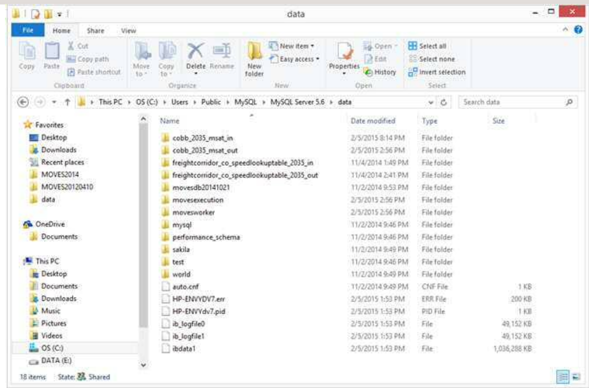


Using MySQL Query Browser: Saving Queries



Copying and sending MySQL databases

- Databases may be copied and zipped for email and review, or archiving



- All input and output databases are stored as folders on your hard drive
  - C:\Users\Public\MySQL Server 5.6\data

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FHWA Resource Center Online MySQL Training

- https:\\connectdot.connectsolutions.com\mysql_training_info\

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Affected Transportation Network

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Affected Transportation Network

- Purpose
  - Capture the anticipated changes in MSAT emissions as a direct result of a proposed project
  - Provide a framework for an objective quantitative assessment, minimizing uncertainty and bias
  - Keep the analysis manageable by analyzing all segments associated with the project plus those segments expecting meaningful changes in emissions (e.g., ± 10% or more)

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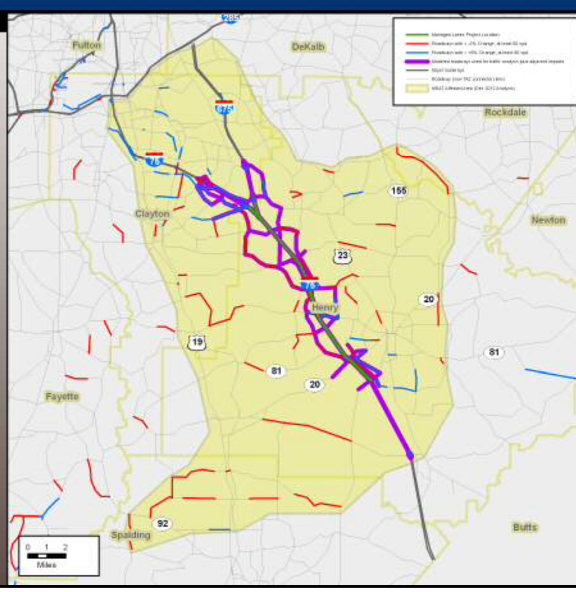
Affected Transportation Network

- Define the network based on available project-specific information such as a supporting technical traffic analysis
- Recommended Metrics
  - Changes of ± 5% or more in AADT on congested highway links of LOS D or worse
  - Changes of ± 10% or more in AADT on uncongested highway links of LOS C or better
  - Changes of ± 10% or more in travel time
  - Changes of ± 10% or more in intersection delay
- Distinguish modeling artifacts from real effects

225

Distinguish Modeling Artifacts from Real Effects



RESOURCE CENTER

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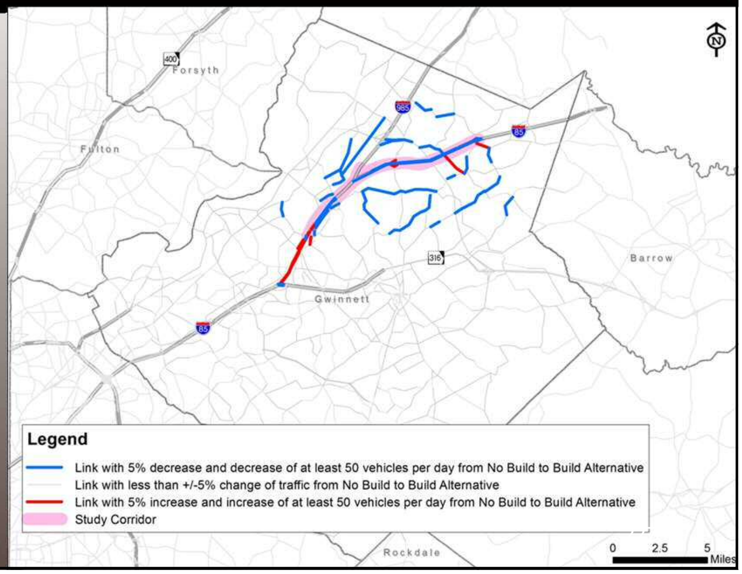
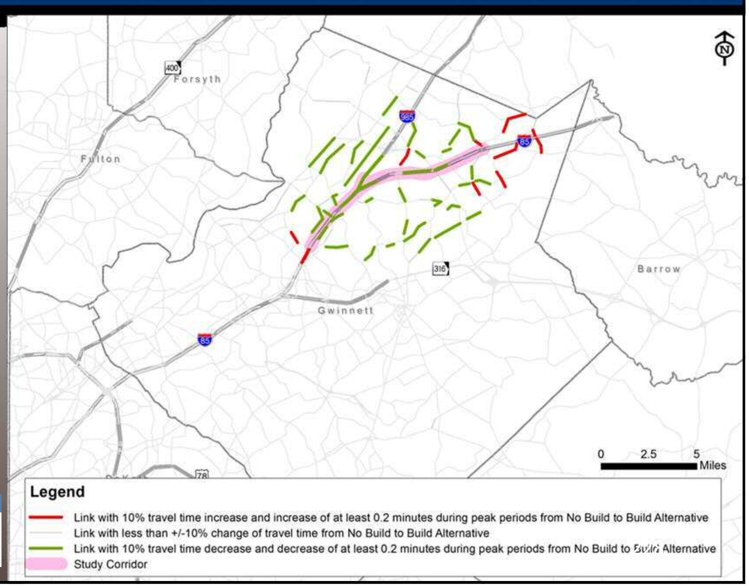
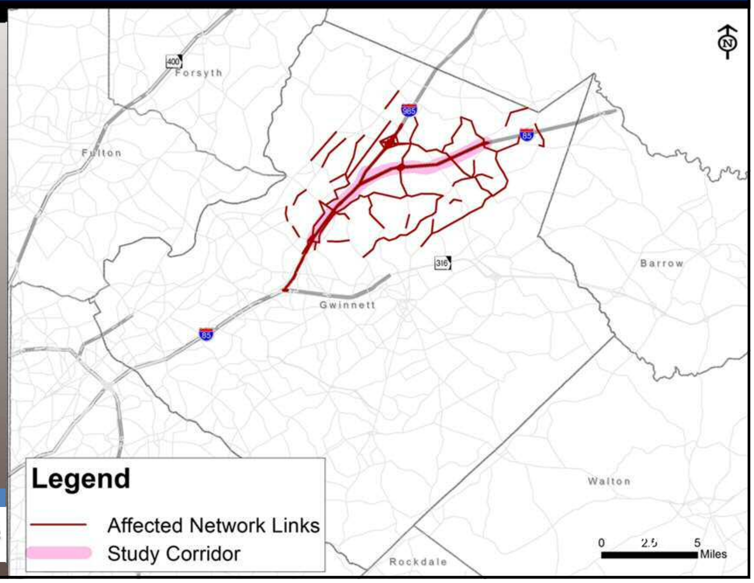
Links with Traffic Volume Changes



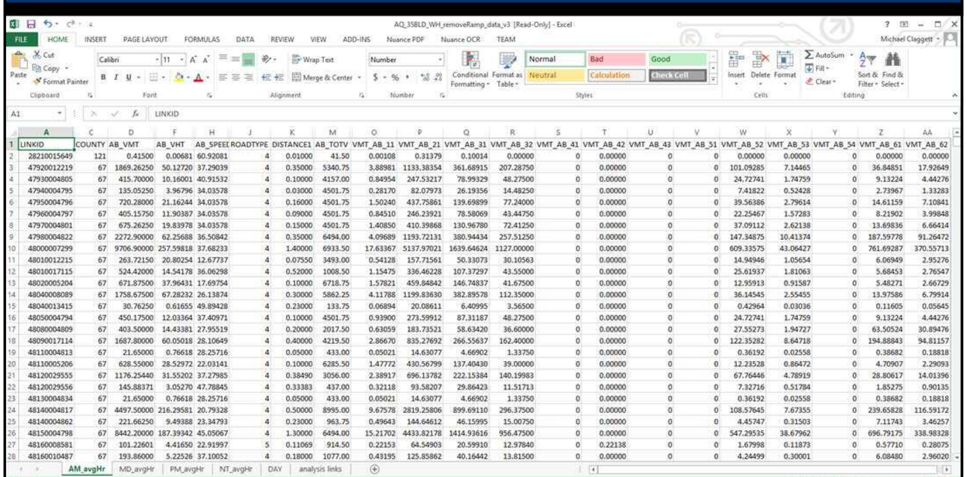
Links with Travel Time Changes



Affected Transportation Network



Affected Transportation Network



LINKID	COUNTY	AB_VMT	AB_VHT	AB_SPEEI	ROADTYPE	DISTANCE1	AB_TOTV	VMT_AB_11	VMT_AB_21	VMT_AB_31	VMT_AB_32	VMT_AB_41	VMT_AB_42	VMT_AB_43	VMT_AB_51	VMT_AB_52	VMT_AB_53	VMT_AB_54	VMT_AB_61	VMT_AB_62
28210015649	121	0.41500	0.00681	60.92081	4	0.01000	41.50	0.00108	0.31379	0.10014	0.00000	0	0.00000	0	0	0.00000	0.00000	0	0.00000	0.00000
47920012219	67	1869.26250	50.12720	37.29039	4	0.35000	5340.75	3.88981	1133.38354	361.68915	207.28750	0	0.00000	0	0	101.09285	7.14465	0	36.84851	17.92649
47930004805	67	415.70000	10.16001	40.91532	4	0.10000	4157.00	0.84954	247.53217	78.99329	48.27500	0	0.00000	0	0	24.72741	1.74759	0	9.13224	4.44276
47940004795	67	135.05250	3.96796	34.03578	4	0.03000	4501.75	0.28170	82.07973	26.19356	14.48250	0	0.00000	0	0	7.41822	0.52428	0	2.73967	1.33283
47950004796	67	720.28000	21.16244	34.03578	4	0.16000	4501.75	1.50240	437.75861	139.69899	77.24000	0	0.00000	0	0	39.56386	2.79614	0	14.61159	7.10841
47960004797	67	405.15750	11.90387	34.03578	4	0.09000	4501.75	0.84510	246.23921	78.58069	43.44750	0	0.00000	0	0	22.25467	1.57283	0	8.21902	3.99848
47970004801	67	675.26250	19.83978	34.03578	4	0.15000	4501.75	1.40850	410.39868	130.96780	72.41250	0	0.00000	0	0	37.09112	2.62138	0	13.69836	6.66414
47980004822	67	2272.90000	62.25688	36.50842	4	0.35000	6494.00	4.09689	1193.72131	380.94434	257.51250	0	0.00000	0	0	147.34875	10.41374	0	187.59778	91.26472
48000007299	67	9706.90000	257.59818	37.68233	4	1.40000	6933.50	17.63367	5137.97021	1639.64624	1127.00000	0	0.00000	0	0	609.33575	43.06427	0	761.69287	370.55713
48010012215	67	263.72150	20.80254	12.67737	4	0.07550	3493.00	0.54128	157.71561	50.33073	30.10563	0	0.00000	0	0	14.94946	1.05654	0	6.06949	2.95276
48010017115	67	524.42000	14.54178	36.06298	4	0.52000	1008.50	1.15475	336.46228	107.37297	43.55000	0	0.00000	0	0	25.61937	1.81063	0	5.68453	2.76547
48020005204	67	671.87500	37.96431	17.69754	4	0.10000	6718.75	1.57821	459.84842	146.74837	41.67500	0	0.00000	0	0	12.95913	0.91587	0	5.48271	2.66729
48040008089	67	1758.67500	67.28232	26.13874	4	0.30000	5862.25	4.11788	1199.83630	382.89578	112.35000	0	0.00000	0	0	36.14545	2.55455	0	13.97586	6.79914
48040013415	67	30.76250	0.61655	49.89428	4	0.23000	133.75	0.06894	20.08611	6.40995	3.56500	0	0.00000	0	0	0.42964	0.03036	0	0.11605	0.05645
48050004794	67	450.17500	12.03364	37.40971	4	0.10000	4501.75	0.93900	273.59912	87.31187	48.27500	0	0.00000	0	0	24.72741	1.74759	0	9.13224	4.44276
48080004809	67	403.50000	14.43381	27.95519	4	0.20000	2017.50	0.63059	183.73521	58.63420	36.60000	0	0.00000	0	0	27.55273	1.94727	0	63.50524	30.89476
48090017114	67	1687.80000	60.05018	28.10649	4	0.40000	4219.50	2.86670	835.27692	266.55637	162.40000	0	0.00000	0	0	122.35282	8.64718	0	194.88843	94.81157
48110004813	67	21.65000	0.76618	28.25716	4	0.05000	433.00	0.05021	14.63077	4.66902	1.33750	0	0.00000	0	0	0.36192	0.02558	0	0.38682	0.18818
48110005206	67	628.55000	28.52972	22.03141	4	0.10000	6285.50	1.47772	430.56799	137.40430	39.00000	0	0.00000	0	0	12.23528	0.86472	0	4.70907	2.29093
48120029555	67	1176.25440	31.55202	37.27985	4	0.38490	3056.00	2.38917	696.13782	222.15384	140.19983	0	0.00000	0	0	67.76446	4.78919	0	28.80617	14.01396
48120029556	67	145.88371	3.05270	47.78845	4	0.33383	437.00	0.32118	93.58207	29.86423	11.51713	0	0.00000	0	0	7.32716	0.51784	0	1.85275	0.90135
48130004834	67	21.65000	0.76618	28.25716	4	0.05000	433.00	0.05021	14.63077	4.66902	1.33750	0	0.00000	0	0	0.36192	0.02558	0	0.38682	0.18818
48140004817	67	4497.50000	216.29581	20.79328	4	0.50000	8995.00	9.67578	2819.25806	899.69110	296.37500	0	0.00000	0	0	108.57645	7.67355	0	239.65828	116.59172
48140004862	67	221.66250	9.49388	23.34793	4	0.23000	963.75	0.49643	144.64612	46.15995	15.00750	0	0.00000	0	0	4.45747	0.31503	0	7.11743	3.46257
48150004798	67	8442.20000	187.39342	45.05067	4	1.30000	6494.00	15.21702	4433.82178	1414.93616	956.47500	0	0.00000	0	0	547.29535	38.67962	0	696.79175	338.98328
48160008581	67	101.22601	4.41650	22.91997	5	0.11069	914.50	0.22153	64.54903	20.59910	12.97840	0	0.22138	0	0	1.67998	0.11873	0	0.57710	0.28075
48160010487	67	193.86000	5.22526	37.10052	4	0.18000	1077.00	0.43195	125.85862	40.16442	13.81500	0	0.00000	0	0	4.24499	0.30001	0	6.08480	2.96020

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Affected Transportation Network

- Process a link table for the affected transportation network to produce MOVES input tables of project-specific data:
  - Average Speed Distribution
  - HPMS VType Year
  - Road Type Distribution
  - Ramp Fraction

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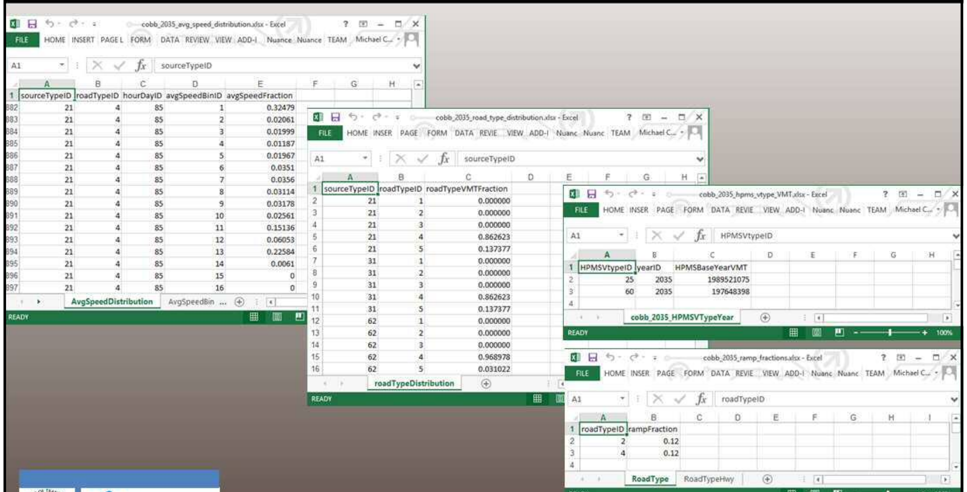
Affected Transportation Network



cobb_2035_avg_speed_distribution.xlsx - Excel

	sourceTypeID	roadTypeID	hourDayID	avgSpeedBinID	avgSpeedFraction
882	21	4	85	1	0.32479
883	21	4	85	2	0.02061
884	21	4	85	3	0.01999
885	21	4	85	4	0.01187
886	21	4	85	5	0.01967
887	21	4	85	6	0.0351
888	21	4	85	7	0.0356
889	21	4	85	8	0.03114
890	21	4	85	9	0.03178
891	21	4	85	10	0.02561
892	21	4	85	11	0.15136
893	21	4	85	12	0.06053
894	21	4	85	13	0.22584
895	21	4	85	14	0.0061
896	21	4	85	15	0
897	21	4	85	16	0

AvgSpeedDistribution

cobb_2035_road_type_distribution.xlsx - Excel

sourceTypeID	roadTypeID	roadTypeVMTFraction
21	1	0.000000
21	2	0.000000
21	3	0.000000
21	4	0.862623
21	5	0.137377
31	1	0.000000
31	2	0.000000
31	3	0.000000
31	4	0.862623
31	5	0.137377
62	1	0.000000
62	2	0.000000
62	3	0.000000
62	4	0.968978
62	5	0.031022

roadTypeDistribution

cobb_2035_hpms_vtype_VMT.xlsx - Excel

HPMSVtypeID	yearID	HPMSBaseYearVMT
25	2035	1989521075
60	2035	197648398

cobb_2035_HPMSVTypeYear

cobb_2035_ramp_fractions.xlsx - Excel

roadTypeID	rampFraction
2	0.12
4	0.12

RoadType | RoadTypeHwy

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Class Exercise – Working with Project Traffic Data for MSAT Analysis

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Class Exercise

- The minimum Project Traffic Data needed to complete a quantitative MSAT analysis are:
  - Link ID
  - MOVES Road Type
  - Length
  - Annual Average Daily Traffic (AADT)
  - % Trucks
  - Peak/Off-peak Travel Fractions
  - Peak/Off-peak Travel Speeds

  for each of the links in the Affected Transportation Network (example in AffectedNetworksLinks.xlsx)

Class Exercise

- This Class Exercise is based on the minimum Project Traffic Data required to complete a quantitative MSAT analysis
- More extensive link data may be available for some projects, including:
  - Vehicle-miles of travel (VMT);
  - Vehicle-hours of travel (VHT);
  - AADT or VMT by one or more vehicle types;
  - AADT or VMT by time period; and/or
  - Speed or VHT by one or more vehicle types

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Class Exercise

- Make direct use of such project-specific data in lieu of developing data from base information as demonstrated in this class exercise

Class Exercise

- Divide into Teams to perform three tasks
- Task 1 – Populate the HPMSVTypeYear tab in the AffectedNetworkLinks.xlsx workbook by completing the following 6 steps
  - Step 1: Add a column to compute the daily VMT for each link

    Daily VMT = AADT (vpd) × Distance (mi)
  - Step 2: Add a column to compute the daily VMT by MOVES SourceTypeID for each link
    - Use data in the CobbSourceTypeVMT tab to allocate link VMT by SourceTypeID based on the HDV ratio
    - HDVs include SourceTypeIDs 41, 42, 43, 51, 52, 53, 54, 61, 62

Class Exercise

- Step 3: Compute the sum total daily VMT by SourceTypeID (Σ Daily $VMT_{SourceTypeID}$) for the affected network
- Step 4: Compute the total annual VMT by SourceTypeID for the affected network

  Annual VMT = Daily VMT × 365 days/yr
- Step 5: Compute the total annual VMT by HPMS vehicle type (HMPSVTypeID) for the affected network

HPMSVTypeID	MOVES SourceTypeID
10	11
25	21 + 31 + 32
40	41 + 42 + 43
50	51 + 52 + 53 + 54
60	61 + 62

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Class Export

– Step 6: Populate the HPMSVTypeYear tab

HPMSVTypeID	yearID	HPMSBaseYearVMT
10	2035	41375904
25	2035	1952816167
40	2035	49154812
50	2035	143126902
60	2035	90740845

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Class Exercise

- Task 2 – Populate the RoadTypeDistribution tab in the AffectedNetworkLinks.xlsx workbook by completing the following 4 steps
  - Step 1: Based on the computations added to the AffectedNetworkLinks tab for Task 1, sort rows by MOVES RoadTypeID
  - Step 2: Compute the sum total daily VMT by SourceTypeID segregated by RoadTypeID (Σ Daily $VMT_{SourceTypeID,RoadTypeID}$)
  - Step 3: Compute the RoadTypeVMTFraction by SourceTypeID segregated by RoadTypeID

RoadTypeVMTFraction =

$$\Sigma \text{ Daily } VMT_{SourceTypeID,RoadTypeID} / \Sigma \text{ Daily } VMT_{SourceTypeID}$$

Class Exercise

– Step 4: Populate the RoadTypeDistribution tab

source TypeID	road TypeID	roadType VMTFraction	source TypeID	road TypeID	roadType VMTFraction
11	4	0.861178	11	5	0.138822
21	4	0.861178	21	5	0.138822
31	4	0.861178	31	5	0.138822
32	4	0.861178	32	5	0.138822
41	4	0.944013	41	5	0.055987
42	4	0.944013	42	5	0.055987
43	4	0.944013	43	5	0.055987
51	4	0.944013	51	5	0.055987
52	4	0.944013	52	5	0.055987
53	4	0.944013	53	5	0.055987
54	4	0.944013	54	5	0.055987
61	4	0.944013	61	5	0.055987
62	4	0.944013	62	5	0.055987

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Class Exercise

- Task 3 – Populate the AvgSpeedDistribution tab in the AffectedNetworkLinks.xlsx workbook by completing the following 7 steps
  - Note: The entire template is included to show the amount of data required to populate an AvgSpeedDistribution spreadsheet. For the Class Exercise, however, compute the average speed distribution for SourceTypeID = 21; RoadTypeIDs = 4, 5; HourDayID = 75; and AvgSpeedBinIDs = 1, 2, 3, 4, 5, 6, 7, 8, 9 ,10, 11, 12, 13, 14, 15, 16

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Class Exercise

– Step 1: Sort rows by MOVES RoadTypeID
– Step 2: Add a column to compute the VHT during the AM peak period for SourceTypeID = 21 for each link

$$VHT_{AM,SType21} = Volume_{AM,SType21}\ (vph) \times Distance\ (mi) / Speed_{AM}\ (mph)$$

– Step 3: Add 16 columns, one to represent each AvgSpeedBin

AvgSpeed BinID	AvgBin Speed	AvgSpeedBinDesc	AvgSpeed BinID	AvgBin Speed	AvgSpeedBinDesc
1	2.5	speed < 2.5mph	9	40	37.5mph <= speed < 42.5mph
2	5	2.5mph <= speed < 7.5mph	10	45	42.5mph <= speed < 47.5mph
3	10	7.5mph <= speed < 12.5mph	11	50	47.5mph <= speed < 52.5mph
4	15	12.5mph <= speed < 17.5mph	12	55	52.5mph <= speed < 57.5mph
5	20	17.5mph <= speed < 22.5mph	13	60	57.5mph <= speed < 62.5mph
6	25	22.5mph <= speed < 27.5mph	14	65	62.5mph <= speed < 67.5mph
7	30	27.5mph <= speed < 32.5mph	15	70	67.5mph <= speed < 72.5mph
8	35	32.5mph <= speed < 37.5mph	16	75	72.5mph <= speed

Class Exercise

– Step 4: Assign the VHT computed in Step 2 to the appropriate AvgSpeedBin added in Step 3
– Step 5: Compute the sum total VHT by AvgSpeedBinID segregated by RoadTypeID ($\Sigma\ VHT_{AvgSpeedBinID,RoadTypeID}$)
– Step 6: Compute the AvgSpeedFraction by AvgSpeedBinID segregated by RoadTypeID

$$AvgSpeedFraction = \Sigma\ VHT_{AvgSpeedBinID,RoadTypeID} / \Sigma\ VHT_{AvgSpeedBinID}$$

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Class Exercise

– Step 7: Populate the AvgSpeedDistribution tab

Source TypeID	Road TypeID	Hour DayID	AvgSpeed BinID	AvgSpeed Fraction	Source TypeID	Road TypeID	Hour DayID	AvgSpeed BinID	AvgSpeed Fraction
21	4	75	1	0.00000	21	4	75	9	0.06899
21	4	75	2	0.00270	21	4	75	10	0.04865
21	4	75	3	0.06524	21	4	75	11	0.00921
21	4	75	4	0.20032	21	4	75	12	0.01902
21	4	75	5	0.32327	21	4	75	13	0.00388
21	4	75	6	0.10162	21	4	75	14	0.00000
21	4	75	7	0.04819	21	4	75	15	0.00000
21	4	75	8	0.10892	21	4	75	16	0.00000

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Class Exercise

– Step 7: Populate the AvgSpeedDistribution tab

Source TypeID	Road TypeID	Hour DayID	AvgSpeed BinID	AvgSpeed Fraction	Source TypeID	Road TypeID	Hour DayID	AvgSpeed BinID	AvgSpeed Fraction
21	5	75	1	0.00000	21	5	75	9	0.00764
21	5	75	2	0.07470	21	5	75	10	0.00209
21	5	75	3	0.17226	21	5	75	11	0.00000
21	5	75	4	0.23281	21	5	75	12	0.00000
21	5	75	5	0.24403	21	5	75	13	0.00000
21	5	75	6	0.16648	21	5	75	14	0.00000
21	5	75	7	0.08126	21	5	75	15	0.00000
21	5	75	8	0.01873	21	5	75	16	0.00000

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Using MOVES at the County-scale versus Project-scale for MSAT Analyses

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Overview

- Pros and cons of using emissions rates runs for MSAT analysis
- Using rates output to calculate MSAT emissions
- MOVES RunSpecs and inputs for rates
- Pros and cons of using Project Scale for MSAT analysis
- MOVES RunSpecs and inputs for Project scale runs

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3 Approaches for Modeling MSATs with MOVES

- County Scale, Inventory
- County Scale, Rates
- Project Scale, Inventory

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Summary: RunSpecs Needed for a County/Inventory MSAT Approach

- One RunSpec for each year and alternative
  - The parameters of the RunSpecs for each year are identical, but each references a different input database (by alternative)
- If DPM being modeled separately from the other MSATs, then two RunSpecs for each year and alternative
  - One RunSpec includes all vehicle types, and the non-DPM MSAT pollutant/process selections
  - The other RunSpec includes only the diesel vehicle types, and DPM pollutant/process selections
  - CDM inputs are the same (need to start with total VMT); can use the same input databases for DPM and non-DPM runs

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Pros and Cons of County Rates runs for MSAT Analysis

- Less pre-processing of travel data is needed to generate inputs
  - Speed, VMT, road type distribution inputs don't have to be project-specific, can even be defaults in most cases
- Considerably more post-processing of MOVES output is needed to generate MSAT inventories for the project alternatives
- Rates runs also take longer

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Types of estimates generated from a MOVES "Rates" run

- Rateperdistance
- Ratepervehicle
- Rateperprofile
- For NEPA MSAT emissions estimates, running emissions (rateperdistance) are used
  - Other forms of rates reflect starts, evaporative emissions from parked cars, truck extended idling, and other non-highway emissions, which are not included in MSAT analysis

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Detail in MOVES rates

- Rates produced for each of 16 speed bins, 4 road types, 2 day types, 24 hours
  - Can add even more detail, such as fuel type, source type, . . .
- Rates produced for up to 12 months, depending on approach to estimate annual emissions
- Separate runs (or more post-processing) needed for DPM versus the other MSATs
  - DPM only comes from diesel vehicles

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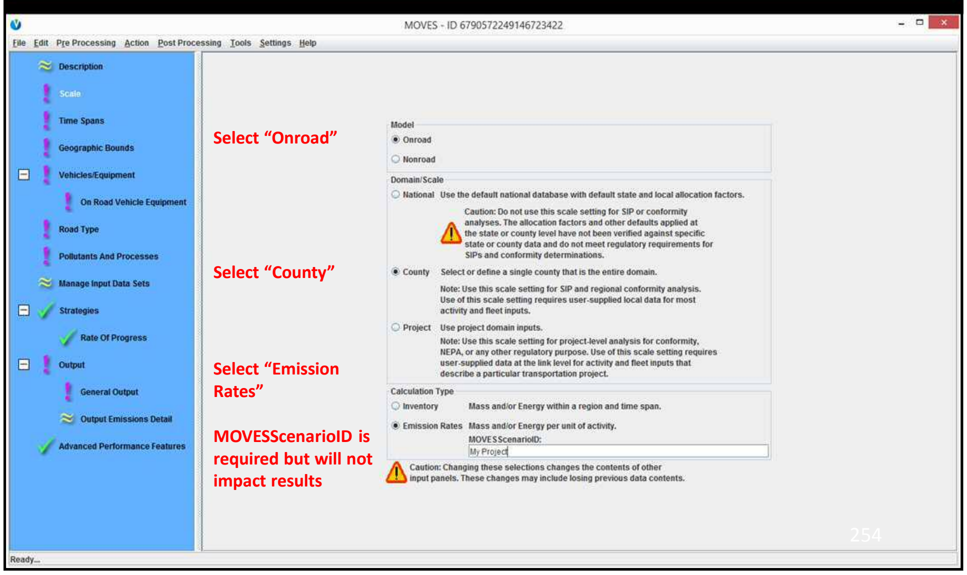
Creating a RunSpec for a Rates Run – Scale



254

Time Spans: Manageable Approach for MSAT Rates RunSpec

- Model 4 hours of a weekday (corresponding to AM Peak, Midday, PM Peak, and Overnight); could be fewer, depending on what traffic data are available
  - Will require separate RunSpecs, since MOVES can't model non-contiguous hours
- Model 4 months to represent seasons (these can all be in the same RunSpec)
  - need to "grow" inventory to annual basis in post-processing

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Creating a RunSpec for a Rates Run – Other Selections

- Other selections are the same as for an inventory run
- Diesel particulate matter:
  - PM10 total exhaust rates are needed for only diesel vehicles, while other MSATs are produced by all vehicle types
  - Rates need to be multiplied by the proper VMT (by fuel type, in this case)
  - Easiest approach is use a separate RunSpec (or set of RunSpecs) with only diesel vehicles selected in "Vehicle/Equipment", and multiply these rates by diesel VMT only
    - If default diesel fractions are used in the Fuel Type and Technologies inputs, then the fraction of diesel VMT can be calculated by doing a National scale run for the year and county, and requesting "distance" and "fuel type" and "road type" in the output

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Creating a RunSpec for a Rates Run – Other Selections

- Remaining MSATs are calculated by doing run(s) with all fuel types, and these rates are multiplied by total VMT (not diesel VMT)

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Summary: RunSpecs needed for a Rates approach

- Base year
  - One RunSpec for all fueltypes for each time period
  - One RunSpec for diesel only for each time period
  - Each RunSpec includes all four seasons
- Repeat for each analysis year
- Unlike Inventory approach, separate RunSpecs are not needed for each alternative
  - Possible exception—if there are major changes in ramp fraction between alternatives

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Creating an Input Database for a Rates Run

- In general, inputs for rates runs are placeholders, and just need to be reasonable for the area
  - The MSAT inventory is calculated outside of MOVES, so exact VMT, speed, etc. is not important as a MOVES input
  - Use local data if available, otherwise national defaults
- Possible exception: ramp fraction
  - This affects the restricted access roadway rates
  - Can either include ramp VMT with associated mainline VMT, and use emissions rate based on mainline speed; or, set up MOVES run to report separate output for ramps (Road Type panel) and then apply ramp rates to ramp VMT based on ramp speed

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Working with Rates Output

- Rates output cannot be accessed via the MOVES Summary Reporter
  - Query/export from your MySQL output database
- Units in grams per vehicle-mile (select these in General Output panel)
- Output rateperdistance table reports a rate for each speed bin
  - Rates will always be reported for each speed bin 1-16 corresponding to 0 mph to 72.5+ mph

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Working with Rates Output

- Inventory is calculated by multiplying the link VMT at a given speed by the emission rate for that speed, road type and time period, and repeating for all of the time periods (and months) in the analysis
- In general, rates cannot be averaged or summed in order to simplify the post-MOVES algebra—need to multiply proper rates by proper VMT
  - Rates for related processes can be summed (e.g., running exhaust and crankcase running exhaust)
  - Rates between two 5mph speed bins can be interpolated to get a rate for an exact speed

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Working with Rates Output

- Be sure to use the correct VMT in calculations of DPM and the other MSATs

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MOVES Project Scale

- Project scale designed for link level analysis
  - CO and PM "Hot-spot" analysis for conformity
  - NEPA
  - Roadway/Intersection level energy and GHG analysis
- Link-specific data must be entered when the Project scale is selected
- Data can be exported or imported with the Project Data Manager (PDM)

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Guidance and Training Available

- These slides don't reflect technical or policy guidance for conformity uses of MOVES at the Project Scale
- EPA has developed guidance for use of MOVES in project-scale CO and PM analyses
  - www.epa.gov/otaq/stateresources/transconf/policy.htm
- Training materials also available for the 3-day PM hotspot modeling course
  - www.epa.gov/otaq/stateresources/transconf/training3day.htm

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More About Project Scale

- Utilizes same MOVES emission rates and correction factors as county and national scale
- It does NOT utilize the default MOVES growth, VMT or population data
  - These must be supplied by the user
- It allows the user to specify only one combination of
  - County
  - Year
  - Month
  - Hour

  per run

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Pros and Cons of Project Scale runs for MSAT Analysis

- More MOVES runs needed
  - because each run can cover only one hour in one month
- Less pre-processing of travel data needed compared to County Inventory
  - because link data can be used directly, rather than converting it into MOVES distributions
- Less post-processing than Rates, but more than County Inventory
  - emissions for individual links need to be summed across hours and months to estimate annual emissions for the network

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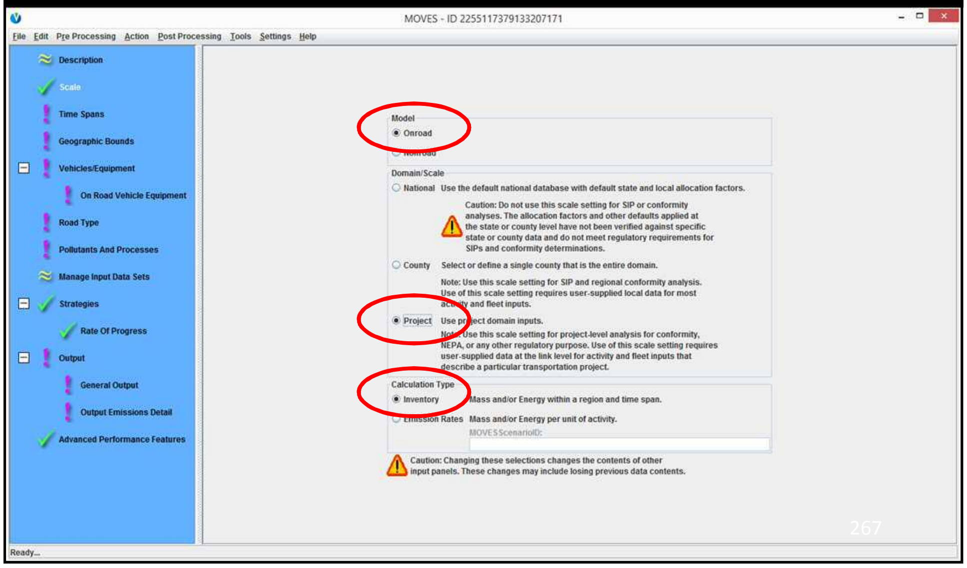
RunSpecs for Project Scale



267

Time Spans at Project Scale

- Model 4 hours of a weekday (corresponding to AM Peak, Midday, PM Peak, and Overnight); could be fewer, depending on what traffic data are available
  - Will require separate RunSpecs, since MOVES can only model one hour at the Project scale
- Model 4 months to represent seasons (these can all be in the same RunSpec)
  - Will also require separate RunSpecs, since MOVES can only model one month at the Project scale

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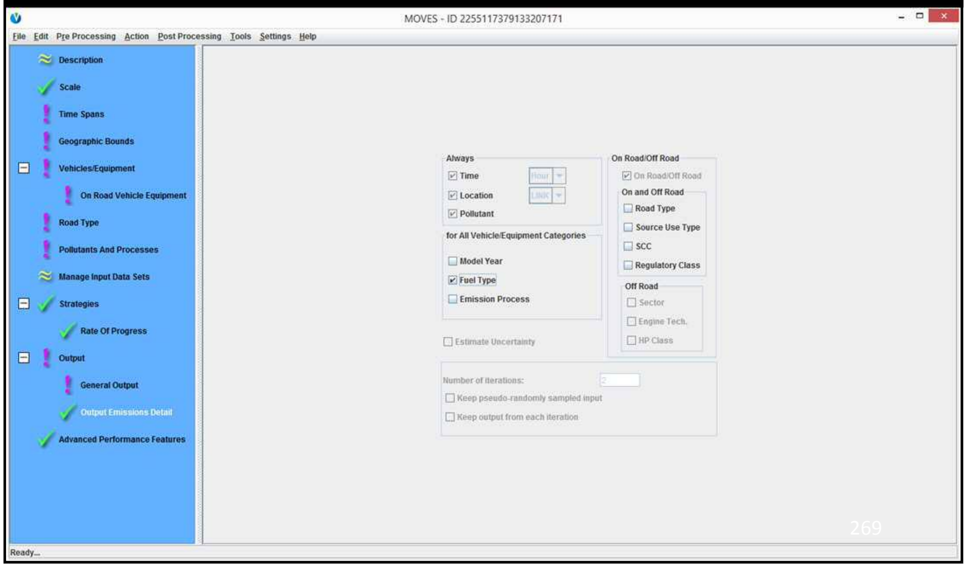
Output Emissions Detail: Select "Fuel Type" to get DPM



Project Scale Inputs

- Links
- Off-Network
  - not used in MSAT analysis
- Link Source Types
- Age Distribution
- Meteorology Data
- Fuel Inputs
- I/M
  - only required for areas with I/M

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Project Scale Inputs

- Operating Mode Distribution
  - optional advanced traffic input for highway projects
  - also required if modeling Off-Network link
- Link Drive Schedules
  - optional advanced traffic input for highway projects

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Project Scale Inputs

- Links
- Off-Network
- Link Source Types
- ***Age Distribution***
- ***Meteorology Data***
- ***Fuel Inputs***
- ***I/M***
- Operating Mode Distribution
- Link Drive Schedules

← **Inputs common to both MOVES County scale and Project scale analyses**

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Project Scale Inputs

- ***Links***
- ***Off-Network***
- ***Link Source Types***
- Age Distribution
- Meteorology Data
- Fuel Inputs
- I/M
- ***Operating Mode Distribution***
- ***Link Drive Schedules***

Inputs unique to MOVES Project scale analyses

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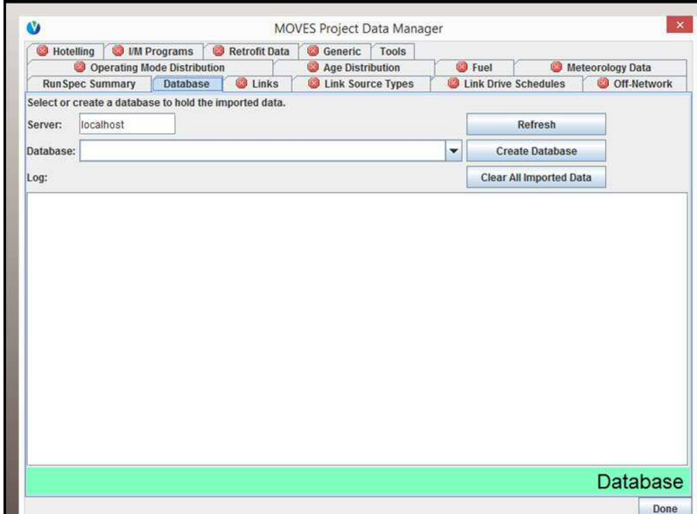
Project Data Manager



- Similar to County Data Manager used in Inventory and Rates runs, but with different inputs

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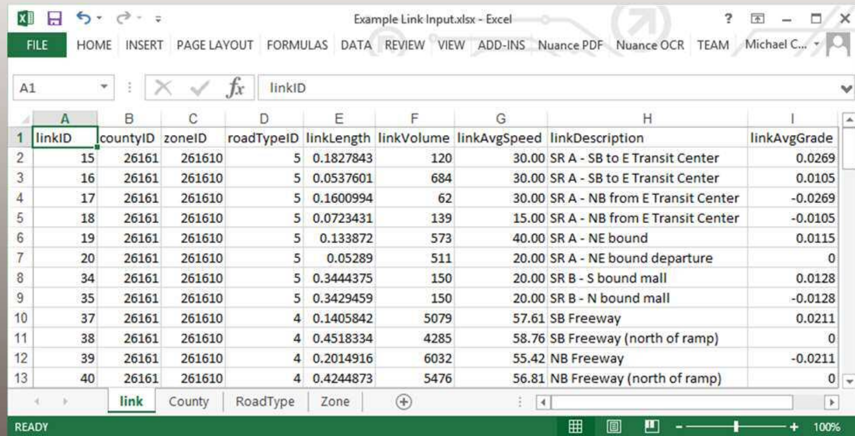
Links Inputs



linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription	linkAvgGrade
15	26161	261610	5	0.1827843	120	30.00	SR A - SB to E Transit Center	0.0269
16	26161	261610	5	0.0537601	684	30.00	SR A - SB to E Transit Center	0.0105
17	26161	261610	5	0.1600994	62	30.00	SR A - NB from E Transit Center	-0.0269
18	26161	261610	5	0.0723431	139	15.00	SR A - NB from E Transit Center	-0.0105
19	26161	261610	5	0.133872	573	40.00	SR A - NE bound	0.0115
20	26161	261610	5	0.05289	511	20.00	SR A - NE bound departure	0
34	26161	261610	5	0.3444375	150	20.00	SR B - S bound mall	0.0128
35	26161	261610	5	0.3429459	150	20.00	SR B - N bound mall	-0.0128
37	26161	261610	4	0.1405842	5079	57.61	SB Freeway	0.0211
38	26161	261610	4	0.4518334	4285	58.76	SB Freeway (north of ramp)	0
39	26161	261610	4	0.2014916	6032	55.42	NB Freeway	-0.0211
40	26161	261610	4	0.4244873	5476	56.81	NB Freeway (north of ramp)	0

RESOURCE CENTER

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Links Inputs

- LinkID: Each link in Project must be entered
- CountyID: MOVES five digit county code
- ZoneID: county ID with zero at the end
- RoadTypeID: MOVES roadtype code
- Link Length: in miles
- Link Volume: total traffic volume in one hour
- Link Average Speed: in mph
- Link Description: optional text field
- Link Grade: in percent grade (100% = 45 degree slope)
  - modelers often use zero for all links

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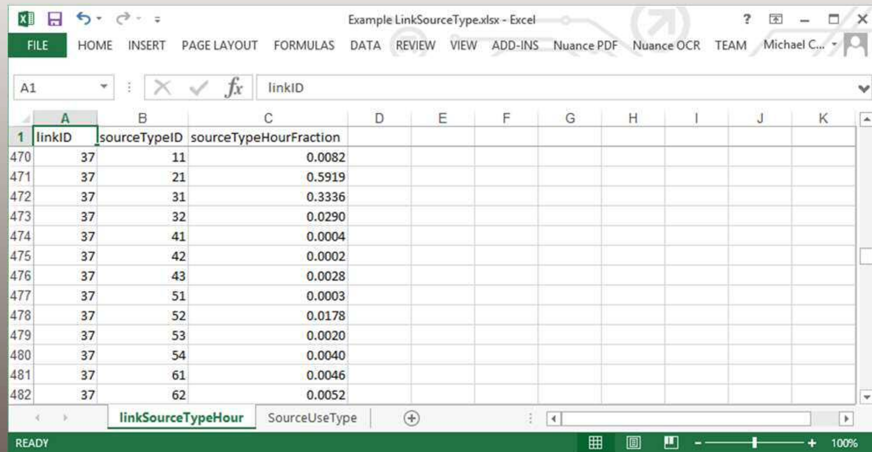
Link Source Type Inputs



Example LinkSourceType.xlsx - Excel

	linkID	sourceTypeID	sourceTypeHourFraction
470	37	11	0.0082
471	37	21	0.5919
472	37	31	0.3336
473	37	32	0.0290
474	37	41	0.0004
475	37	42	0.0002
476	37	43	0.0028
477	37	51	0.0003
478	37	52	0.0178
479	37	53	0.0020
480	37	54	0.0040
481	37	61	0.0046
482	37	62	0.0052

linkSourceTypeHour | SourceUseType

RESOURCE CENTER

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Link Source Type Inputs

- LinkID
  - Must include all LinkIDs defined in Links Input
- SourceType
  - Must include all source types selected in On Road Vehicle/Equipment panel
    - e.g., all 13 source types, unless some don't operate on specific links
- SourceTypeHourFraction
  - Specify vehicle mix (fraction of VHT) on each link
  - Fractions must sum to "1" for each linkID

278

Defining Vehicle Activity in MOVES

- Users may choose one or more options:
- Define a link average speed (through the "Links table")
  - MOVES includes default OpMode distributions based on typical driving cycles
  - Appropriate for MSAT analysis
- Enter a link specific drive cycle
  - User defines a second-by-second drive cycle for each link
- Directly enter a link specific OpMode distribution
  - Precisely describes distribution of activity on a link (fraction of time spent in each OpMode bin)
  - OpMode distribution is required if modeling an off-network link

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Summary of RunSpecs and Input Databases Needed

- If modeling 4 hours (time periods) and 4 months, need 16 RunSpecs per calendar year
- Will also need a unique input database for each time period and calendar year and project alternative
  - because traffic input data vary by year, time of day and alternative
- Can run multiple input databases (one for each alternative) through the same RunSpec, as long as the other conditions are the same
  - e.g., traffic and met inputs are for the time period listed in the RunSpec (explain this in the Description panel)

280

Working with Project Output

- Summary reporter does not report emissions by link
  - Will sum emissions for all links
- Calculate DPM based on diesel VMT on links, and other MSATs based on all VMT on links
- Need to "grow" inventory to annual basis in post-processing
  - Multiply emissions for each representative hour by the # of hours in the time period to get daily emissions
  - Multiply emissions for each representative day (seasons represented by one month) to get annual emissions

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Summary: 3 Approaches for Modeling MSATs with MOVES

- County Scale, Inventory
  - Pre-processing of travel data to produce inputs
  - No post-processing (MOVES produces the inventory)
  - Use of Summary Reporter for results
- County Scale, Rates
  - Very little pre-processing of inputs
  - Considerable post-processing to assemble inventory
- Project Scale, Inventory
  - Some pre-processing of input data
  - Some post-processing of outputs

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Using MOVES for Energy or GHG Analyses

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Overview

- Available guidance
- Adding GHGs and energy to MOVES RunSpecs and inputs for MSAT runs
- FHWA tool for construction and maintenance GHGs and energy
- Reporting results in NEPA documents

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Disclaimer

- No federal guidance currently requires GHG analysis in NEPA documents
  - Analysis to date has been a result of state requirements, responses to scoping comments, etc.
  - If future CEQ guidance does require this analysis, FHWA's preference will be PEL approaches based on planning-level analysis
- Energy analysis has always been required in NEPA, but qualitative analysis has been sufficient
- These slides provide technical recommendations on modeled GHG and energy analysis with MOVES, but the analyses themselves are optional

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MOVES for GHG/energy Analysis

- MOVES was designed from the start as an energy model
- MOVES validated against national fuel sales data
- Compared to MOBILE6 and older models, MOVES energy/GHG estimates take congestion into account, and grade (at the Project scale)

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EPA MOVES GHG Guidance

- In 2012, EPA issued guidance on use of MOVES for inventories of GHGs and energy consumption
  - www.epa.gov/otaq/stateresources/420b12068.pdf
- Oriented toward regional inventory analysis, but much of it also applicable to project-level
- MOVES2010b didn't include newest LD and HD fuel economy/GHG standards, but MOVES2014 does

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Adding energy/GHG analysis to MSAT analysis

- MSAT RunSpecs already require Total Energy and Total Gaseous Hydrocarbons (chained pollutants)
- For GHGs, add:
  - Methane
  - Nitrous Oxide
  - Atmospheric CO2
- "CO2 Equivalent" will convert emissions of these three pollutants to equivalent emissions of CO2

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Black Carbon

- If you want to model "black carbon" as a GHG, use "Primary PM10 – Elemental Carbon" from DPM runs
- BC is not included in CO2e calculations (no Global Warming Potential has been established for black carbon)

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Adding energy/GHG analysis to MSAT analysis

- These pollutants can be added to existing MSAT RunSpecs; don't need separate runs
- County- or project-level inputs remain the same (no additional input data)
- Can include these pollutants in any necessary post-processing (e.g., from using MOVES in Rates mode)

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Electricity in MOVES

- MOVES allows some but not all vehicle types to be EVs
  - EVs in MOVES are full-time grid-charged electric vehicles, not hybrids
- Can estimate electricity consumption if
  - Electricity selected as a fuel type
  - "Fuel type and technology" inputs include EV fractions (default is zero)
  - "Fuel Type" selected in Output Emissions Detail

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Construction and Maintenance Energy/GHGs: FHWA ICE Tool

- FHWA has developed a spreadsheet tool, the Infrastructure Carbon Estimator, to estimate energy and CO2 from construction and maintenance
- Covers construction materials, equipment fuel use, maintenance materials and fuel use
- Estimates emissions/energy reductions from mitigation strategies
- Can be used to estimate payback periods (e.g., when do energy savings from the project offset construction energy?)

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Construction and Maintenance Energy/GHGs: FHWA ICE Tool

- Tool and User Guide available at: www.fhwa.dot.gov/environment/climate_change/mitigation/publications_and_tools/carbon_estimator/index.cfm

Using the Tool: Step 1

- Step 1: Input general information about your

Project location (state)	AK
Project lifetime (years)	20

Roadway Routine Maintenance	
Total existing centerline miles	50000
Total existing lane miles	200000
Total newly-constructed centerline miles	1.75
Total newly-constructed lane miles	7

Rail, Bus, and Bicycle Routine Maintenance	
Total existing track miles of light rail	30
Total existing track miles of heavy rail	50
Total newly-constructed track miles of rail	0
Total existing lane miles of bus rapid transit	20
Total newly-constructed lane miles of bus rapid transit	0
Total existing lane miles of bicycle lanes	50
Total newly-constructed lane miles of bicycle lanes	1

Using the Tool: Step 2

- Step 2: Input information about construction and maintenance activities

Roadway Projects							
	Roadway Construction					Roadway Rehabilitation	
Facility type	New Roadway (lane miles)	Construct Additional Lane (lane miles)	Re-Alignment (lane miles)	Lane Widening (lane miles)	Shoulder Improvement (centerline miles)	Re-construct Pavement (lane miles)	Resurface Pavement (lane miles)
Rural Interstates	0	0	0	0	50	0	10
Rural Principal Arterials	5	0	0	10	0	0	30
Rural Minor Arterials	0	0	20	0	0	0	0
Rural Collectors	0	0	0	20	0	0	0
Urban Interstates / Expressways	0	0	0	0	40	20	30
Urban Principal Arterials	0	0	0	0	0	0	10
Urban Minor Arterials / Collectors	0	0	0	0	0	0	0

Using the Tool: Step 3

- Step 3: Input information about construction delay

Total project-days of lane closure	
Average daily traffic per directional segment for facilities requiring lane closure	
Percentage of facility lanes closed during construction	50%

Using the Tool: Step 4

- Step 4: Input mitigation strategies

Energy / GHG reduction strategies				
Strategy	Baseline deployment	Planned deployment	Max potential deployment	Applied to
Alternative fuels and vehicle hybridization				
Hybrid maintenance vehicles and equipment	0%	10%	44%	Fuel use by maintenance equipment
Switch from diesel to B20 in maintenance vehicles and equipment	0%	10%	100%	Fuel use by maintenance equipment
Switch from diesel to B100 in maintenance vehicles and equipment	0%	10%	100%	Fuel use by maintenance equipment
Combined hybridization/B20 in maintenance vehicles and equipment	0%	10%	44%	Fuel use by maintenance equipment
Vegetation management				
Alternative vegetation management strategies (hardscaping, alternative mowing, integrated roadway/vegetation management)	No	Yes	N/A	Fuel use by vegetation management equipment
Snow fencing and removal strategies				
Alternative snow removal strategies (snow fencing, wing plows)	No	Yes	N/A	Fuel use by snow removal equipment
In-place roadway recycling				
Cold In-place recycling	0%	0%	99%	Asphalt and fuel use by construction equipment in roadway resurfacing and BRT conversions

Using the Tool: Step 5

- Step 5: View impacts of construction and maintenance activities

	Annualized energy use (mmBTUs), per year over 20 years					
	Unmitigated					
	Roadway - new construction	Roadway-rehabilitation	Roadway - total	Bridges	Rail, bus, bicycle, ped.	Total
Upstream Energy						
Materials	89,975	152,838	242,813	24,643	178,067	**445,523**
Direct Energy						
Construction Equipment	33,942	27,079	60,021	10,747	61,606	**132,374**
Routine Maintenance						**158,585**
Total	**123,917**	**179,917**	**302,834**	**35,390**	**239,673**	**736,482**

	Annual GHG emissions (MT CO2e), per year over 20 years					
	Unmitigated					
	Roadway - new construction	Roadway-rehabilitation	Roadway - total	Bridges	Rail, bus, bicycle, ped.	Total
Upstream Emissions						
Materials	5,626	9,276	14,902	2,065	12,507	**29,474**
Direct Emissions						
Construction Equipment	2,402	1,975	4,377	784	4,491	**9,652**
Routine Maintenance						**11,564**
Total	**8,028**	**11,251**	**19,279**	**2,849**	**16,998**	**50,690**

Reporting results in NEPA docs: GHGs

- Can use similar techniques to report GHG results as used for MSAT results (e.g., trend graphs)
- Include a point of reference
  - Many FHWA NEPA docs compare project emissions to state and global emissions

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Reporting results in NEPA docs: energy

- Energy results can be reported in MOVES units (e.g., million Btus), or converted to fuel-based units (e.g., gallons of gasoline equivalent (GGe))
- Conversion factor: 1 gallon gasoline = 124,000 Btu
  - Can also do this conversion for each of the fuel types, if you need that much detail
- Can also convert GGe estimates to cost estimates, based on price of gasoline

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Documenting MOVES Work for Reviewers and the Project Files

301

Best practices

- Use naming conventions
  - Use consistent names for RunSpecs, input spreadsheets, input databases, output databases so you (and your reviewers) know which files go together
- Use descriptions
  - Use the Description panel in the RunSpec to explain what each run does; can also type descriptions in the CDM before importing each data item

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Be kind to your reviewers

- When sending a group of files for review, include a brief "readme" file explaining what each file is (easier if you've created the master list of RunSpecs and inputs described earlier)
- Explain any anomalies (e.g., an output database that contains more than one run when others don't, etc.)

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Managing files

- Group of spreadsheets for each run, or one spreadsheet
- Back up/archive files when complete
- RunSpecs, data spreadsheets, input and output databases can be stored on external media when no longer needed
- Also save the MOVES install package you used and any updated default database
  - In case you have to duplicate your work years later

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Session 3: Using MOVES for Highway Air Dispersion Modeling

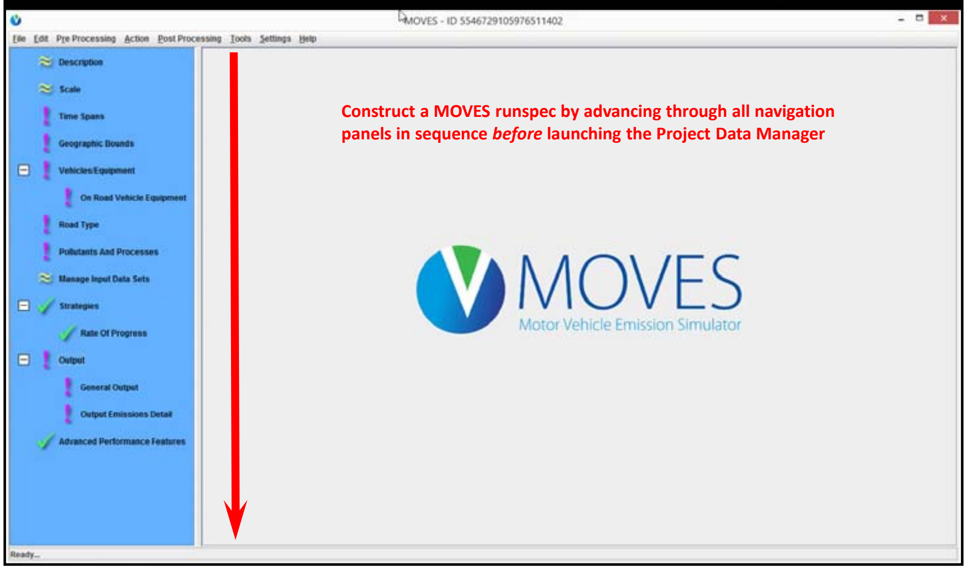
1

Session Outline

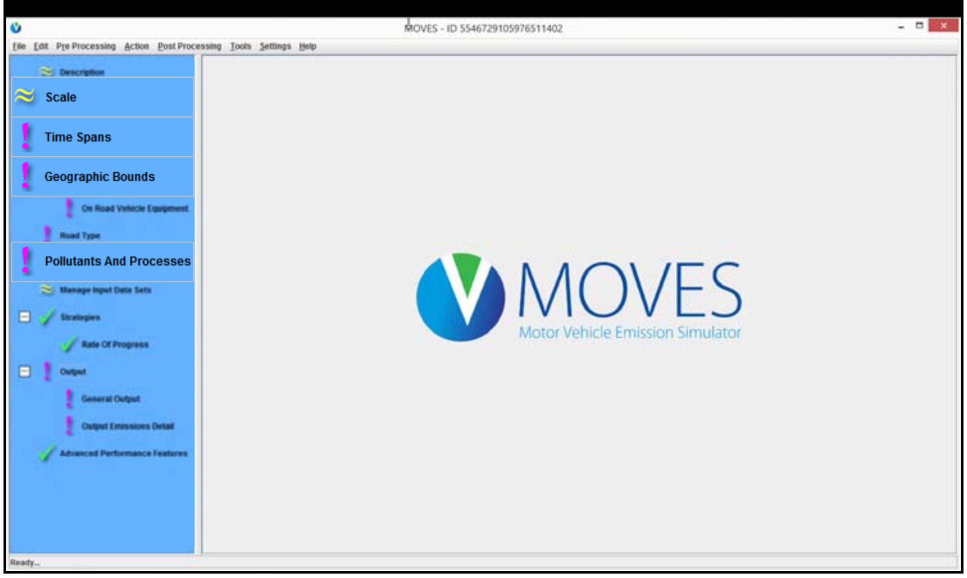
- Setting Up a MOVES Runspec
  - Pertinent navigation panels
- MOVES Project Data Manager
  - Specifying project data
- Class Exercise
  - Constructing a CO speed look-up table

2

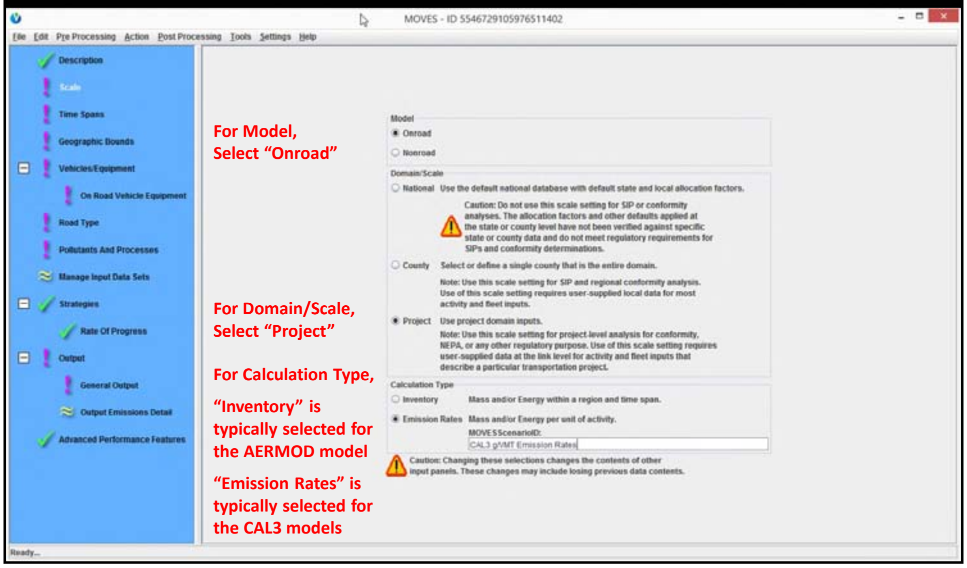
Setting Up a MOVES Runspec



Pertinent Navigation Panels



Scale



Scale

- A MOVES Project scale Inventory Calculation provides results reported as Mass (or Energy) for the specified Time Span, e.g., grams for the Year/Month/Day/Hour
- A MOVES Project scale Emission Rates Calculation provides results reported as Mass (or Energy) per Activity (such as distance traveled) for the specified Time Span, e.g., g/VMT for the Year/Month/Day/Hour

RESOURCE CENTER

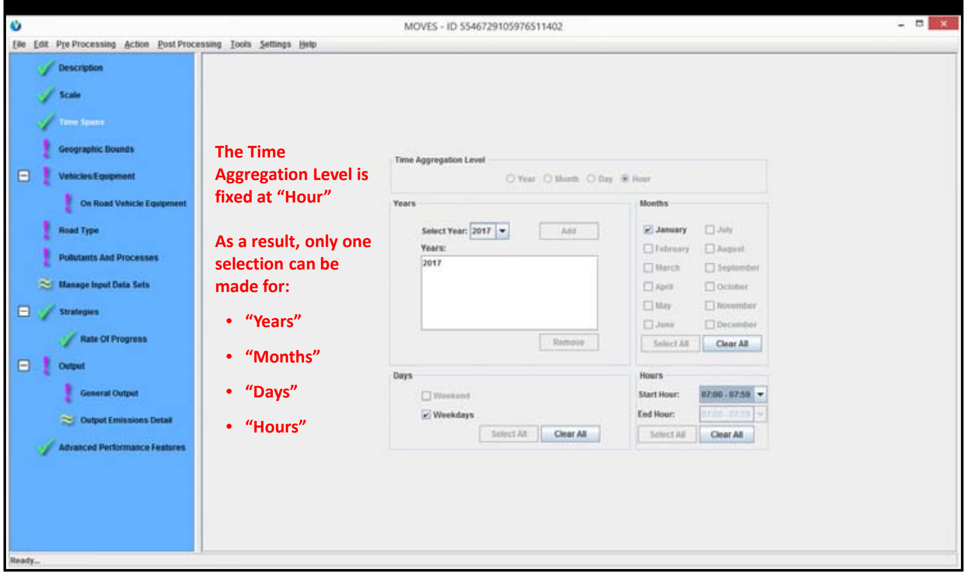
6

Scale

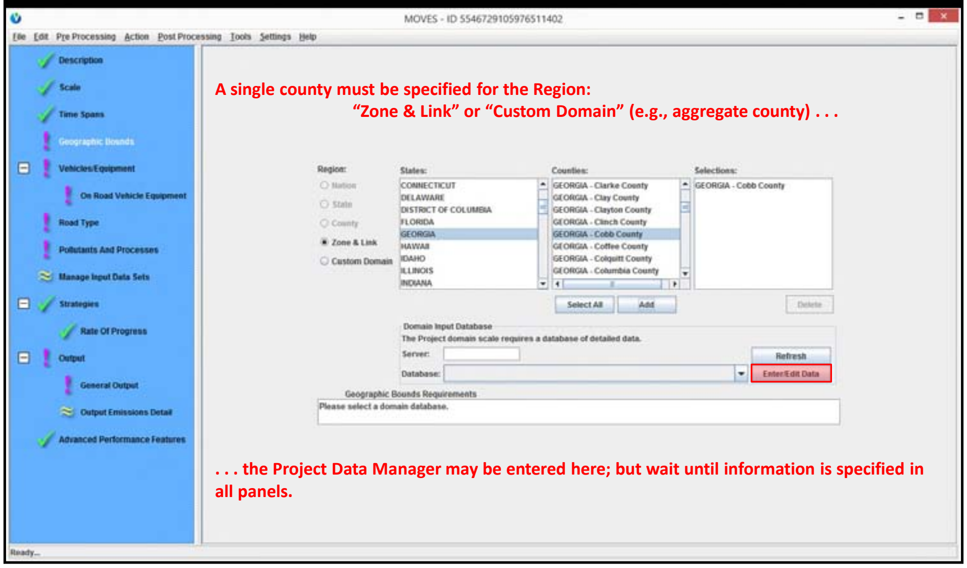
- ***TIP:***
  - The same result will be obtained for a simulation using either the Inventory or Emission Rates Calculation Type by entering lengths of 1 mi and volumes of 1 vph on the Links Project Data Manager tab

7

Time Spans



Geographic Bounds

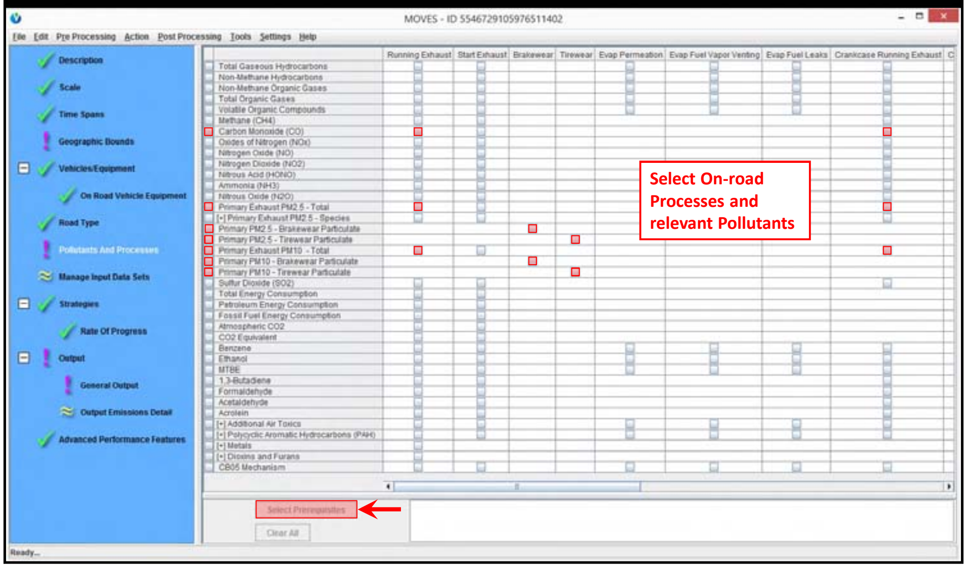


Geographic Bounds: Selecting the Project County

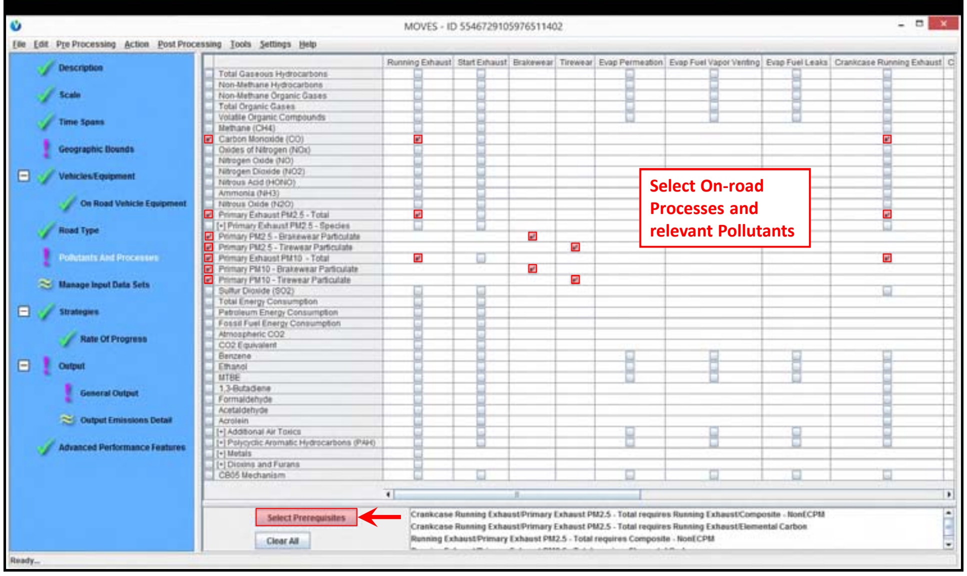
- If a project spans multiple counties, users have three options:
  - If the fuel supply and age distribution of vehicles in the fleet are the same for all of the counties, select the county in which the majority of the project area is located;
  - If not, separate the project into multiple parts (each of which is in a separate county) and do separate MOVES runs for each part; or
  - Use the custom domain option to model one unique area that represents all the project counties

10

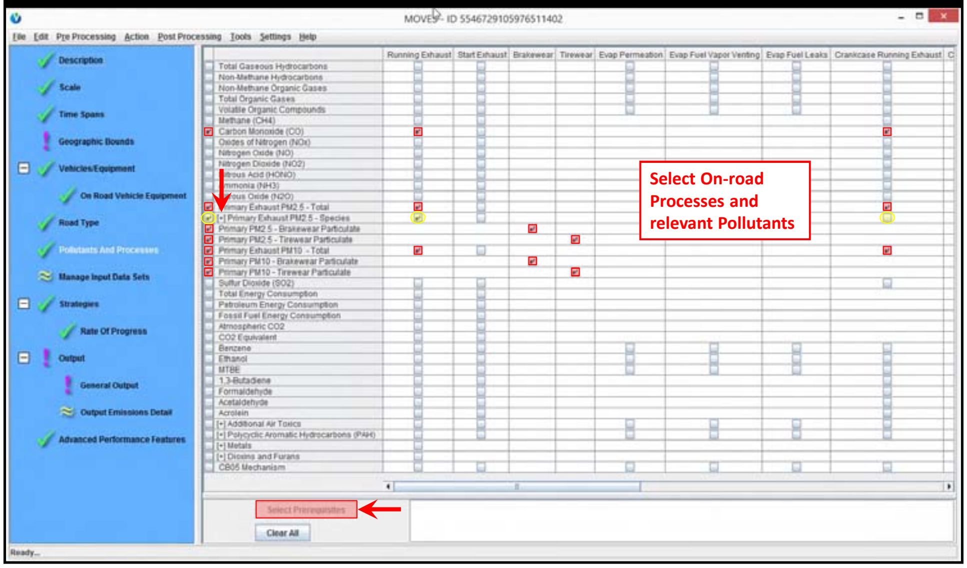
Pollutants and Processes: On Road Components



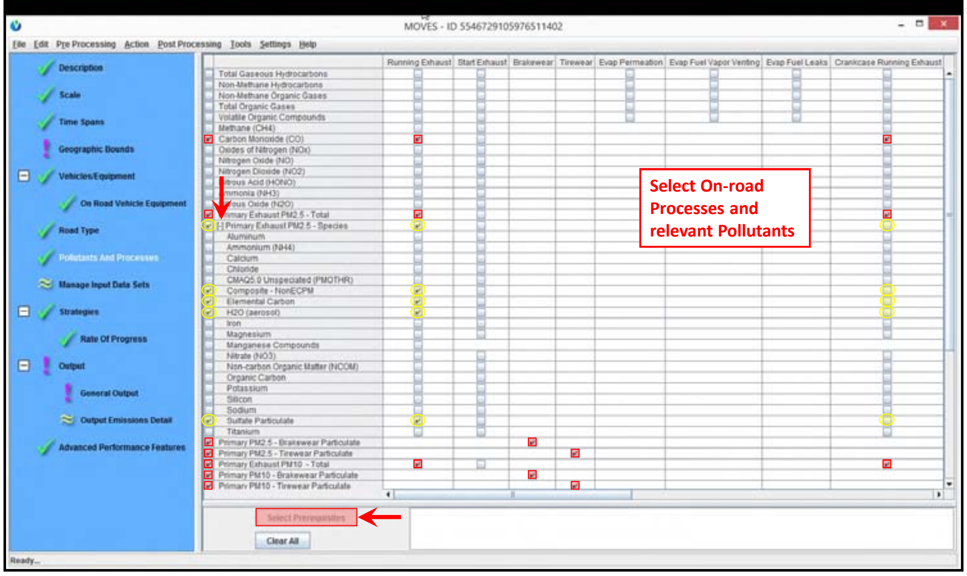
Pollutants and Processes: On Road Components



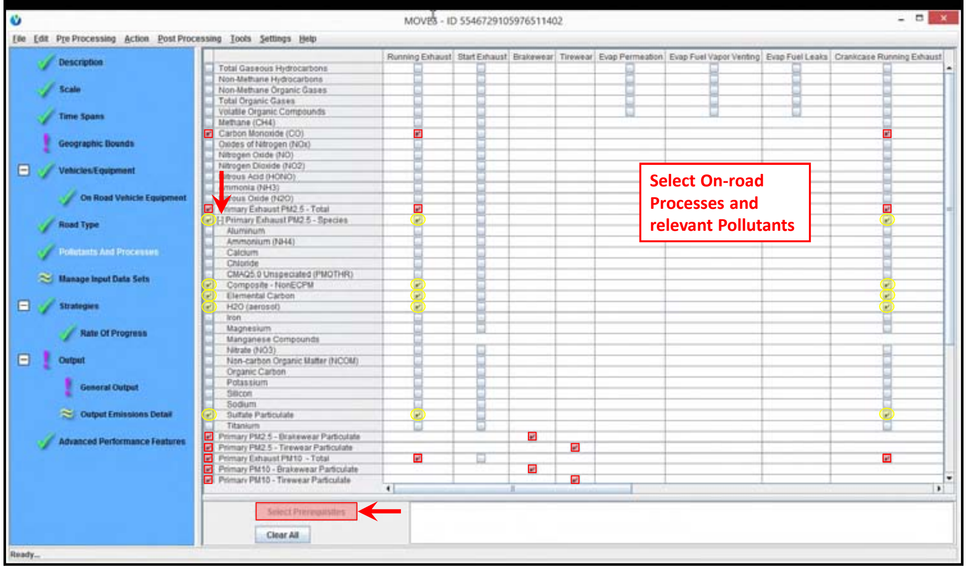
Pollutants and Processes: On Road Components



Pollutants and Processes: On Road Components



Pollutants and Processes: On Road Components



Pollutants and Processes: Off-network Components

- Start Exhaust
- Extended Idle Exhaust
- Crankcase Start Exhaust
- Crankcase Extended Idle Exhaust

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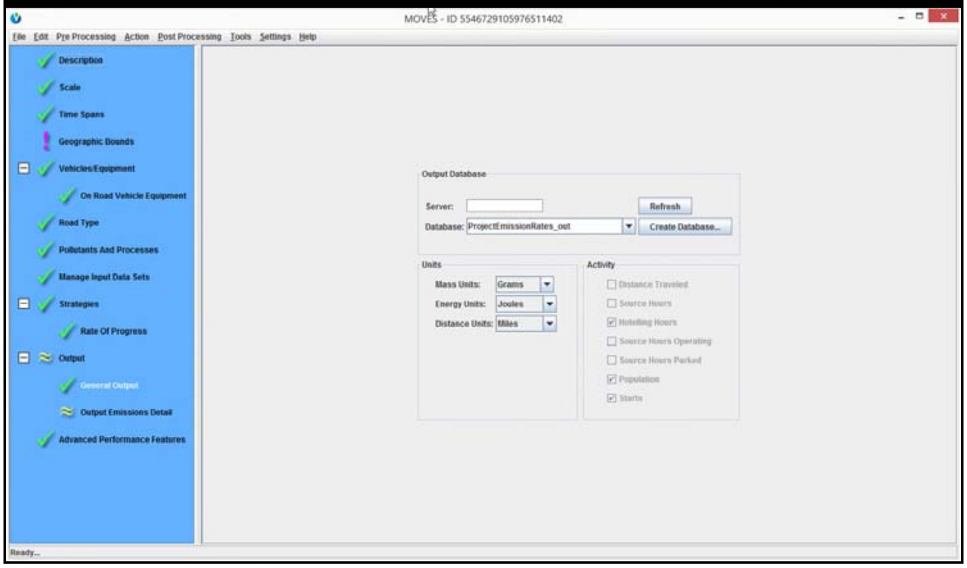
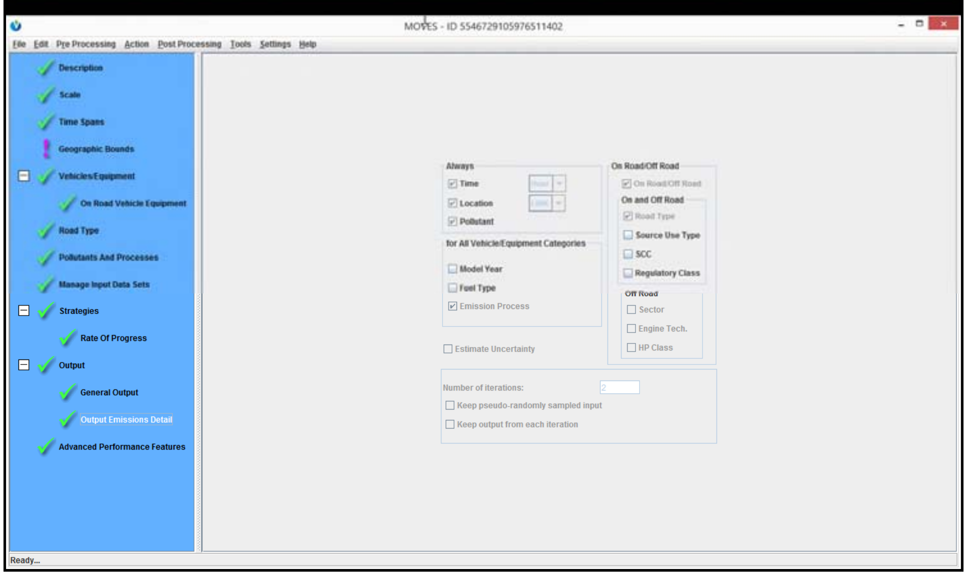
General Output



Output Emissions Detail



Output Emissions Detail

- If the Emission Rates option is selected on the Scale panel, EPA states that output by Source Use Type, Model Year, or Fuel Type should likewise not be selected

RESOURCE CENTER

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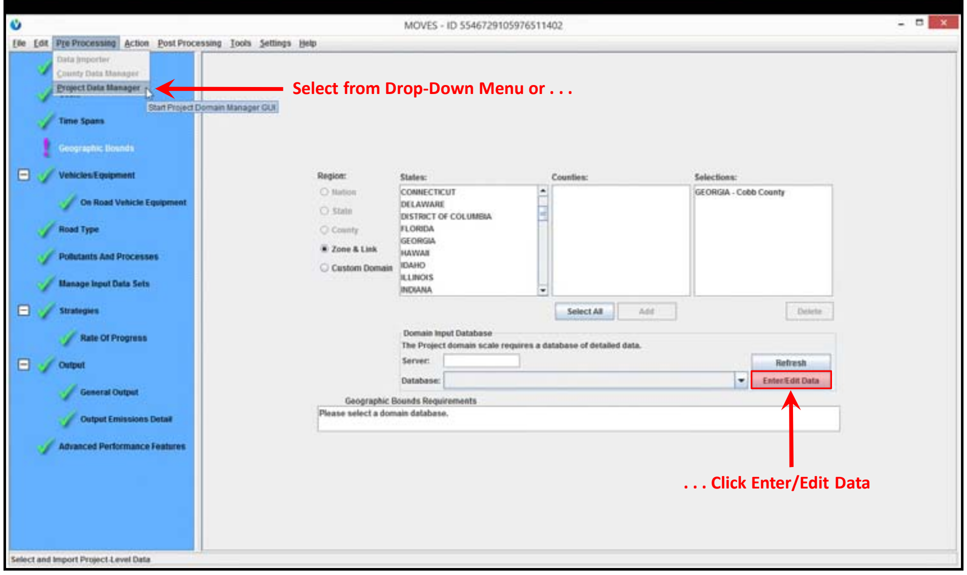
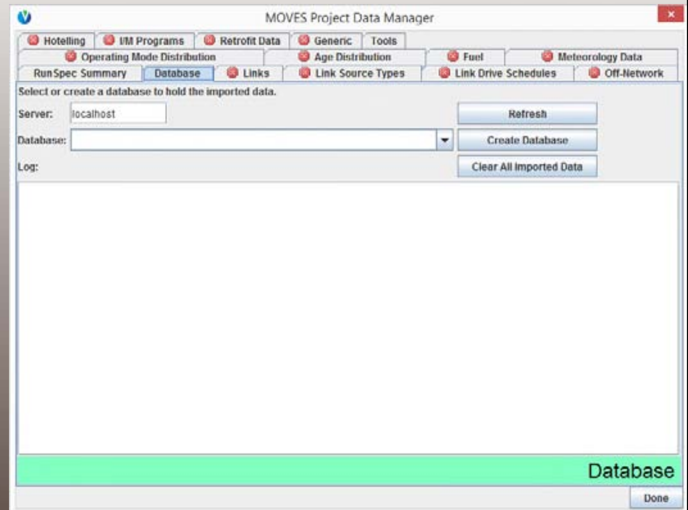
Enter Project Data Manager



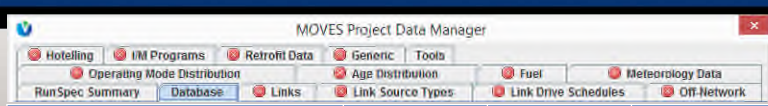
MOVES Project Data Manager

Database tab functions:

- Refresh
- Create Database
- Clear All Imported Data



Specifying Project Data



Data Manager Tab	Project	County	Importer
Links	✓		
Link Source Types	✓		
Link Drive Schedules	✓		
Off-Network	✓		
Operating Mode Distribution	✓		
Age Distribution	✓	✓	✓
Fuel	✓	✓	✓
Meteorology Data	✓	✓	✓
Hoteling	✓	✓	✓

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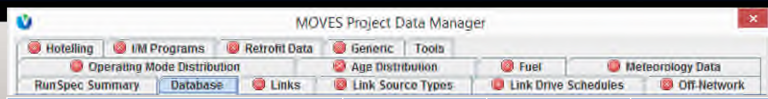
Specifying Project Data



Data Manager Tab	Project	County	Importer
I/M Programs	✓	✓	✓
Retrofit Data	✓	✓	✓
Generic	✓	✓	✓
Average Speed Distribution		✓	✓
Ramp Fraction		✓	✓
Road Type Distribution		✓	✓
Source Type Population		✓	✓
Starts		✓	✓
Vehicle Type VMT		✓	✓

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Defining Links

- Highway segments of collective traffic activity, emission conditions, and highway configuration
- Define a distinct link whenever a change in traffic, emissions, and/or highway configuration occurs
- Traffic
  - Volume
  - Speed
  - Truck percentage

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Defining Links

- Emissions
  - Traffic
  - Road type (drive schedule)
  - Road grade
- Highway configuration
  - Traffic and emissions
  - Width
  - Directional orientation or bearing

RESOURCE CENTER

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Characterizing Project Emissions

- Link Average Vehicle Speed
  - Default drive cycles
- Link Drive Schedules*
  - User-defined drive cycles representing the fleet average
- Operating Mode (OpMode) Distribution*
  - User-defined drive cycles by individual source type
- *Advanced Applications
  - Modal emission rates
  - Operating mode look-up tables

RESOURCE CENTER

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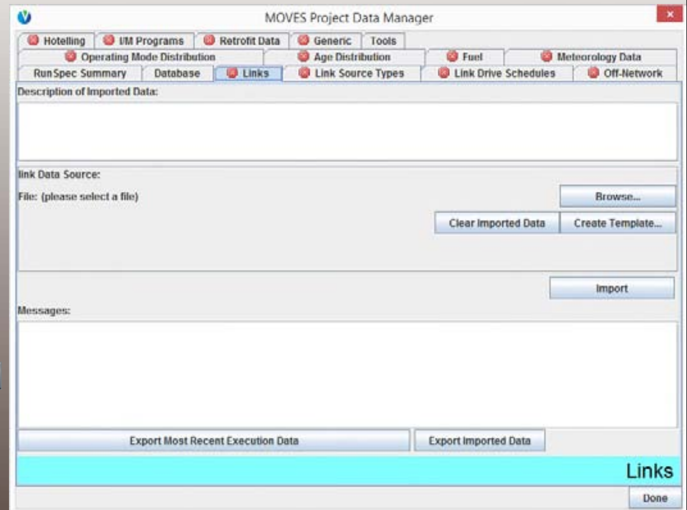
MOVES Project Data Manager

Common tab functions:

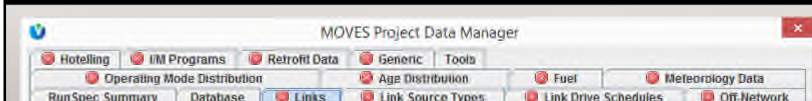
- Browse...
- Create Template...
- Clear Imported Data
- Import
- Export Imported Data

Alternate tab functions:

- Export Most Recent Execution Data
- Export Default Data



Links Template



linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription	linkAvgGrade
	13067	130670	1					
	13067	130670	2					
	13067	130670	3					
	13067	130670	4					

link | County | RoadType | Zone

linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription	linkAvgGrade
1	13067	130670	4	0.2010	6032	55.4	NB Freeway Segment 1 - AM Peak	1
2	13067	130670	4	0.0644	5476	55.9	NB Freeway Segment 2 - AM Peak	1
3	13067	130670	4	0.3785	5476	56.8	NB Freeway Segment 3 - AM Peak	1
4	13067	130670	4	0.3777	4260	58.8	SB Freeway Segment 1 - AM Peak	-1
5	13067	130670	4	0.0948	4260	58.2	SB Freeway Segment 2 - AM Peak	-1
6	13067	130670	4	0.1739	5079	57.6	SB Freeway Segment 3 - AM Peak	-1

link | County | RoadType | Zone

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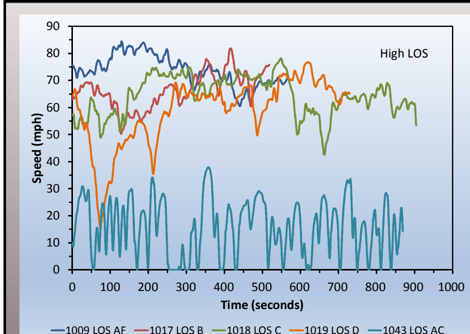
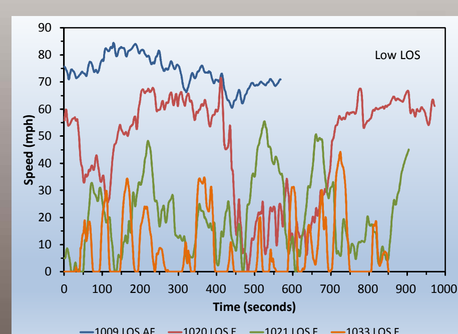
Default Drive Schedules

ID	Average Speed (mph)	Drive Schedule Name	ID	Average Speed (mph)	Drive Schedule Name	ID	Average Speed (mph)	Drive Schedule Name
199	34.6	LD Freeway Ramp	304	19.4	HD 20mph Non-Freeway	1009	73.7991	Final FC01 LOS AF Cycle
201	4.6	MD 5mph Non-Freeway	305	25.6	HD 25mph Non-Freeway	1017	66.3632	Final FC11 LOS B Cycle
202	10.7	MD 10mph Non-Freeway	306	32.5	HD 30mph Non-Freeway	1018	64.3993	Final FC11 LOS C Cycle
203	15.6	MD 15mph Non-Freeway	351	34.3	HD 30mph Freeway	1019	58.7949	Final FC11 LOS D Cycle
204	20.8	MD 20mph Non-Freeway	352	47.1	HD 40mph Freeway	1020	46.132	Final FC11 LOS E Cycle
205	24.5	MD 25mph Non-Freeway	353	54.2	HD 50mph Freeway	1021	20.6006	Final FC11 LOS F Cycle
206	31.5	MD 30mph Non-Freeway	354	59.4	HD 60mph Freeway	1033	8.71909	Final FC14 LOS F Cycle
251	34.4	MD 30mph Freeway	355	71.7	HD High Speed Freeway	1043	15.733	Final FC19 LOS AC Cycle
252	44.5	MD 40mph Freeway	399	25.3	HD Freeway Ramp	1011	49.0722	Final FC02 LOS DF Cycle
253	55.4	MD 50mph Freeway	401	15	Bus Low Speed Urban	1029	31.0232	Final FC14 LOS B Cycle
254	60.4	MD 60mph Freeway	402	30	Bus 30 mph Flow	1030	25.379	Final FC14 LOS C Cycle
255	72.8	MD High Speed Freeway	403	45	Bus 45 mph Flow	1041	18.5781	Final FC17 LOS D Cycle
299	31	MD Freeway Ramp	501	2.2	Refuse Truck Urban	1024	63.66	Final FC12 LOS C Cycle
301	5.8	HD 5mph Non-Freeway	101	2.5	LD Low Speed 1	1025	52.8263	Final FC12 LOS D Cycle
302	11.2	HD 10mph Non-Freeway	153	30.5	LD LOS E Freeway	1026	43.2662	Final FC12 LOS E Cycle
303	15.6	HD 15mph Non-Freeway	158	76	LD High Speed Freeway 3			

Default Drive Schedules: Restricted Access





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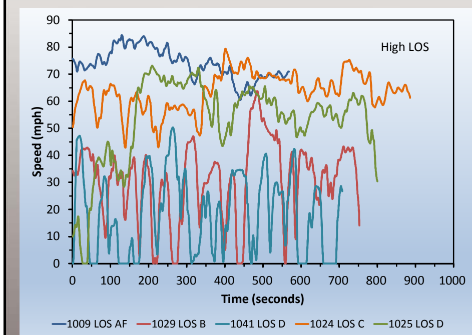
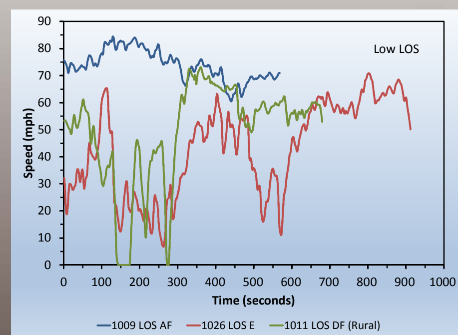
Default Drive Schedules: Unrestricted Access





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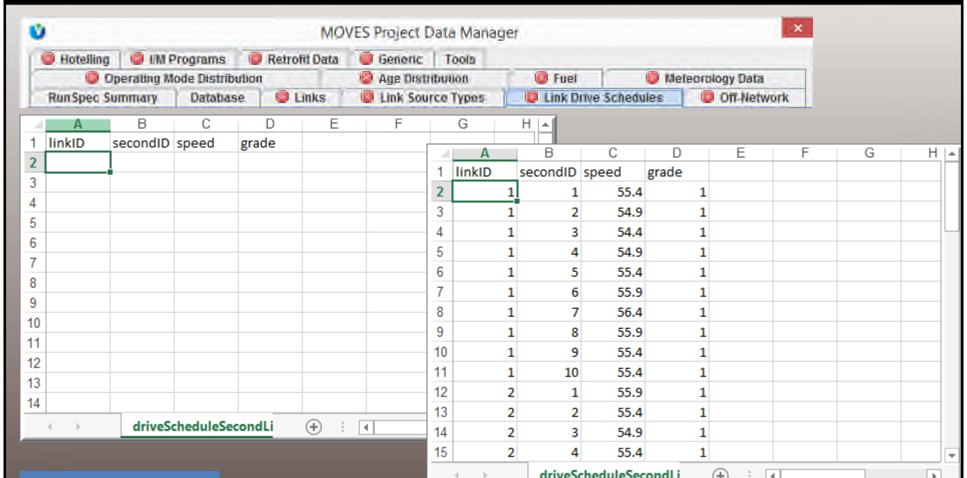
Link Drive Schedules Template



linkID	secondID	speed	grade
1	1	55.4	1
1	2	54.9	1
1	3	54.4	1
1	4	54.9	1
1	5	55.4	1
1	6	55.9	1
1	7	56.4	1
1	8	55.9	1
1	9	55.4	1
1	10	55.4	1
2	1	55.9	1
2	2	55.4	1
2	3	54.9	1
2	4	55.4	1

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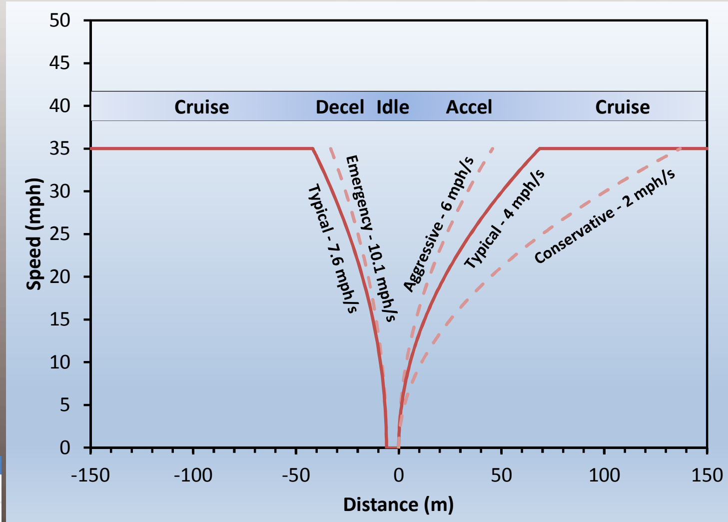
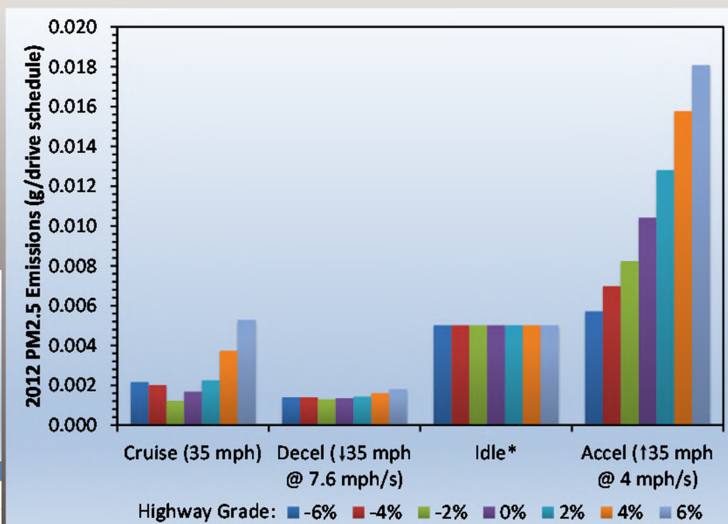
Link Drive Schedules – Modal Activity

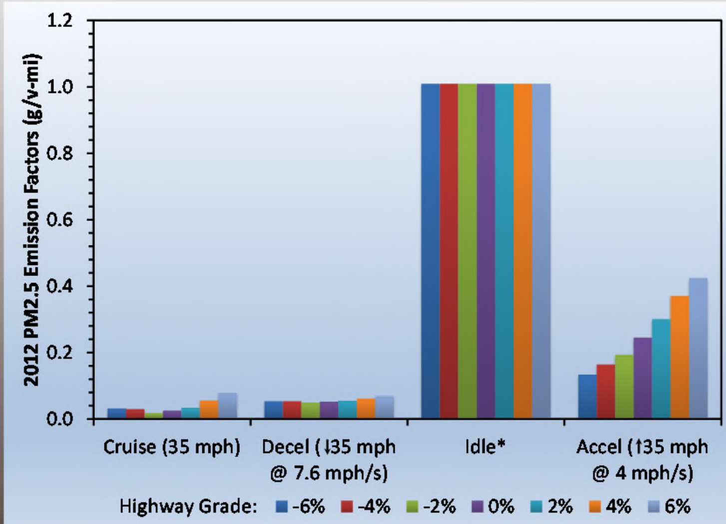


Link Drive Schedules – Emissions



*Idle emissions are a function of idle delay time. Highly congested LOS E (idle delay = 60 s) conditions are represented

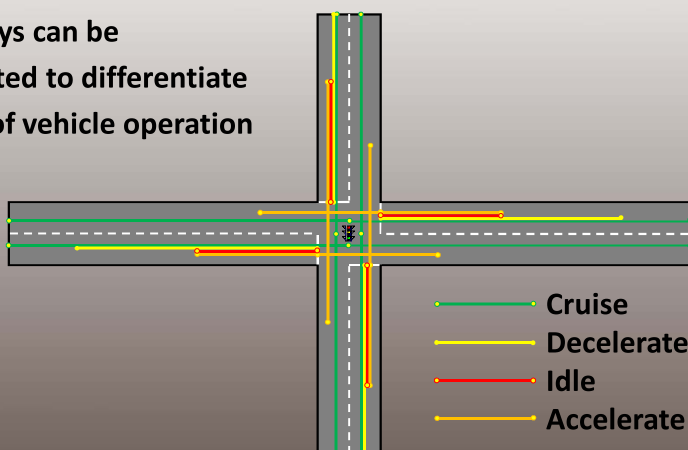
Link Drive Schedules – Emissions



*Idle emissions are a function of idle delay time. Highly congested LOS E (idle delay = 60 s) conditions are represented

Spatial Differentiation

Roadways can be segmented to differentiate modes of vehicle operation



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Operating Mode Distribution Template

MOVES Project Data Manager

Hotelling | I/M Programs | Retrofit Data | Generic | Tools
Operating Mode Distribution | Age Distribution | Fuel | Meteorology Data
RunSpec Summary | Database | Links | Link Source Types | Link Drive Schedules | Off-Network

sourceTypeID	hourDayID	linkID	polProcessID	opModeID	opModeFraction
11	85		201	0	
11	85		201	1	
11	85		201	11	
11	85		201	12	
11	85		201	13	
11	85		201	14	
11	85		201	15	
11	85		201	16	
11	85		201	21	
11	85		201	22	
11	85		201	23	
11	85		201	24	
11	85		201	25	
11	85		201	27	

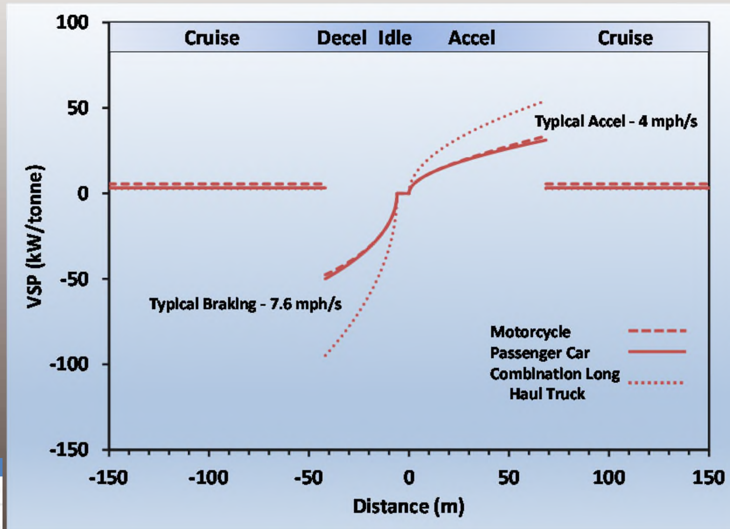
opModeDistribution

Vehicle Specific Power (VSP)

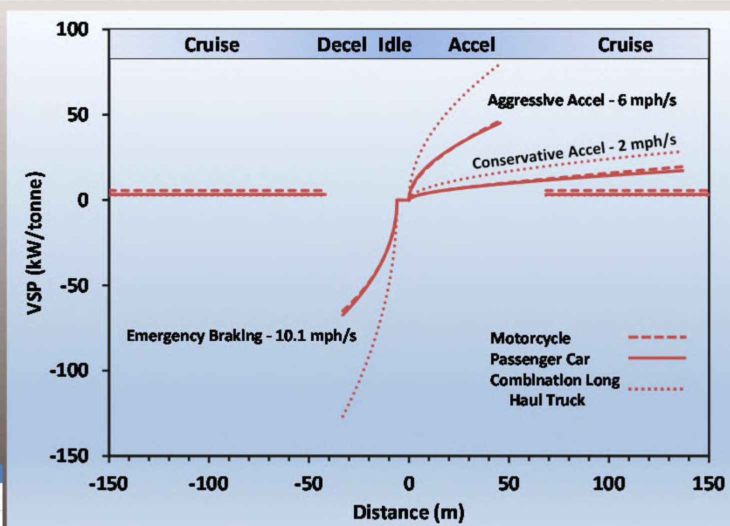
$$VSP = \frac{A\,v + B\,v^2 + C\,v^3 + m\,a\,v + m\,v\,g\sin\theta}{m_{fixed}}$$

Where
- A = rolling Term A,
- B = rolling Term B,
- C = drag Term C,
- v = average vehicle velocity (m/s)
- a = vehicle acceleration (m/s^2),
- m = source mass (metric tons),
- m_{fixed} = fixed mass factor (metric tons),
- g = gravitational constant, and
- θ = road grade

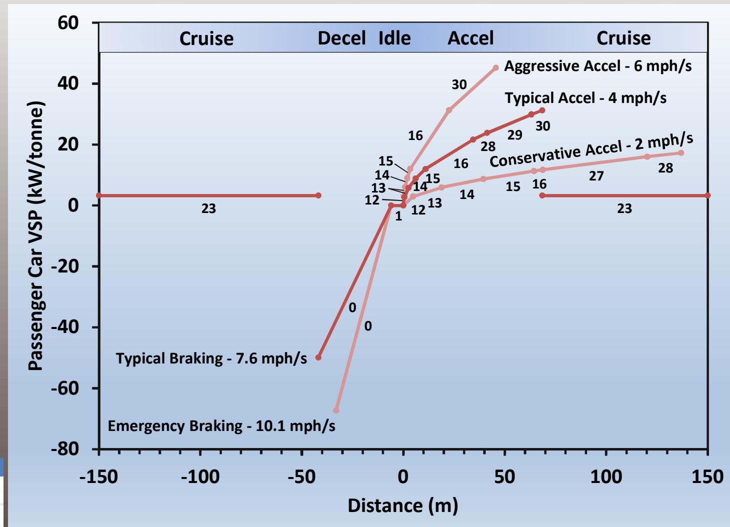
Single Vehicle VSP Trajectories



Ranges of VSP Trajectories



Passenger Car OpMode Trajectories



MOVES OpMode Bin Definitions

Description	VSP (kW/tonne)	Speed (mph) 1 – 25	25 – 50	≥ 50
Cruise / Acceleration	> 30	16	30	40
	27 – 30		29	39
	24 – 27			
	21 – 24		28	38
	18 – 21			
	15 – 18		27	37
	12 – 15			
	9 – 12	15	25	35
	6 – 9	14	24	
	3 – 6	13	23	33
	0 – 3	12	22	
Coasting	< 0	11	21	

MOVES OpMode Bin Definitions

Description	VSP (kW/tonne)	Speed (mph)		
		1 – 25	25 – 50	≥ 50
Braking	0			
Idling	1			
Running	301 – 316			
Tire Wear	400 – 416			

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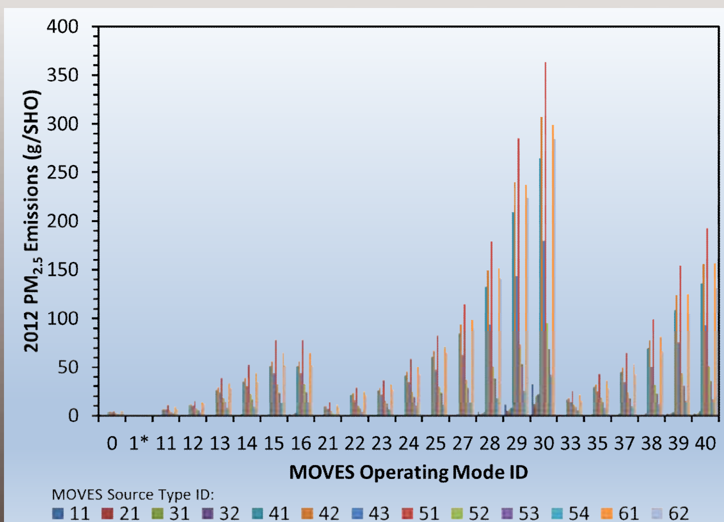
OpMode Emissions

SHO (Source Hours Operating) = Link Volume × Travel Distance / Link Average Speed



OpMode Look-Up Table

OpMode	2010 PM2.5 Exhaust Emissions (g/SHO) by Source Type												
	11	21	31	32	41	42	43	51	52	53	54	61	62
0	0.159	0.0936	0.176	0.651	4.47	4.49	4.30	5.07	3.23	3.19	1.74	5.17	5.22
1	0.191	0.0769	0.155	0.676	4.88	4.89	4.67	5.53	3.48	3.47	1.84	5.64	5.70
11	0.210	0.0830	0.255	0.912	8.16	8.58	7.42	12.3	6.31	4.46	2.66	10.1	7.00
12	0.251	0.1008	0.236	0.837	13.0	13.4	11.6	16.9	8.69	7.18	3.80	15.2	13.4
13	0.260	0.1599	0.411	1.46	32.2	33.7	28.1	42.8	21.1	17.2	9.10	37.8	31.5
14	0.380	0.1904	0.494	1.79	43.4	46.2	35.9	59.3	26.7	20.2	10.7	50.5	39.4
15	0.571	0.2472	0.695	2.18	63.3	66.6	52.1	87.3	39.0	28.9	15.2	73.5	58.7
16	1.86	0.709	1.62	3.80	63.3	66.7	52.4	87.4	39.7	29.2	16.3	73.5	58.7
21	0.236	0.1492	0.279	0.727	11.9	12.5	8.16	16.2	5.83	3.47	2.08	13.1	8.85
22	0.187	0.1618	0.296	0.993	26.6	27.6	18.8	32.3	11.8	8.88	4.26	28.3	23.8

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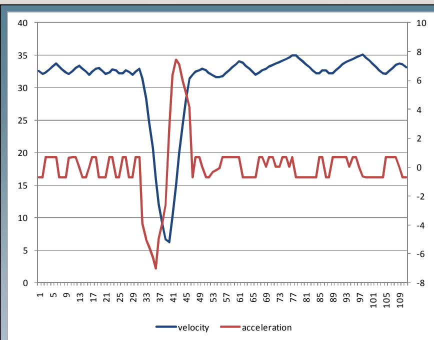
OpMode Look-Up Table

OpMode	2010 PM2.5 Exhaust Emissions (g/SHO) by Source Type												
	11	21	31	32	41	42	43	51	52	53	54	61	62
23	0.225	0.1634	0.298	1.04	31.8	33.3	25.5	40.7	18.1	14.7	7.53	35.9	29.5
24	0.302	0.1940	0.350	1.24	51.2	53.9	40.8	65.3	28.5	23.6	11.7	57.3	48.0
25	0.606	0.2460	0.437	1.46	74.3	78.1	55.7	91.0	35.2	28.5	13.1	80.7	72.4
27	0.889	0.427	0.734	1.86	103	110	74.2	126	43.9	34.5	15.2	111	101
28	4.66	1.922	3.21	4.56	162	176	112	197	61.5	46.7	21.1	171	159
29	13.5	6.53	8.21	9.59	255	283	171	314	89.3	65.6	30.9	268	254
30	38.3	16.11	24.8	26.8	322	362	216	400	117	83.9	52.0	338	322
33	0.485	0.411	0.727	1.48	21.2	22.5	17.3	28.7	13.9	10.44	6.49	24.8	17.0
35	0.434	0.430	0.807	2.07	36.6	38.4	29.4	48.0	22.0	17.25	9.45	41.4	31.6
37	0.598	0.462	0.971	2.42	56.2	59.7	41.8	72.4	28.6	21.50	11.2	61.6	48.3
38	1.02	0.842	1.43	2.90	86.9	93.6	60.9	111	38.2	27.74	13.7	93.3	74.9
39	2.60	2.05	3.06	4.62	135	148	91.1	172	53.4	37.3	18.4	143	118
40	2.84	2.39	3.64	5.87	169	187	112	216	63.3	43.5	20.6	179	149

Example Traffic Micro-Simulation Model Trajectories



Source: Chamberlin R., B. Swanson, E. Talbot, Jeff Dumont, and S. Pesci; *Utilizing MOVES' Link Drive Schedule for Estimating Project-Level Emissions*; presented at the TRB Workshop on Integrating MOVES with Transportation Micro-Simulation Models; 2010; http://trbairquality.org/wp-content/uploads/2011/02/Chamberlin-Presentation.pdf.

VISSIM Vehicle Record File (.fzp)

t	VehNr	DistX	a	v
3600	846	496	-0.58	29.87
3600	841	3020	0.51	31.73
3600	833	3654	-0.72	31.6
3600	829	3734	0.77	32.6
3600	824	3822	0.3	32.48
3600	819	3987	0.77	30.91
3600	832	4500	-0.76	31.68
3600	831	4792	0.53	29.57
3600	827	5354	-0.04	30.46
3600	826	5429	0.7	30.94
3600	825	5517	-0.63	31.41
3600	822	6127	0.89	31.5
3600	818	6195	0.81	31.78
3600	814	6274	0.41	32.21
3600	813	6527	-0.48	32.71
3600	848	359	0.65	28.94

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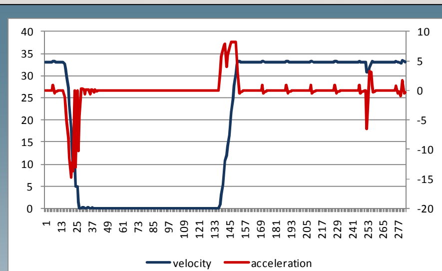
Example Traffic Micro-Simulation Model Trajectories



Source: Chamberlin R., B. Swanson, E. Talbot, Jeff Dumont, and S. Pesci; *Utilizing MOVES' Link Drive Schedule for Estimating Project-Level Emissions*; presented at the TRB Workshop on Integrating MOVES with Transportation Micro-Simulation Models; 2010; http://trbairquality.org/wp-content/uploads/2011/02/Chamberlin-Presentation.pdf.

Paramics vehicle-trajectory.csv

time	ID	x	y	v	a
3600.5	848	-68.27	1634.37	0.52	0.32
3600.5	856	-1286.25	1634.37	34.38	0
3600.5	861	-2306.02	1634.37	33.09	0
3600.5	862	-2435.31	1634.37	33.46	0
3600.5	863	-2615.37	1634.37	33.64	0
3600.5	842	19.68	1646.47	0	0
3600.5	843	40.97	1646.47	0.21	0.18
3600.5	844	71.3	1646.47	2.66	-0.84
3600.5	847	111.63	1646.47	3.64	-0.63
3600.5	849	150.51	1646.47	3.35	-0.59
3600.5	850	195.95	1646.47	10.75	-3.85
3600.5	851	352.91	1646.47	22.15	-5.17
3600.5	853	681.48	1646.47	32.73	-2.15
3600.5	855	1297.49	1646.47	32.91	0
3600.5	858	1843.25	1646.47	31.63	0
3600.5	860	2144.19	1646.47	32.91	0

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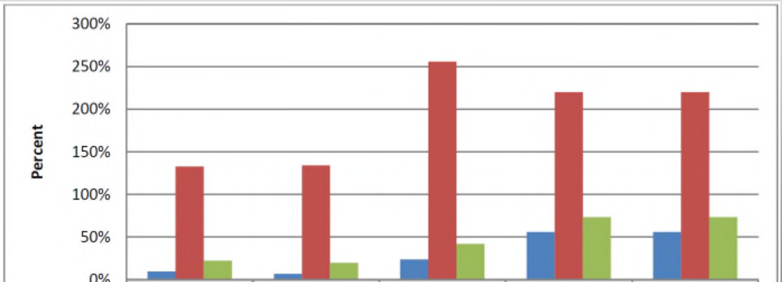
Example MOVES Results for OpMode Distribution Versus Average Speed



	CO	HC	NOx	PM10	PM25
FREEWAY	10%	7%	24%	56%	56%
ARTERIAL	133%	134%	256%	220%	220%
TOTAL	22%	20%	42%	73%	73%

Source: Lee, G., S. You, S. Ritchie, J. Saphores, and R. Jayakrishnan; *Air Quality and Health Impacts of a Major Urban Freight Corridor*; Research in Progress, University of California – Irvine; University of California Transportation Center; 2011.

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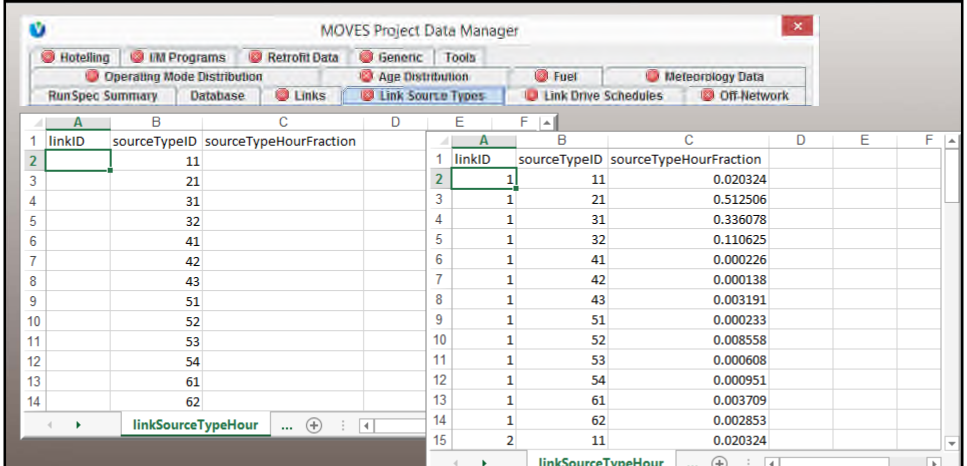
Link Source Types Template



linkID	sourceTypeID	sourceTypeHourFraction
	11	
	21	
	31	
	32	
	41	
	42	
	43	
	51	
	52	
	53	
	54	
	61	
	62	

linkID	sourceTypeID	sourceTypeHourFraction
1	11	0.020324
1	21	0.512506
1	31	0.336078
1	32	0.110625
1	41	0.000226
1	42	0.000138
1	43	0.003191
1	51	0.000233
1	52	0.008558
1	53	0.000608
1	54	0.000951
1	61	0.003709
1	62	0.002853
2	11	0.020324

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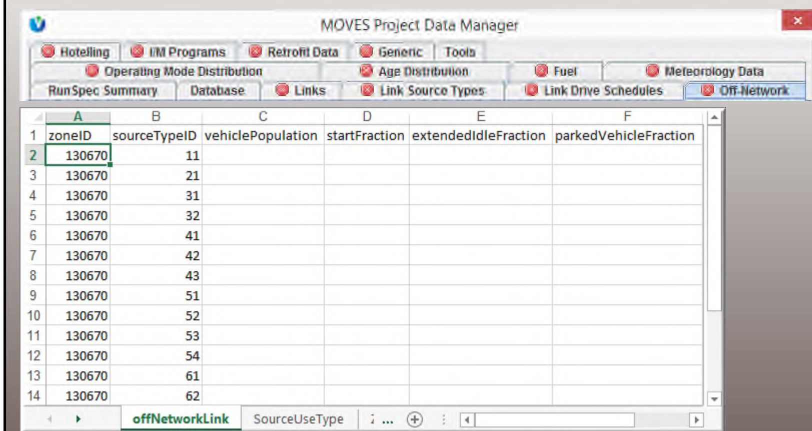
Off-Network Template



	A	B	C	D	E	F
1	zoneID	sourceTypeID	vehiclePopulation	startFraction	extendedIdleFraction	parkedVehicleFraction
2	130670	11				
3	130670	21				
4	130670	31				
5	130670	32				
6	130670	41				
7	130670	42				
8	130670	43				
9	130670	51				
10	130670	52				
11	130670	53				
12	130670	54				
13	130670	61				
14	130670	62				

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Number of MOVES Runs as per EPA PM Hot-spot Guidance

- Typically, complete 16 unique MOVES runs to account for variability of PM emissions
  - during the day (4 time periods)
    - morning peak – 6 am to 9 am
    - midday – 9 am to 4 pm
    - evening peak – 4 pm to 7 pm
    - overnight – 7 pm to 6 am
  - and season (4 months)
    - January
    - April
    - July
    - October

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Class Exercise: CO Speed Look-Up Table

- Divide into Teams
- Construct a speed look-up table of on-road, project scale CO emissions (in g/VMT) for an urban restricted roadway serving as a freight corridor during the morning peak hour traffic condition in Cobb County, Georgia for 2035
- Discuss the proposed methodology with respect to the MOVES navigation panels
  - Scale
  - Time spans
  - Geographic bounds
  - Pollutants and processes

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Class Exercise: CO Speed Look-Up Table

- Using the Project Data Manager, specify project data by completing templates for
  - Links
  - Link source types
  - Meteorology
- Specify Links to represent vehicle speeds in 5 mph increments from 0 to 75 mph
  - Emissions for idling vehicles are obtained by specifying a vehicle speed of 0 mph

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Class Exercise: CO Speed Look-Up Table

- Modify the available MPO data for Link Source Types for urban restricted access roadways to account for the large number of trucks expected to use the corridor
  - Supplied data file – MPO_LinkSourceTypes_UrbanRestrictedAccess.xls
  - % Trucks for project = 18%
    - Trucks = sourceTypeIDs 41, 42, 43, 51, 52, 53, 54, 61, and 62
    - Non-Trucks = sourceTypeIDs 11, 21, 31, and 32
- Export default Meteorology

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Class Exercise: CO Speed Look-Up Table

- Use MPO supplied data for
  - Age distribution
  - Fuel
  - I/M programs
- Set-up the runspec; import project data; and run MOVES
- Post processing
  - Run MySQL script on output database
    - CO_Grams_Per_Veh_Mile.sql
- Review results in MySQL Workbench

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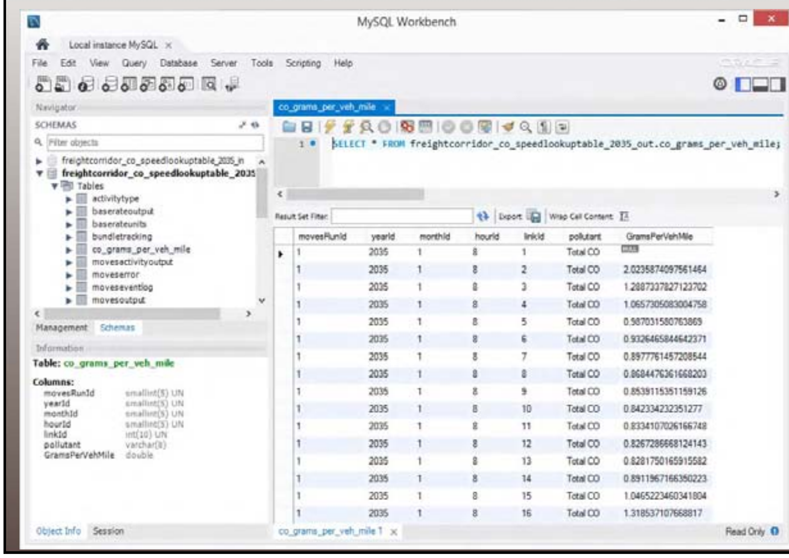
Review Results in MySQL Workbench



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SESSION 4: Highway Air Dispersion Modeling

1

Session Outline

- Need for Dispersion Modeling of Highway Projects
- Overview of the Environmental Protection Agency's (EPA) Dispersion Models for Highway Applications
  - Spatial Regimes
  - Dispersion Model Characteristics
  - Dispersion Model Formulation
  - Summary of Input Data Requirements
  - Mechanics of Running the Models
  - Input / Output Files

2

Session Outline

- Recommendations for Streamlining the Modeling Process
  - Defining Links
  - Input File Templates
  - Technical Tools (Utility Programs)
  - Graphical User Interfaces
  - CO Categorical Finding
- Agency Experiences in Conducting Dispersion Modeling for Quantitative Hot-spot Analyses of Highway Projects in Particulate Matter (PM) Areas

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3

Need for Dispersion Modeling of Highway Projects

- NEPA and Conformity Regulatory Requirements
  - Guideline for Modeling Carbon Monoxide from Roadway Intersections
  - Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas
  - 40 CFR Part 51 Appendix W, Guideline on Air Quality Models

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4

Spatial Regimes

- Project Scale / Microscale:
  - Concentrations > ± 20% for Distances ≤ 100 m
- Systems Scale / Mesoscale:
  - Concentrations < ± 20% for Distances between 100 m and 10,000 m
- Regional Scale / Macroscale:
  - Concentrations < ± 20% for Distances > 10,000 m

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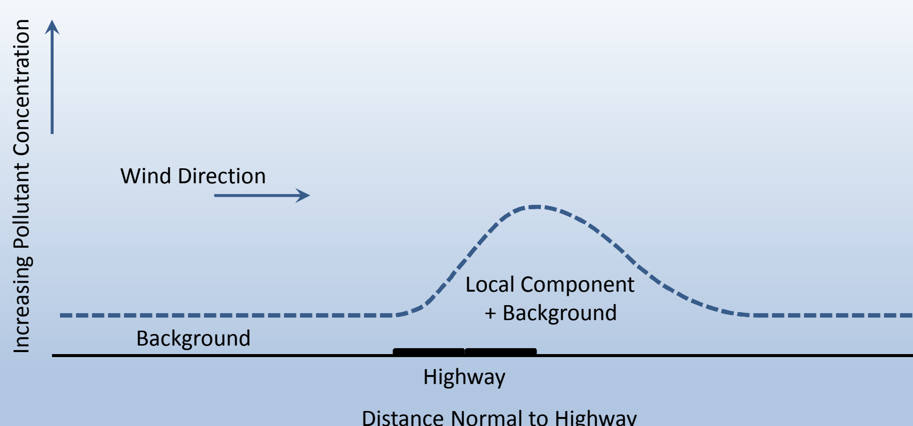
Project Scale



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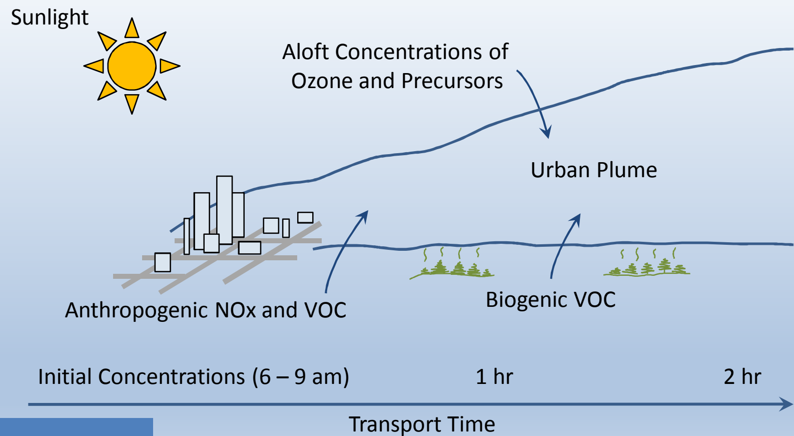
Systems Level



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Dispersion Model Characteristics

Atmospheric Scale

Microscale (Project Scale)
Mesoscale (Systems Scale)

Exposure Scale

Pollutant Applicability

Regulatory Applicability

Mathematical Class

Level of Sophistication

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Dispersion Model Characteristics

Atmospheric Scale

Exposure Scale

- **Acute (short-term, 1 to 24-hours)**
- **Chronic (long-term, annual)**

Pollutant Applicability

Regulatory Applicability

Mathematical Class

Level of Sophistication

9

Dispersion Model Characteristics

Atmospheric Scale

Exposure Scale

Pollutant Applicability

- **Inert pollutants, relatively unreactive in the microscale (CO, PM_{10}, $PM_{2.5}$, and NO_2)**
- **Reactive pollutants in the mesoscale (O_3, NO_2, and $PM_{2.5}$)**

Regulatory Applicability

Mathematical Class

Level of Sophistication

10

Dispersion Model Characteristics

Atmospheric Scale

Exposure Scale

Pollutant Applicability

Regulatory Applicability

- **Highways with free-flow traffic**
- **Signalized intersections**
- **Transportation terminals**
- **Urban areas**

Mathematical Class

Level of Sophistication

11

Dispersion Model Characteristics

Atmospheric Scale

Exposure Scale

Pollutant Applicability

Regulatory Applicability

Mathematical Class

- **Gaussian**
- **Numerical**
- **Statistical or Empirical**
- **Physical**

Level of Sophistication

12

Dispersion Model Characteristics

Atmospheric Scale

Exposure Scale

Pollutant Applicability

Regulatory Applicability

Mathematical Class

Level of Sophistication	**Screening** **Refined**

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Model Characteristics for Highway Applications

- CALINE3
  - ✓ Atmospheric Scale: Microscale
  - ✓ Exposure Scale: Acute
  - ✓ Pollutant Applicability: Inert, relatively unreactive in the microscale, no secondary pollutant formation (CO)
  - ✓ Regulatory Applicability: Free-flow traffic
  - ✓ Model Class: Gaussian
  - ✓ Level of Sophistication: Refined

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Model Characteristics for Highway Applications

- CAL3QHC
  - ✓ Atmospheric Scale: Microscale
  - ✓ Exposure Scale: Acute
  - ✓ Pollutant Applicability: Inert, relatively unreactive in the microscale, no secondary pollutant formation (CO)
  - ✓ Regulatory Applicability: Free-flow traffic and signalized intersections
  - ✓ Model Class: Gaussian
  - ✓ Level of Sophistication: Refined

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Model Characteristics for Highway Applications

- CAL3QHCR
  - ✓ Atmospheric Scale: Microscale
  - ✓ Exposure Scale: Acute and chronic
  - ✓ Pollutant Applicability: Inert, relatively unreactive in the microscale, no secondary pollutant formation (CO, PM_{10}, $PM_{2.5}$, NO_2)
  - ✓ Regulatory Applicability: Free-flow traffic and signalized intersections
  - ✓ Model Class: Gaussian
  - ✓ Level of Sophistication: Refined

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Model Characteristics for Highway Applications

- AERMOD
  - ✓ Atmospheric Scale: Microscale
  - ✓ Exposure Scale: Acute and chronic
  - ✓ Pollutant Applicability: Inert, relatively unreactive in the microscale, no secondary pollutant formation (CO, PM_{10}, $PM_{2.5}$, NO_2)
  - ✓ Regulatory Applicability: Free-flow traffic, signalized intersections, and transportation terminals
  - ✓ Model Class: Gaussian
  - ✓ Level of Sophistication: Refined

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Model Characteristics for Highway Applications

- CMAQ – Community Multi-scale Air Quality
  - ✓ Atmospheric Scale: Mesoscale
  - ✓ Exposure Scale: Acute and chronic
  - ✓ Pollutant Applicability: Inert and reactive, secondary pollutant formation (O_3, $PM_{2.5}$, and NO_2)
  - ✓ Regulatory Applicability: Urban area
  - ✓ Model Class: Numerical
  - ✓ Level of Sophistication: Refined

RESOURCE CENTER

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Model Characteristics for Highway Applications

- UAM – Urban Airshed Model
  - ✓ Atmospheric Scale: Mesoscale
  - ✓ Exposure Scale: Acute and chronic
  - ✓ Pollutant Applicability: Inert (CO)
  - ✓ Regulatory Applicability: Urban area
  - ✓ Model Class: Numerical
  - ✓ Level of Sophistication: Refined

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Model Characteristics for Highway Applications

Model Characteristics	Atmospheric Scale					
	Project Scale Models				Systems Scale Models	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	CMAQ	UAM
Exposure Scale						
Acute	●	●	●	●	●	●
Chronic			●	●	●	●
Regulatory Applicability						
Free-flow Highways	●	●	●	●		
Signalized Intersections		●	●	●		
Transportation Terminals				●		
Urban Areas					●	●
Pollutant Applicability						
Inert Pollutants	●	●	●	●	●	●
Reactive Pollutants					●	
Model Class						
Gaussian	●	●	●	●		
Numerical					●	●
Statistical or Empirical						
Physical						
Level of Sophistication						
Screening						
Refined	●	●	●	●	●	●

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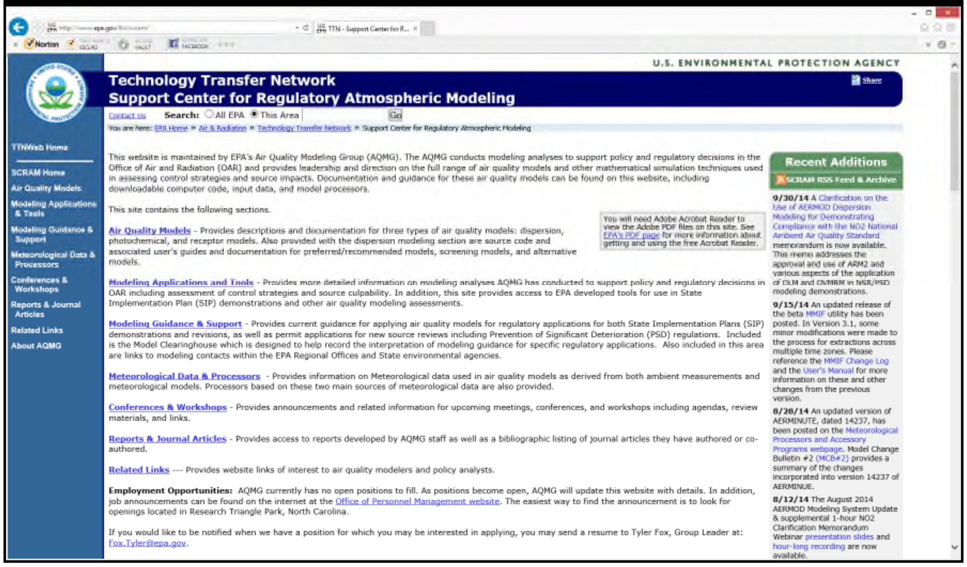
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About AQMG

This website is maintained by EPA's Air Quality Modeling Group (AQMG). The AQMG conducts modeling analyses to support policy and regulatory decisions in the Office of Air and Radiation (OAR) and provides leadership and direction on the full range of air quality models and other mathematical simulation techniques used in assessing control strategies and source impacts. Documentation and guidance for these air quality models can be found on this website, including downloadable computer code, input data, and model processors.

This site contains the following sections.

You will need Adobe Acrobat Reader to view the Adobe PDF files on this site. See EPA's PDF page for more information about getting and using the free Acrobat Reader.

Air Quality Models - Provides descriptions and documentation for three types of air quality models: dispersion, photochemical, and receptor models. Also provided with the dispersion modeling section are source code and associated user's guides and documentation for preferred/recommended models, screening models, and alternative models.

Modeling Applications and Tools - Provides more detailed information on modeling analyses AQMG has conducted to support policy and regulatory decisions in OAR including assessment of control strategies and source culpability. In addition, this site provides access to EPA developed tools for use in State Implementation Plan (SIP) demonstrations and other air quality modeling assessments.

Modeling Guidance & Support - Provides current guidance for applying air quality models for regulatory applications for both State Implementation Plans (SIP) demonstrations and revisions, as well as permit applications for new source reviews including Prevention of Significant Deterioration (PSD) regulations. Included is the Model Clearinghouse which is designed to help record the interpretation of modeling guidance for specific regulatory applications. Also included in this area are links to modeling contacts within the EPA Regional Offices and State environmental agencies.

Meteorological Data & Processors - Provides information on Meteorological data used in air quality models as derived from both ambient measurements and meteorological models. Processors based on these two main sources of meteorological data are also provided.

Conferences & Workshops - Provides announcements and related information for upcoming meetings, conferences, and workshops including agendas, review materials, and links.

Reports & Journal Articles - Provides access to reports developed by AQMG staff as well as a bibliographic listing of journal articles they have authored or co-authored.

Related Links --- Provides website links of interest to air quality modelers and policy analysts.

Employment Opportunities: AQMG currently has no open positions to fill. As positions become open, AQMG will update this website with details. In addition, job announcements can be found on the internet at the Office of Personnel Management website. The easiest way to find the announcement is to look for openings located in Research Triangle Park, North Carolina.

If you would like to be notified when we have a position for which you may be interested in applying, you may send a resume to Tyler Fox, Group Leader at: Fox.Tyler@epa.gov.

Recent Additions
SCRAM RSS Feed & Archive

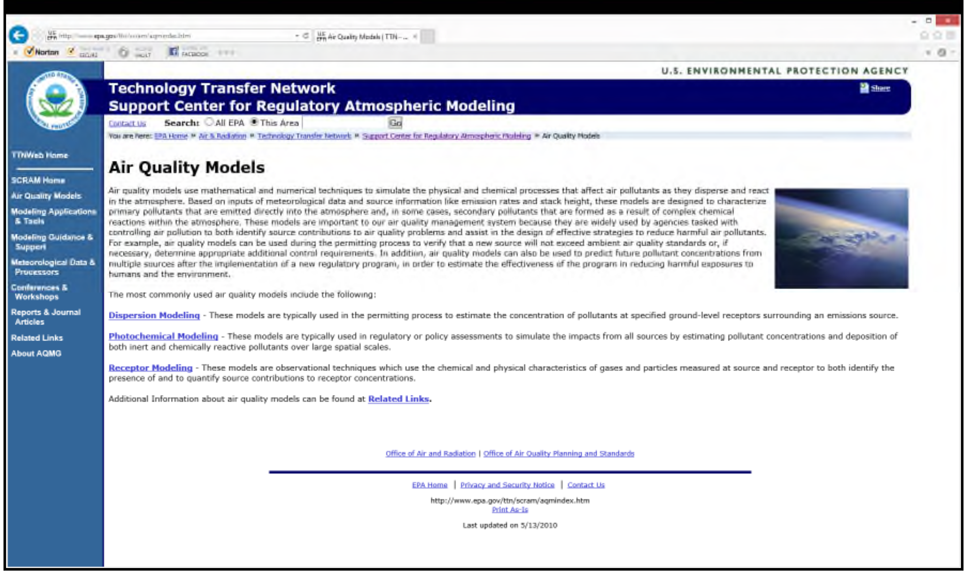
9/30/14 A Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO2 National Ambient Air Quality Standard memorandum is now available. This memo addresses the approval and use of ARM2 and various aspects of the application of OLM and PVMRM in NSR/PSD modeling demonstrations.

9/15/14 An updated release of the beta MMIF utility has been posted. In Version 3.1, some minor modifications were made to the process for extractions across multiple time zones. Please reference the MMIF Change Log and the User's Manual for more information on these and other changes from the previous version.

8/28/14 An updated version of AERMINUTE, dated 14237, has been posted on the Meteorological Processors and Accessory Programs webpage. Model Change Bulletin #2 (MCB#2) provides a summary of the changes incorporated into version 14237 of AERMINUE.

8/12/14 The August 2014 AERMOD Modeling System Update & supplemental 1-hour NO2 Clarification Memorandum Webinar presentation slides and hour-long recording are now available.

www.epa.gov/ttn/scram/ aqmindex.htm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Air Quality Models

Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Based on inputs of meteorological data and source information like emission rates and stack height, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere. These models are important to our air quality management system because they are widely used by agencies tasked with controlling air pollution to both identify source contributions to air quality problems and assist in the design of effective strategies to reduce harmful air pollutants. For example, air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. In addition, air quality models can also be used to predict future pollutant concentrations from multiple sources after the implementation of a new regulatory program, in order to estimate the effectiveness of the program in reducing harmful exposures to humans and the environment.

The most commonly used air quality models include the following:

Dispersion Modeling - These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.

Photochemical Modeling - These models are typically used in regulatory or policy assessments to simulate the impacts from all sources by estimating pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales.

Receptor Modeling - These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations.

Additional Information about air quality models can be found at **Related Links**.

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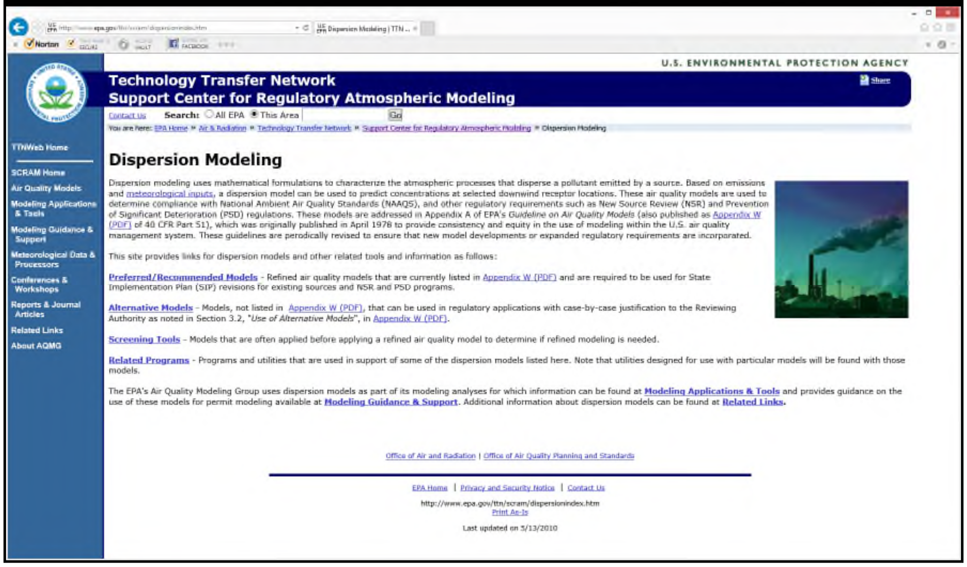

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Dispersion Modeling

Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations. These air quality models are used to determine compliance with National Ambient Air Quality Standards (NAAQS), and other regulatory requirements such as New Source Review (NSR) and Prevention of Significant Deterioration (PSD) regulations. These models are addressed in Appendix A of EPA's *Guideline on Air Quality Models* (also published as Appendix W (PDF) of 40 CFR Part 51), which was originally published in April 1978 to provide consistency and equity in the use of modeling within the U.S. air quality management system. These guidelines are periodically revised to ensure that new model developments or expanded regulatory requirements are incorporated.

This site provides links for dispersion models and other related tools and information as follows:

Preferred/Recommended Models - Refined air quality models that are currently listed in Appendix W (PDF) and are required to be used for State Implementation Plan (SIP) revisions for existing sources and NSR and PSD programs.

Alternative Models - Models, not listed in Appendix W (PDF), that can be used in regulatory applications with case-by-case justification to the Reviewing Authority as noted in Section 3.2, "*Use of Alternative Models*", in Appendix W (PDF).

Screening Tools - Models that are often applied before applying a refined air quality model to determine if refined modeling is needed.

Related Programs - Programs and utilities that are used in support of some of the dispersion models listed here. Note that utilities designed for use with particular models will be found with those models.

The EPA's Air Quality Modeling Group uses dispersion models as part of its modeling analyses for which information can be found at **Modeling Applications & Tools** and provides guidance on the use of these models for permit modeling available at **Modeling Guidance & Support**. Additional information about dispersion models can be found at **Related Links**.

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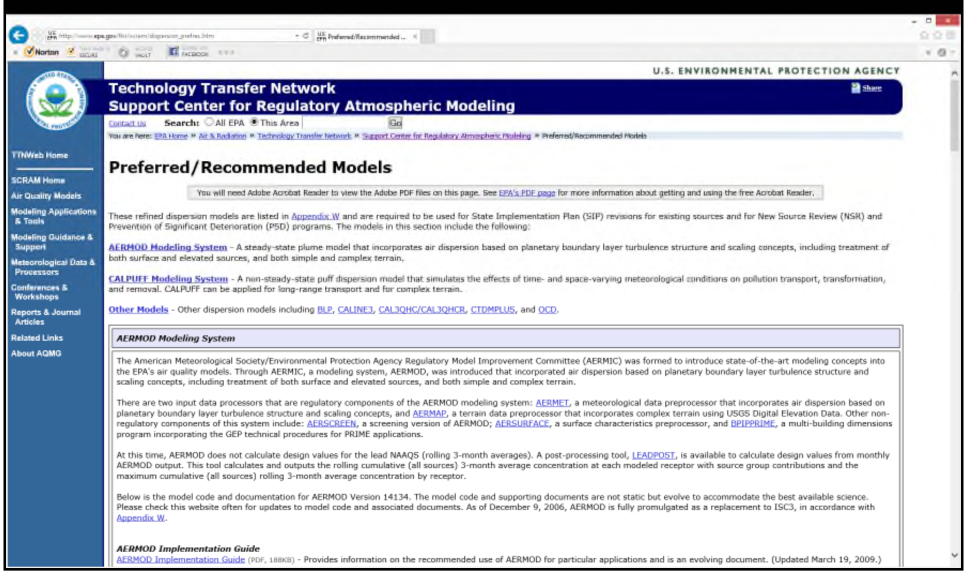
www.epa.gov/ttn/scram/dispersion_prefrec.htm



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Preferred/Recommended Models

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These refined dispersion models are listed in Appendix W and are required to be used for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. The models in this section include the following:

AERMOD Modeling System - A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

CALPUFF Modeling System - A non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

Other Models - Other dispersion models including BLP, CALINE3, CAL3QHC/CAL3QHCR, CTDMPLUS, and OCD.

AERMOD Modeling System

The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) was formed to introduce state-of-the-art modeling concepts into the EPA's air quality models. Through AERMIC, a modeling system, AERMOD, was introduced that incorporated air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET, a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include: AERSCREEN, a screening version of AERMOD; AERSURFACE, a surface characteristics preprocessor, and BPIPPRIME, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

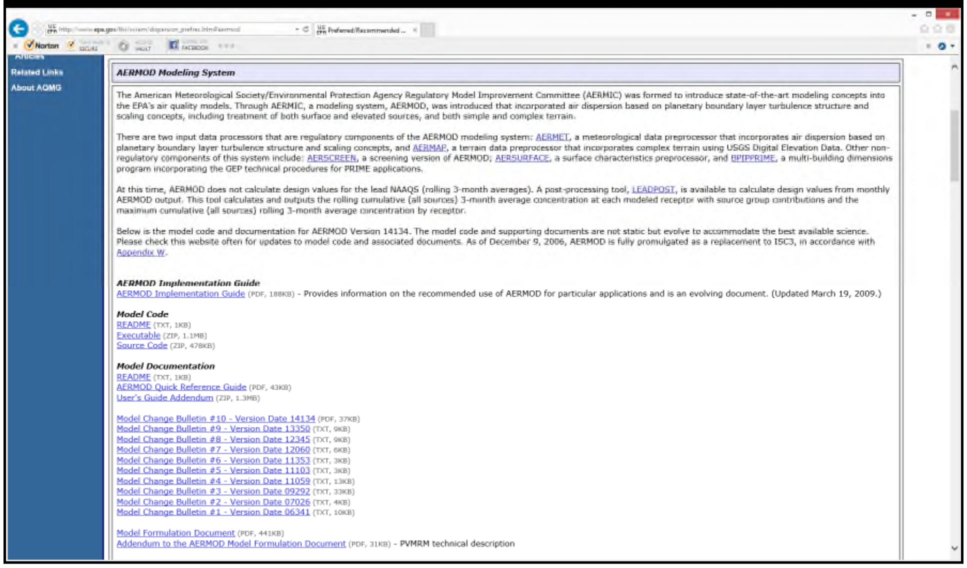
At this time, AERMOD does not calculate design values for the lead NAAQS (rolling 3-month averages). A post-processing tool, LEADPOST, is available to calculate design values from monthly AERMOD output. This tool calculates and outputs the rolling cumulative (all sources) 3-month average concentration at each modeled receptor with source group contributions and the maximum cumulative (all sources) rolling 3-month average concentration by receptor.

Below is the model code and documentation for AERMOD Version 14134. The model code and supporting documents are not static but evolve to accommodate the best available science. Please check this website often for updates to model code and associated documents. As of December 9, 2006, AERMOD is fully promulgated as a replacement to ISC3, in accordance with Appendix W.

AERMOD Implementation Guide

AERMOD Implementation Guide (PDF, 188KB) - Provides information on the recommended use of AERMOD for particular applications and is an evolving document. (Updated March 19, 2009.)

www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod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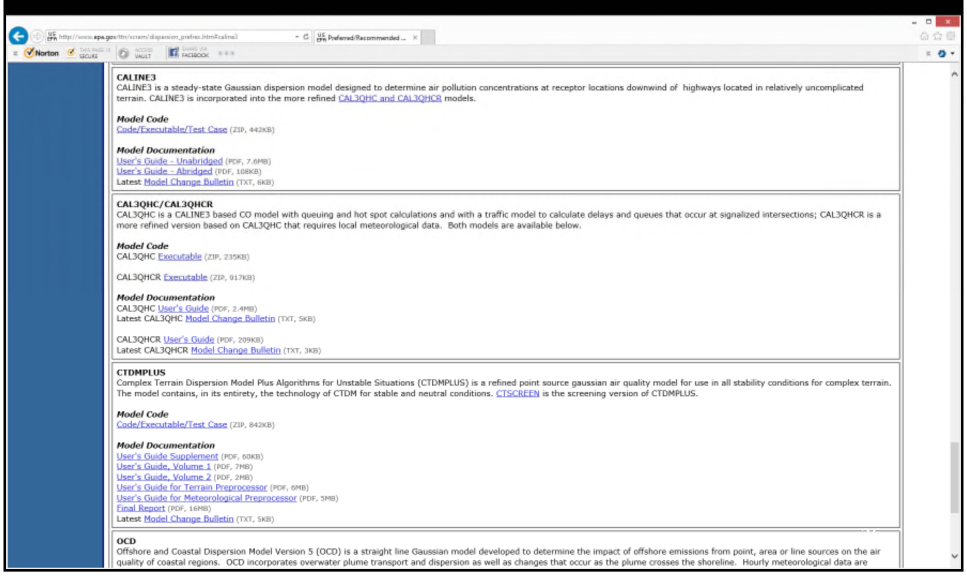
Model Code
README (TXT, 1KB)
Executable (ZIP, 1.1MB)
Source Code (ZIP, 478KB)

Model Documentation
README (TXT, 1KB)
AERMOD Quick Reference Guide (PDF, 43KB)
User's Guide Addendum (ZIP, 1.3MB)

Model Change Bulletin #10 - Version Date 14134 (PDF, 37KB)
Model Change Bulletin #9 - Version Date 13350 (TXT, 9KB)
Model Change Bulletin #8 - Version Date 12345 (TXT, 9KB)
Model Change Bulletin #7 - Version Date 12060 (TXT, 6KB)
Model Change Bulletin #6 - Version Date 11353 (TXT, 3KB)
Model Change Bulletin #5 - Version Date 11103 (TXT, 3KB)
Model Change Bulletin #4 - Version Date 11059 (TXT, 13KB)
Model Change Bulletin #3 - Version Date 09292 (TXT, 33KB)
Model Change Bulletin #2 - Version Date 07026 (TXT, 4KB)
Model Change Bulletin #1 - Version Date 06341 (TXT, 10KB)

Model Formulation Document (PDF, 441KB)
Addendum to the AERMOD Model Formulation Document (PDF, 31KB) - PVMRM technical description

www.epa.gov/ttn/scram/dispersion_prefrec.htm#caline3


CALINE3
CALINE3 is a steady-state Gaussian dispersion model designed to determine air pollution concentrations at receptor locations downwind of highways located in relatively uncomplicated terrain. CALINE3 is incorporated into the more refined CAL3QHC and CAL3QHCR models.

Model Code
Code/Executable/Test Case (ZIP, 442KB)

Model Documentation
User's Guide - Unabridged (PDF, 7.6MB)
User's Guide - Abridged (PDF, 108KB)
Latest Model Change Bulletin (TXT, 6KB)

CAL3QHC/CAL3QHCR
CAL3QHC is a CALINE3 based CO model with queuing and hot spot calculations and with a traffic model to calculate delays and queues that occur at signalized intersections; CAL3QHCR is a more refined version based on CAL3QHC that requires local meteorological data. Both models are available below.

Model Code
CAL3QHC Executable (ZIP, 235KB)

CAL3QHCR Executable (ZIP, 917KB)

Model Documentation
CAL3QHC User's Guide (PDF, 2.4MB)
Latest CAL3QHC Model Change Bulletin (TXT, 5KB)

CAL3QHCR User's Guide (PDF, 209KB)
Latest CAL3QHCR Model Change Bulletin (TXT, 3KB)

CTDMPLUS
Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) is a refined point source gaussian air quality model for use in all stability conditions for complex terrain. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions. CTSCREEN is the screening version of CTDMPLUS.

Model Code
Code/Executable/Test Case (ZIP, 842KB)

Model Documentation
User's Guide Supplement (PDF, 60KB)
User's Guide, Volume 1 (PDF, 7MB)
User's Guide, Volume 2 (PDF, 2MB)
User's Guide for Terrain Preprocessor (PDF, 6MB)
User's Guide for Meteorological Preprocessor (PDF, 5MB)
Final Report (PDF, 16MB)
Latest Model Change Bulletin (TXT, 5KB)

OCD
Offshore and Coastal Dispersion Model Version 5 (OCD) is a straight line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are

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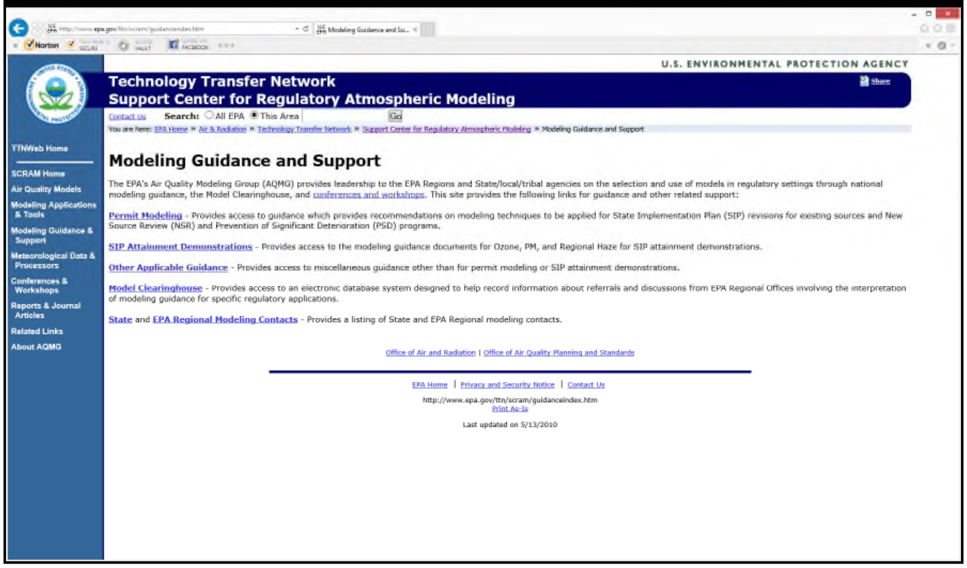
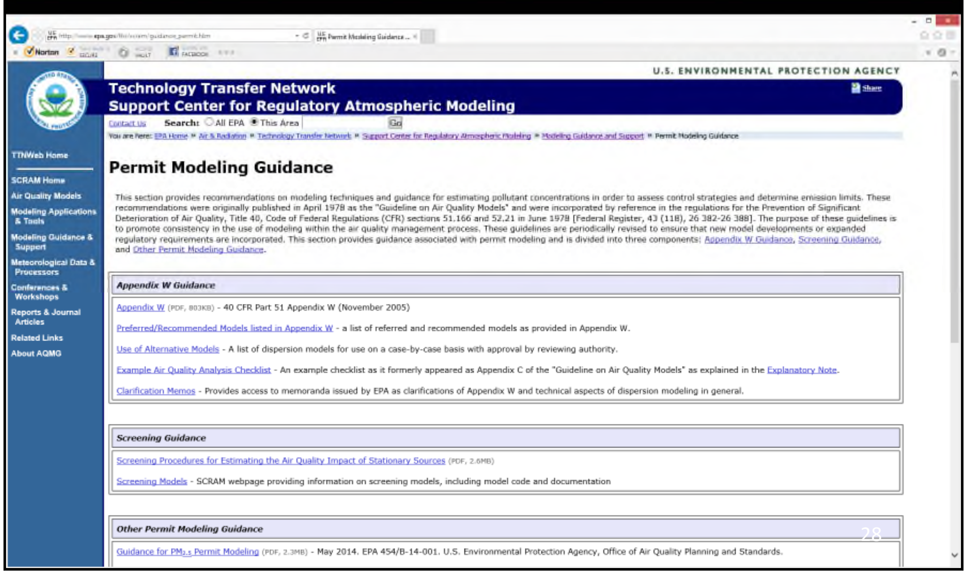


www.epa.gov/ttn/scram/guidance_permit.htm



www.epa.gov/ttn/scram/guidance_permit.htm

[Screening Procedures for Estimating the Air Quality Impact of Stationary Sources](PDF, 2.6MB)

Screening Models - SCRAM webpage providing information on screening models, including model code and documentation

Other Permit Modeling Guidance

Guidance for $PM_{2.5}$ Permit Modeling (PDF, 3.3MB) - May 2014. EPA 454/B-14-001. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards.

Draft Guidance for $PM_{2.5}$ Permit Modeling (PDF, 4.6MB) - March 2013. EPA 454/D-13-001. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards.

- There is an accompanying $PM_{2.5}$ SILs/SMC Court Decision Question and Answer Document (PDF, 99KB) that provides additional context for the *Draft Guidance for $PM_{2.5}$ Permit Modeling* with regards to the January 22, 2013, United States Court of Appeals for the District of Columbia Circuit decision concerning $PM_{2.5}$ SILs and SMC.

Area Source Estimated Concentrations Related Update

Guideline for Determination of GEP Stack Height - Technical Support Document

Protocol for Determining the Best Performing Model (ZIP, 124KB)

Guidance Concerning the Implementation of the 1-hour SO2 NAAQS for the Prevention of Significant Deterioration Program

Guidance Concerning the Implementation of the 1-hour NO2 NAAQS for the Prevention of Significant Deterioration Program

Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas (PDF, 1.8MB) - December 2010. EPA-420-B-10-040. U.S. Environmental Protection Agency, Office of Transportation and Air Quality.

Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas - Appendix (PDF, 1.9MB) - December 2010. EPA-420-B-10-040. U.S. Environmental Protection Agency, Office of Transportation and Air Quality.

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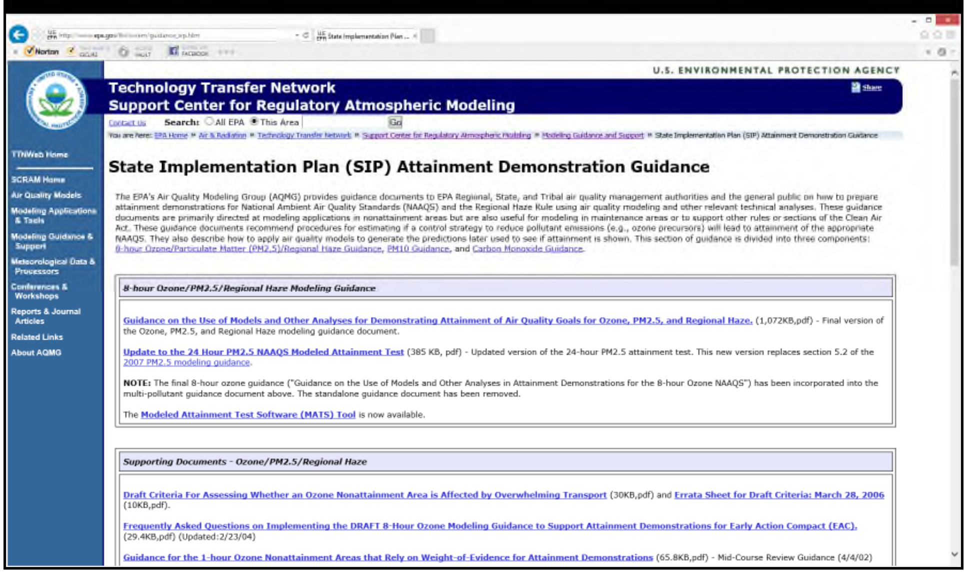

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State Implementation Plan (SIP) Attainment Demonstration Guidance

The EPA's Air Quality Modeling Group (AQMG) provides guidance documents to EPA Regional, State, and Tribal air quality management authorities and the general public on how to prepare attainment demonstrations for National Ambient Air Quality Standards (NAAQS) and the Regional Haze Rule using air quality modeling and other relevant technical analyses. These guidance documents are primarily directed at modeling applications in nonattainment areas but are also useful for modeling in maintenance areas or to support other rules or sections of the Clean Air Act. These guidance documents recommend procedures for estimating if a control strategy to reduce pollutant emissions (e.g., ozone precursors) will lead to attainment of the appropriate NAAQS. They also describe how to apply air quality models to generate the predictions later used to see if attainment is shown. This section of guidance is divided into three components: 8-hour Ozone/Particulate Matter (PM2.5)/Regional Haze Guidance, PM10 Guidance, and Carbon Monoxide Guidance.

8-hour Ozone/PM2.5/Regional Haze Modeling Guidance

Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze. (1,072KB,pdf) - Final version of the Ozone, PM2.5, and Regional Haze modeling guidance document.

Update to the 24 Hour PM2.5 NAAQS Modeled Attainment Test (385 KB, pdf) - Updated version of the 24-hour PM2.5 attainment test. This new version replaces section 5.2 of the 2007 PM2.5 modeling guidance.

NOTE: The final 8-hour ozone guidance ("Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS") has been incorporated into the multi-pollutant guidance document above. The standalone guidance document has been removed.

The **Modeled Attainment Test Software (MATS) Tool** is now available.

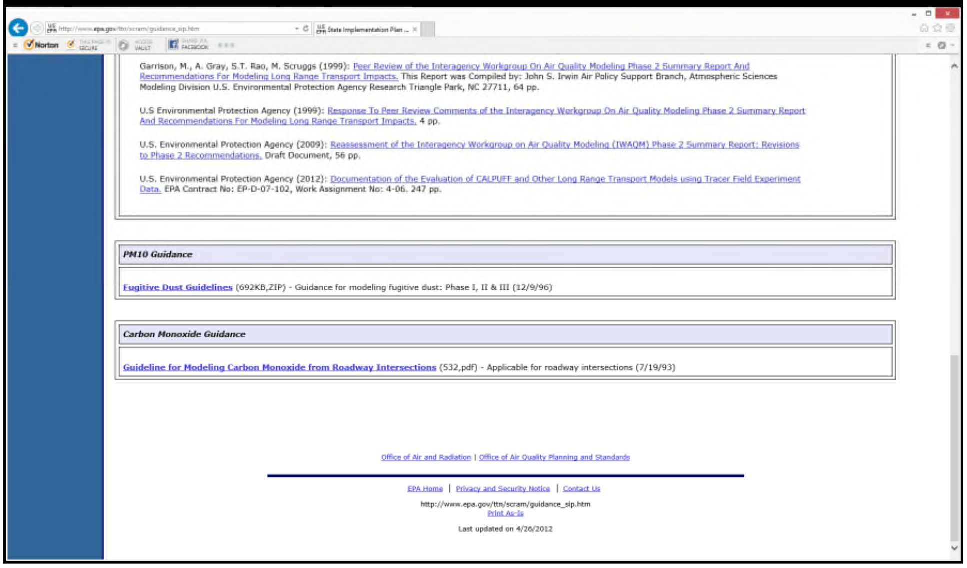
Supporting Documents - Ozone/PM2.5/Regional Haze

Draft Criteria For Assessing Whether an Ozone Nonattainment Area is Affected by Overwhelming Transport (30KB,pdf) and **Errata Sheet for Draft Criteria: March 28, 2006** (10KB,pdf).

Frequently Asked Questions on Implementing the DRAFT 8-Hour Ozone Modeling Guidance to Support Attainment Demonstrations for Early Action Compact (EAC). (29.4KB,pdf) (Updated:2/23/04)

Guidance for the 1-hour Ozone Nonattainment Areas that Rely on Weight-of-Evidence for Attainment Demonstrations (65.8KB,pdf) - Mid-Course Review Guidance (4/4/02)

www.epa.gov/ttn/scram/guidance_sip.htm


Garrison, M., A. Gray, S.T. Rao, M. Scruggs (1999): Peer Review of the Interagency Workgroup On Air Quality Modeling Phase 2 Summary Report And Recommendations For Modeling Long Range Transport Impacts. This Report was Compiled by: John S. Irwin Air Policy Support Branch, Atmospheric Sciences Modeling Division U.S. Environmental Protection Agency Research Triangle Park, NC 27711, 64 pp.

U.S Environmental Protection Agency (1999): Response To Peer Review Comments of the Interagency Workgroup On Air Quality Modeling Phase 2 Summary Report And Recommendations For Modeling Long Range Transport Impacts. 4 pp.

U.S. Environmental Protection Agency (2009): Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations. Draft Document, 56 pp.

U.S. Environmental Protection Agency (2012): Documentation of the Evaluation of CALPUFF and Other Long Range Transport Models using Tracer Field Experiment Data. EPA Contract No: EP-D-07-102, Work Assignment No: 4-06. 247 pp.

PM10 Guidance

Fugitive Dust Guidelines (692KB,ZIP) - Guidance for modeling fugitive dust: Phase I, II & III (12/9/96)

Carbon Monoxide Guidance

Guideline for Modeling Carbon Monoxide from Roadway Intersections (532,pdf) - Applicable for roadway intersections (7/19/93)

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Dispersion Model Formulation

Meteorology
- Wind Speed
- Wind Direction
- Atmospheric Stability
- Mixing Height

Emissions
- Highway Configuration
- Traffic Parameters
- Emission Factors

Air Dispersion Model
- Transport
- Diffusion
- Chemical Transformation

Receptor Concentration

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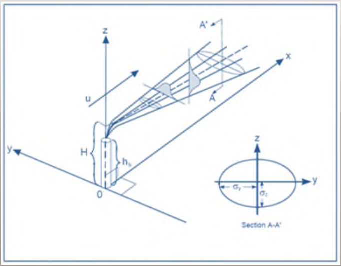
Dispersion Model Formulation

- Steady-state Gaussian Dispersion
  - ✓ Emission rate, wind speed, wind direction, and atmospheric stability are constant during the life of the plume
  - ✓ Concentrations are assumed to follow a Gaussian distribution in the cross-wind horizontal and vertical directions
  - ✓ Assumes dispersion along the transport wind direction has a small effect on the plume
  - ✓ Computationally simple



33

Basics of the Gaussian Plume Equation

$$\chi_{avg} = \frac{Q}{u \times A}$$

where χ_{avg} is the average pollutant concentration in the plume cross-section (g/m^3);

Q is the pollutant emission rate (g/s);

u is the transport wind speed (m/s); and

A is the plume cross-sectional area

34

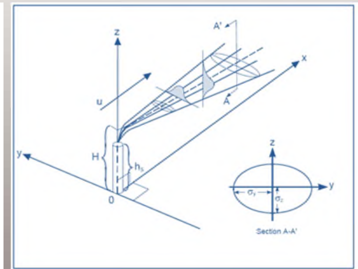
Basics of the Gaussian Plume Equation

$$g/m^3 \; \Delta \; \frac{g/s}{m/s \times m^2}$$

$$\chi_{avg} = \frac{Q}{u \times \pi \, r_y \, r_z}$$

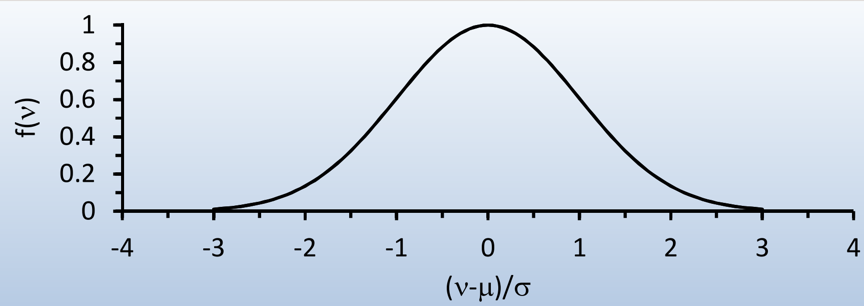
where r_y is the horizontal radius of the plume (m) and

r_z is the vertical radius of the plume (m)



35

Basics of the Gaussian Plume Equation



The Gaussian or normal distribution can be expressed mathematically: $f(\nu) = \frac{1}{\sqrt{2\pi}\,\sigma}\left\{\exp\left[-\frac{1}{2}\left(\frac{\nu-\mu}{\sigma}\right)^2\right]\right\}$

36

The Gaussian Plume Equation

$$\chi = \frac{Q}{2\pi\, u\, \sigma_y\, \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Dilution Term | Crosswind Term | Vertical Term | Reflection Term

What is the form of this equation for:

- ✓ ground-level concentrations (z = 0)
- ✓ on plume centerline (y = 0)
- ✓ due to a ground-level source (H = 0)?

HINT: exp(0) = ?

RESOURCE CENTER

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Basics of the Gaussian Plume Equation

$$\chi = \frac{Q}{\pi\, u\, \sigma_y\, \sigma_z}$$

$$\chi = \frac{Q}{\pi\, u\, r_y\, r_z}$$

RESOURCE CENTER

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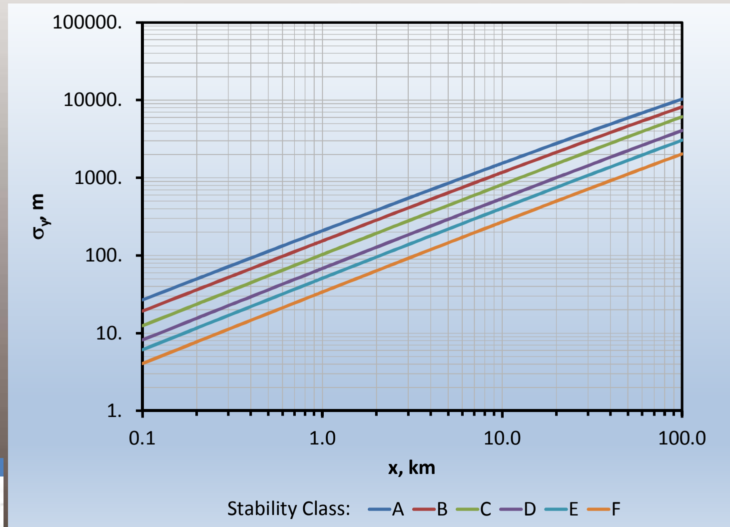
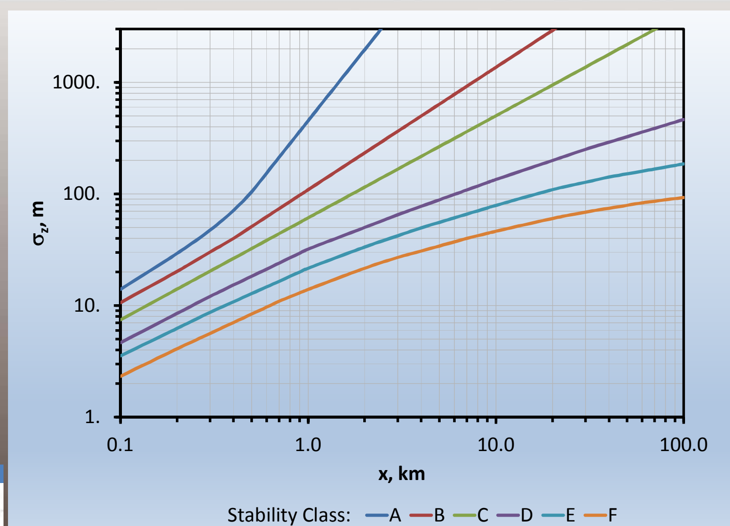
Horizontal Dispersion Coefficients – σy

adapted from Slade, 1968



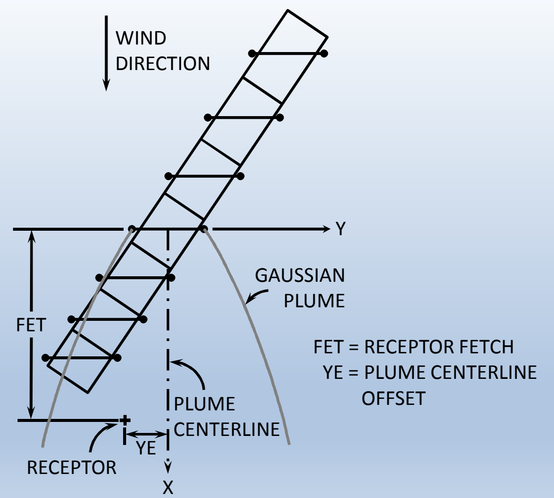
Vertical Dispersion Coefficients – σz

adapted from Slade, 1968



Plume Dispersion from Highways – CAL3 Series

adapted from Benson, 1979



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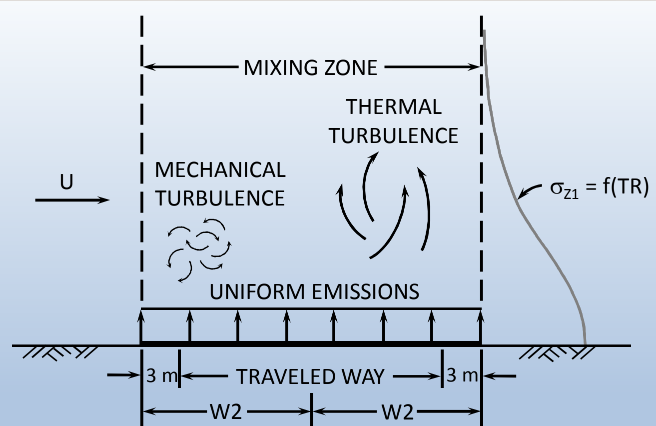
Plume Dispersion from Highways – Uniform Mixing Zone (CAL3 Series)

adapted from Benson, 1979



σ_{Z1} = INITIAL VERTICAL DISPERSION PARAMETER

TR = MIXING ZONE RESIDENCE TIME

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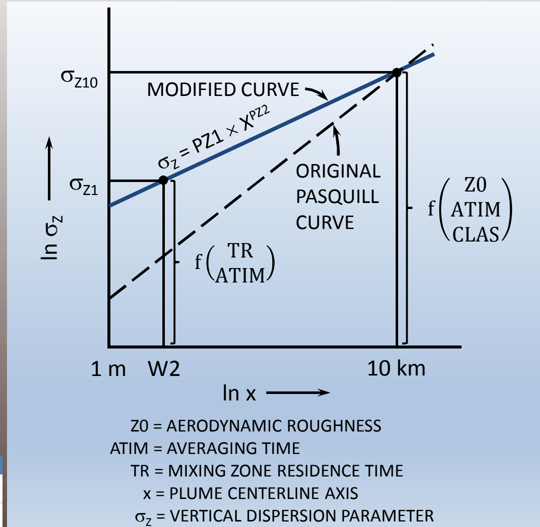
Vertical Dispersion Parameter – CAL3 Series

adapted from Benson, 1979



43

Surface Roughness for Various Land Uses

adapted from Benson, 1979

Type of Surface	z_0 (cm)
Smooth mud flats	0.001
Tarmac (pavement)	0.002
Dry lake bed	0.003
Smooth desert	0.03
Grass (5-6 cm)	0.75
Grass (4 cm)	0.14
Alfalfa (15.2 cm)	2.72
Grass (60-70 cm)	11.4
Wheat (60 cm)	22
Corn (220 cm)	74
Citrus orchard	198
Fir forest	283
City land use	
Single family residential	108
Apartment residential	370
Office	175
Central Business District	321
Park	127

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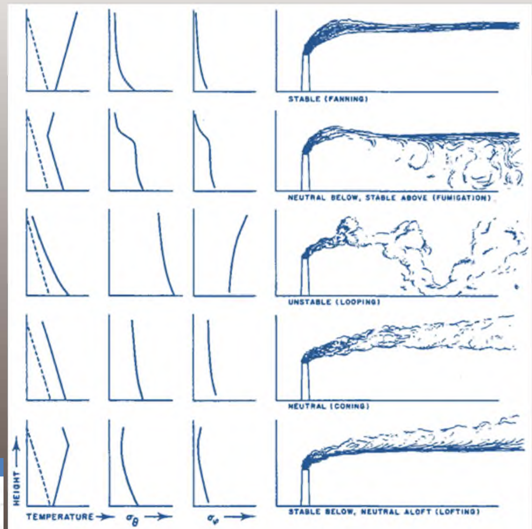
Atmospheric Stability

from Slade, 1968



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Pasquill's Stability Categories

adapted from Slade, 1968

Surface Wind Speed (m/s)	Daytime Insolation			Nighttime Conditions	
	Strong	Moderate	Slight	≥ 4/8 Clouds	≤ 3/8 Clouds
< 2	A	A-B	B		
2	A-B	B	C	E	F
4	B	B-C	C	D	E
6	C	C-D	D	D	D
> 6	C	D	D	D	D

A: Extremely unstable
B: Moderately unstable
C: Slightly unstable
D: Neutral
E: Slightly stable
F: Moderately stable

Notes on Pasquill's Stability Categories

- Night – 1 hour before sunset to 1 hour after sunrise
- D stability should be used (regardless of wind speed) for:
  - ✓ overcast conditions during day or night and
  - ✓ any sky condition during the hour preceding or following night

RESOURCE CENTER

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Monin-Obukhov Length

- AERMOD provides for a continuous measure of atmospheric stability and dispersion based on the Obukhov length (L)
- Also known as the Monin-Obukhov length, L is used to describe the effects of buoyancy on turbulent flows in the planetary boundary layer
  - ✓ L < 0 indicates unstable conditions
  - ✓ L = 0 indicates neutral conditions
  - ✓ L > 0 indicates stable conditions

RESOURCE CENTER

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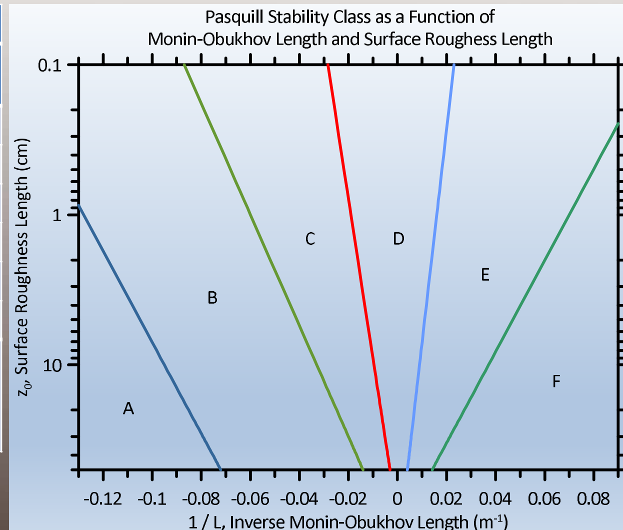
Characterizing Atmospheric Stability

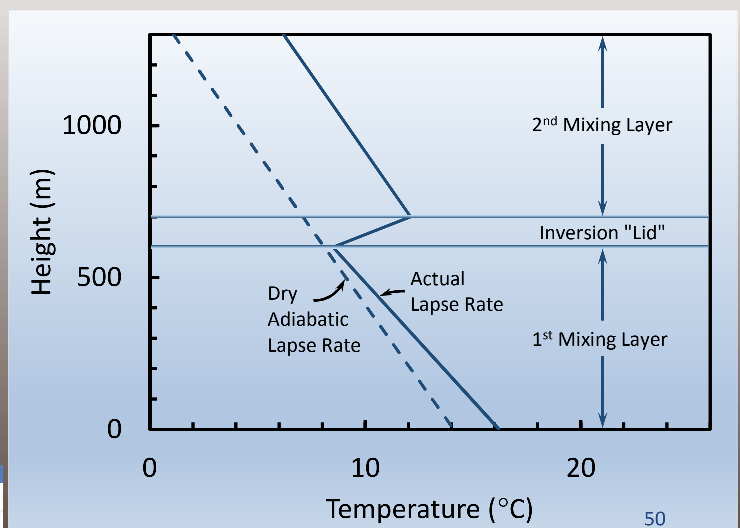
$z_0 \geq 50$ cm	
Stability Class	L (m)
A	-6.9
B	-42.6
C	-200.5
D	-8888
E	159.3
F	35.4

Based on Golder (1972) as implemented in EPA's AERMOD, CALPUFF, and CTDMPlus models



Mixing Height

adapted from Beaton, 1972



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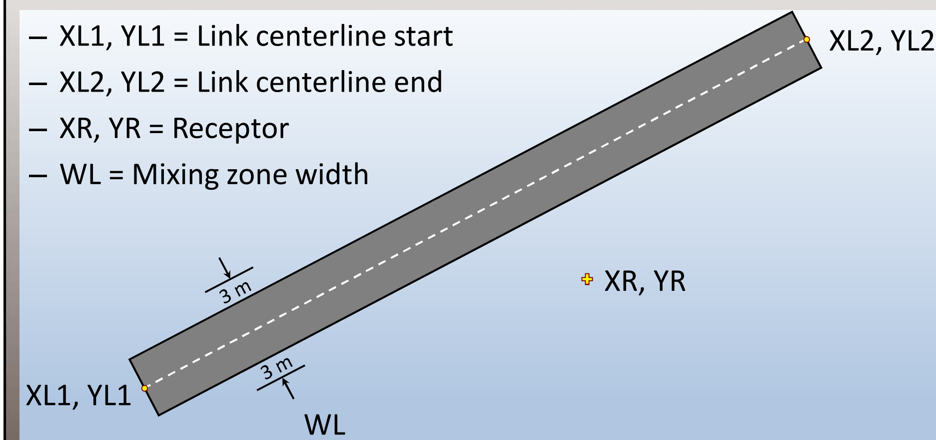
Link / Receptor Configuration – CAL3 Series

– XL1, YL1 = Link centerline start
– XL2, YL2 = Link centerline end
– XR, YR = Receptor
– WL = Mixing zone width



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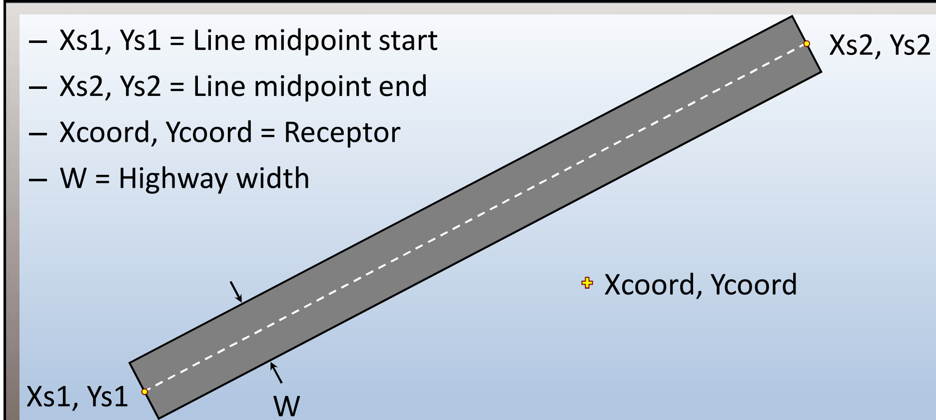
Link / Receptor Configuration – AERMOD Line

– Xs1, Ys1 = Line midpoint start
– Xs2, Ys2 = Line midpoint end
– Xcoord, Ycoord = Receptor
– W = Highway width



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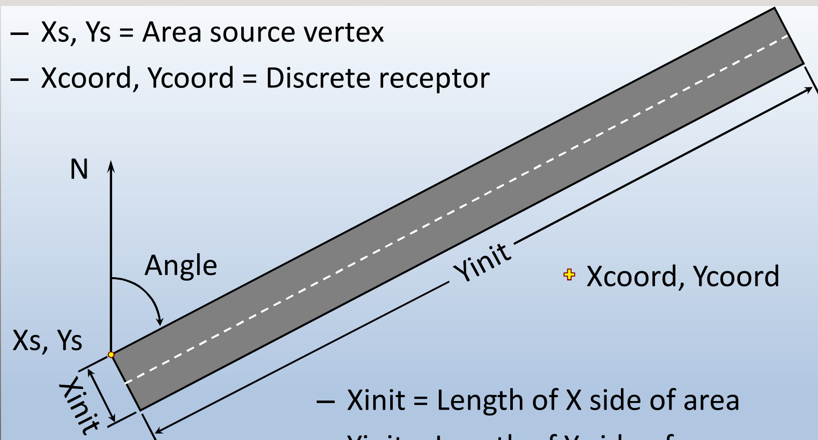
Link / Receptor Configuration – AERMOD Area

- Xs, Ys = Area source vertex
- Xcoord, Ycoord = Discrete receptor



- Xinit = Length of X side of area
- Yinit = Length of Y side of area
- Angle = Orientation angle from north

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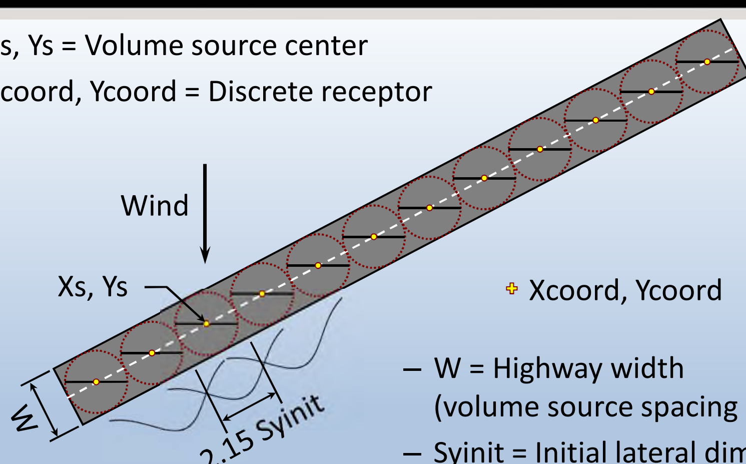
Link / Receptor Configuration – AERMOD Volume

- Xs, Ys = Volume source center
- Xcoord, Ycoord = Discrete receptor



- W = Highway width (volume source spacing = W)
- Syinit = Initial lateral dimension of volume source (W / 2.15)

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Summary on Input Data Requirements

Program Controls

- **Run options**
- **Output options**

Receptor Location

Highway Configuration

Emissions

Meteorology

55

Summary on Input Data Requirements

Program Controls

Receptor Location

- **X and Y location coordinates**
- **Height of the breathing zone (Z)**

Highway Configuration

Emissions

Meteorology

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Summary on Input Data Requirements

Program Controls

Receptor Location

Highway Configuration
- **Source coordinates**
- **Source height**
- **Source width**

Emissions

Meteorology

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Summary on Input Data Requirements

Program Controls

Receptor Location

Highway Configuration

Emissions
- **Traffic volume**
- **Emission factor or rate**

Meteorology

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Summary on Input Data Requirements

Program Controls

Receptor Location

Highway Configuration

Emissions

Meteorology

Basic parameters:
- Wind speed
- Wind direction
- Atmospheric stability measure
- Mixing height

MPRM Met Data – CAL3QHCR Input Requirements

Year	Month	Day	Hour	Bearing	U	Temp	Class	Zrur	Zurb
12	1	1	1	**0**	**0**	278.1	**7**	**15**	**400**
12	1	1	2	**305**	**2.03**	278.8	**6**	**48**	**400**
12	1	1	3	**304**	**1.18**	277	**7**	**21**	**400**
12	1	1	4	**297**	**1.13**	275.9	**7**	**17**	**400**
12	1	1	5	**263**	**1.21**	275.4	**7**	**19**	**400**
12	1	1	6	**0**	**0**	275.4	**7**	**5**	**400**
12	1	1	7	**0**	**0**	273.8	**7**	**9**	**400**
12	1	1	8	**309**	**1.04**	275.9	**6**	**18**	**400**
12	1	1	9	**312**	**1.25**	279.9	**5**	**92**	**400**
12	1	1	10	**0**	**0**	282.5	**4**	**119**	**400**

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AERMET Surface Data

Year	Month	Day	Jday	Hour	H	u*	w*	VPTG	Zic	Zim	L	z0
12	1	1	1	1	-1.2	0.034	-9	-9	**-999**	**15**	**3**	0.048
12	1	1	1	2	-6	0.076	-9	-9	**-999**	**48**	**6.5**	0.048
12	1	1	1	3	-2	0.044	-9	-9	**-999**	**21**	**3.8**	0.048
12	1	1	1	4	-1.6	0.039	-9	-9	**-999**	**17**	**3.2**	0.029
12	1	1	1	5	-1.8	0.041	-9	-9	**-999**	**19**	**3.3**	0.027
12	1	1	1	6	-0.3	0.017	-9	-9	**-999**	**5**	**1.4**	0.021
12	1	1	1	7	-0.7	0.025	-9	-9	**-999**	**9**	**2**	0.027
12	1	1	1	8	-1.5	0.039	-9	-9	**-999**	**18**	**3.5**	0.048
12	1	1	1	9	13.7	0.117	0.229	0.013	**31**	**92**	**-10.4**	0.048
12	1	1	1	10	61.4	0.111	0.588	0.012	**119**	**85**	**-2**	0.038

B0	r	Ws	Wd	Zref	Temp	Ztemp	IPcode	Pamt	RH	Pres	CCVR	WSadj
0.99	1	**0.92**	**127**	10	278.1	2	0	0	75	1005	0	ADJ-A1
0.99	1	**2.03**	**125**	10	278.8	2	0	0	75	1005	0	ADJ-A1
0.99	1	**1.18**	**124**	10	277	2	0	0	78	1004	0	ADJ-A1
0.99	1	**1.13**	**117**	10	275.9	2	0	0	85	1004	0	ADJ-A1
0.99	1	**1.21**	**83**	10	275.4	2	0	0	85	1004	0	ADJ-A1
0.99	1	**0.53**	**50**	10	275.4	2	0	0	81	1005	0	ADJ-A1
0.99	1	**0.75**	**86**	10	273.8	2	0	0	84	1006	0	ADJ-A1
0.99	0.61	**1.04**	**129**	10	275.9	2	0	0	81	1007	0	ADJ-A1
0.99	0.35	**1.25**	**132**	10	279.9	2	0	0	76	1007	0	ADJ-A1
0.99	0.26	**0.99**	**176**	10	282.5	2	0	0	68	1007	0	ADJ-A1

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Mechanics of Running the Models

- EPA distributed versions of the models
- Tips for managing files
- Run the models
- Input file structures
- Constructing input files
- Output file structures

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EPA Distributed Versions of the Models

- CALINE3 (Dated 12317) files in caline3_32.zip
  - CALINE3.FOR – Fortran source code
  - CALINE3_32.EXE – Executable program
  - CALINE3.EXP – Input file for the test case
  - CALINE3.LST – Output file for the test case
  - CALINE3_32.RME – Readme file

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EPA Distributed Versions of the Models

- CAL3QHC (Dated 04244) files in cal3qhc.zip
  - CAL3QHC.FOR – Fortran source code
  - CAL3QHC.EXE – Executable program
  - EX1.BAT, EX2.BAT, EX3.BAT, EXP.BAT – Batch files for executing the test cases
  - EX-1.DAT, EX-2.DAT, EX-3.DAT, EX-P.DAT – Input data files for the test cases
  - EX-1.OUT, EX-2.OUT, EX-3.OUT, EX-P.OUT – Output files for the test cases

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EPA Distributed Versions of the Models

- CAL3QHC (Dated 04244) files in cal3qhc.zip
  - FC1.BAT, FC2.BAT, FC3.BAT, FCP.BAT – Batch files for comparing user results with test case results
  - READMEHC.TXT – Readme file

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EPA Distributed Versions of the Models

- CAL3QHCR (Dated 13196) files in cal3qhcr_13196.zip
  - CAL3QHCR.FOR – Fortran source code
  - CAL3QHCR.EXE – Executable program
  - C1C.BAT, Med.BAT, R1C.BAT, R1P.BAT, R2C.BAT, R2P.BAT – Batch files for executing the test cases
  - C1C.INP, Med.INP, R1C.INP, R1P.INP, R2C.INP, R2P.INP – Input data files for the test cases
  - C1C.OUT, Med.OUT, R1C.OUT, R1P.OUT, R2C.OUT, R2P.OUT – Output files for the test cases

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EPA Distributed Versions of the Models

- CAL3QHCR (Dated 13196) files in cal3qhcr_13196.zip
  - FCC1C.BAT, FCMed.BAT, FCR1C.BAT, FCR1P.BAT, FCR2C.BAT, FCR2P.BAT – Batch files for comparing user results with test case results
  - READMEHC.TXT – Readme file
  - C1C.CTL, Med.CTL, R1C.CTL, R1P.CTL, R2C.CTL, R2P.CTL – Control files with a list of input and output filenames read by the program

RESOURCE CENTER

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EPA Distributed Versions of the Models

- CAL3QHCR (Dated 13196) files in cal3qhcr_13196.zip
  - C1C.MSG, Med.MSG, R1C.MSG, R1P.MSG, R2C.MSG, R2P.MSG – Files containing error and other messages
  - C1C.ET1, Med.ET1, R1C.ET1, R1P.ET1, R2C.ET1, R2P.ET1 – copy of vehicular emissions, traffic volume, and signalization (ETS) data as read from the input control file
  - C1C.ET2, Med.ET2, R1C.ET2, R1P.ET2, R2C.ET2, R2P.ET2 – preprocessed *.ET1 data
  - C1C.ILK, Med.ILK, R1C.ILK, R1P.ILK, R2C.ILK, R2P.ILK – link data output files

RESOURCE CENTER

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EPA Distributed Versions of the Models

- CAL3QHCR (Dated 13196) files in cal3qhcr_13196.zip
  - C1C.DIF, Med.DIF, R1C.DIF, R1P.DIF, R2C.DIF, R2P.DIF – link data output files
  - C1C.PLT, Med.PLT, R1C.PLT, R1P.PLT, R2C.PLT, R2P.PLT – link data output files
  - PIT-64.MET, S2422590.ASC, TC1.MET – processed meteorological data files
  - readmeR.txt – Readme file

RESOURCE CENTER 69

EPA Distributed Versions of the Models

- AERMOD (Dated 14134) in aermod_exe.zip
  - aermod.exe – Executable program
  - aermod_readme – Readme file
- AERMOD (Dated 14134) in aermod_source.zip
  - Fortran source code

• aermod.for	evset.for	ouset.for	setup.for
• calc1.for	iblval.for	output.for	siggrid.for
• calc2.for	inpsum.for	pitarea.for	sigmas.for
• coset.for	meset.for	prime.for	soset.for
• evcalc.for	metext.for	prise.for	tempgrid.for
• evoutput.for	modules.for	reset.for	windgrid.for

RESOURCE CENTER 70

Tips for Managing Files

- Use a descriptive root filename, e.g., Build_AltA_2017, NoBuild_2017, etc.
  – *.inp – input data file
  – *.met – input meteorological data file
  – *.out – descriptive output file
  – *.pst – postfile output of hourly concentrations at each receptor for post-processing
  – *.plt – plotfile output of design value concentrations at each receptor for plotting
  – *.bat – batch file for executing DOS commands to run a model

RESOURCE CENTER

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Run the Models

- Step 1 – Create an input file, *.inp
  – Use a text editor
    - Like Notepad, supplied with Windows®
  – Use a word processor
    - Caution: be sure to use the “Save As” command to save as a Plain Text file
  – Use Microsoft Excel®
    - Caution: be sure “Save As” as a CSV (Comma Delimited file) – requires subsequent editing
  – Use a free commercial text editor
    - NoteTab Light, Notepad++, Programmer’s Notepad, or TotalEdit

RESOURCE CENTER

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Run the Models

- Step 2 – Save the input file with a descriptive name
  - e.g., Build_AltA_2017.inp, NoBuild_2017.inp, etc.
- Step 3 – Copy the input file saved in Step 2 to the model default input filename
  - For AERMOD, AERMOD.inp
  - For CAL3QHCRi, CAL3QHCR.inp
  - For CAL3QHCi, CAL3QHC.inp
  - For CALINE3i, CALINE3.inp

RESOURCE CENTER

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Run the Models

- Step 4 – Execute the model
  - Option 1 – using Windows Explorer
    - Right-click the Widows Start Icon
    - Select Open Windows Explorer
    - Navigate to the “Project” folder containing the input file, met data file (for AERMOD and CAL3QHCRi), and model executable
    - Double-click on the model application *.exe file

RESOURCE CENTER

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Run the Models

- Step 4 – Execute the model
  - Option 2 – using a command prompt Window
    - Click the Widows Start Icon
    - Select All Programs
    - Select Accessories
    - Select Command Prompt
    - Navigate to the "Project" folder containing the input file, met data file (for AERMOD and CAL3QHCRi), and model executable
    - Type the model name and hit enter, i.e.,

      AERMOD, CAL3QHCRi, CAL3QHCi, or CALINE3i

RESOURCE CENTER 75

Run the Models

- Some useful DOS commands for navigation:
  - C:\> Example command prompt
  - C:\> d: Navigate to drive D:
  - D:\> cd Change directories
  - D:\> dir Obtain directory (list)
  - D:\> dir /w Obtain directory (wide list)
  - D:\> cls Clear screen

RESOURCE CENTER 76

Run the Models

- In-class Demonstration

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Input File Structure – AERMOD

- An AERMOD input file is divided into 5 functional pathways applicable to PM hot-spot analyses for specifying data:
  - CO – COntrol options
  - SO – SOurce data
  - RE – REceptor data
  - ME – MEteorology data
  - OU – OUtput options

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Input File Structure – AERMOD

- Each line or data record in the input file consists of:
  - One of the 2-character pathway IDs in columns 1 and 2
  - One blank space in column 3
  - An 8-character keyword in columns 4 though 11
  - One blank space in column 12
  - A parameter list (data values) in columns 13 through 132, as necessary
    - Continue additional required data values on the next line
  - Example

```
SO EMISFACT NBFwy1 SEASHR 6*2.9E-07 3*6.7E-07 7*2.5E-07 3*5.6E-07 5*2.9E-07
SO EMISFACT NBFwy1 SEASHR 6*2.0E-07 3*4.6E-07 7*1.7E-07 3*3.6E-07 5*2.0E-07
SO EMISFACT NBFwy1 SEASHR 6*1.5E-07 3*3.4E-07 7*1.4E-07 3*3.1E-07 5*1.5E-07
SO EMISFACT NBFwy1 SEASHR 6*1.9E-07 3*4.3E-07 7*1.6E-07 3*3.6E-07 5*1.9E-07
```

Input File Structure – AERMOD

- Use only 1 space between the pathway ID and keyword
- Any number of spaces can separate the keyword and data values in the parameter list
- Do not use the tab key
- End the line after the last data value using the enter key with no extra spaces
- The order of data values is important

RESOURCE CENTER

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Input File Structure – AERMOD

- First line of each pathway uses the STARTING keyword
- Last line of each pathway uses the FINISHED keyword
- Blank lines and comment lines can be effectively used to document the data file
  - Blank lines can be used to separate pathways, sources, etc.
  - Comment lines start with ** as the first two characters on a line and can be used to document information and as column headings to label input data values
- All input data values are in metric units

RESOURCE CENTER

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CO Pathway Mandatory Keywords – AERMOD

Keyword	Description
STARTING	Indicates the beginning of inputs for the pathway; this keyword mandatory on each of the pathways
TITLEONE	A user-specified title line (up to 68 characters) that will appear each page of the printed output file (an optional second title line also available with the keyword TITLE TWO)
MODELOPT	Controls the modeling options selected for a particular run through series of secondary keywords
AVERTIME	Identifies the averaging periods to be calculated for a particular run
POLLUTID	Identifies the type of pollutant being modeled. At the present time, this option has no influence on the results
RUNORNOT	A special keyword that tells the model whether to run the full model executions or not. If the user selects not to run, then the runstream setup file will be processed and any input errors reported, but no dispersion calculations will be made
FINISHED	Indicates that the user is finished with the inputs for this pathway; this keyword is also mandatory on each of the other pathways

RESOURCE CENTER

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SO Pathway Mandatory Keywords – AERMOD

Keyword	Description
STARTING	
LOCATION	Identifies a particular source ID and specifies the source type and location of that source
SRCPARAM	Specifies the source parameters for a particular source ID identified by a previous LOCATION card
SRCGROUP	Specifies how sources will be grouped for calculation purposes. There is always at least one group, even though it may be the group of ALL sources and even if there is only one source
FINISHED	

RESOURCE CENTER

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RE Pathway Mandatory* Keywords – AERMOD

Keyword	Description
STARTING	
GRIDCART	Defines a Cartesian grid receptor network
GRIDPOLR	Defines a polar grid receptor network
DISCCART	Defines the discretely placed receptor locations referenced to a Cartesian system
DISCPOLR	Defines the discretely placed receptor locations referenced to a polar system
FINISHED	
*At least one of the Receptor pathway keywords must be present	

RESOURCE CENTER

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ME Pathway Mandatory Keywords – AERMOD

Keyword	Description
STARTING	
SURFFILE	SURFFILE - Specifies the filename and format for the input surface meteorological data file
PROFFILE	Specifies the filename and format for the input profile meteorological data file
SURFDATA	Specifies information about the surface meteorological data which will be used in the modeling
UAIRDATA	Specifies information about the upper air meteorological data which will be used in the modeling
PROFBASE	Specifies the base elevation above MSL for the potential temperature profile
FINISHED	

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OU Pathway Mandatory* Keywords – AERMOD

Keyword	Description
STARTING	
RECTABLE	Specifies the selection of high value by receptor table output options
MAXTABLE	Specifies the selection of overall maximum value table output options
DAYTABLE	Specifies the selection of printed results (by receptor) for each day of data processed (this option can produce very large files and such be used with care)
FINISHED	

*All of the keywords on the Output pathway are optional, although the model will warn the user if no printed outputs are requested and will halt processing if no outputs (printed results or file outputs) are selected.

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Constructing an Input File – AERMOD

```
CO STARTING
   TITLEONE AERMOD Class Project
   TITLETWO 2008-2012 Meteorology
   MODELOPT FLAT CONC
   AVERTIME 24 ANNUAL
   URBANOPT 2000000
   POLLUTID PM2.5
   FLAGPOLE 1.5
   RUNORNOT RUN
   ERRORFIL ERRORS.OUT
CO FINISHED
```

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Constructing an Input File – AERMOD

```
SO STARTING
**                            Xs1    Ys1    Xs2    Ys2
**           Scrid   Srctyp   (m)    (m)    (m)    (m)
**         -------- ------ ----- ----- ----- -----
   LOCATION NB_Fwy_1  LINE   600.9 -88.1 450.7 198.5
** Line Source         Lnemis  Relhgt Width Szinit
** Parameters:        (g/s-m2)   (m)    (m)    (m)
**         -------- -------- ------ ----- ------
   SRCPARAM NB_Fwy_1    1.0      1.3  14.63   1.2

** Variable             Qflag      ON        AM   . MD . PM . ON
** Emission Rates:     ------ --------- ---------
   EMISFACT  NB_Fwy_1 SEASHR 6*2.9E-07 3*6.7E-07
   EMISFACT  NB_Fwy_1 SEASHR 6*2.0E-07 3*4.6E-07
   EMISFACT  NB_Fwy_1 SEASHR 6*1.5E-07 3*3.4E-07
   EMISFACT  NB_Fwy_1 SEASHR 6*1.9E-07 3*4.3E-07
```

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Constructing an Input File – AERMOD

```
    URBANSRC   ALL
    SRCGROUP   ALL
SO  FINISHED
```

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Determining AERMOD Emission Rate for Area and Line Sources

- Typically, complete 16 unique MOVES runs to account for variability of PM emissions
  - during the day (4 time periods)
    - morning peak – 6 am to 9 am
    - midday – 9 am to 4 pm
    - evening peak – 4 pm to 7 pm
    - overnight – 7 pm to 6 am
  - and during each season (4 months)
    - January
    - April
    - July
    - October

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Determining AERMOD Emission Rate for Area and Line Sources

- Obtain emission results in grams per hour using the MOVES Inventory Calculation Type
- Convert emissions in grams per hour to grams per second
- Divide emissions in grams per second by the link length and the link width to obtain emissions in grams per second per square meters

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EPA Guidance on Determining Release Height

- May be estimated from the midpoint of the initial vertical dimension
  - For moving light-duty vehicles, this is about 1.3 meters
  - For moving heavy-duty vehicles, it is 3.4 meters
- Release height of mixed fleets may be estimated using an emissions-weighted or volume-weighted average
  - Emissions-weighted average – for a 40%/60% light-duty/heavy-duty emissions share, the source release height would be

    $$(0.4 * 1.3) + (0.6 * 3.4) = 2.6 \text{ meters}$$

  - Or could be based on traffic volumes, i.e., light-duty/ heavy-duty vehicle fractions

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EPA Guidance on Determining Initial Vertical Dispersion Coefficient (Szinit)

- Assume the initial vertical dimension is about 1.7 times the average vehicle height to account for the effects of vehicle-induced turbulence
  - For light-duty vehicles, about 2.6 meters
  - For heavy-duty vehicles, about 6.8 meters
- For mixed fleets, base estimates on an emissions-weighted or volume-weighted average
  - For example, if light-duty and heavy-duty vehicles contribute 40% and 60% of the emissions of a given volume source, respectively, the initial vertical dimension would be (0.4 * 2.6) + (0.6 * 6.8) = 5.1 meters

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EPA Guidance on Determining Initial Vertical Dispersion Coefficient (Szinit)

- Calculate Szinit
  - Divide the initial vertical dimension of the source by 2.15
  - For typical light-duty vehicles, this corresponds to an Szinit of 1.2 meters
  - For typical heavy-duty vehicles, the value of Szinit is 3.2 meters

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Constructing an Input File – AERMOD

```
RE STARTING
**         Xcoord Ycoord
**           (m)    (m)
**         ------ ------
   DISCCART  485.0  193.0
RE FINISHED
```

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Constructing an Input File – AERMOD

```
ME STARTING
   SURFFILE 23155_2008-2012.sfc
   PROFFILE 23155_2008-2012.pfl
   SURFDATA 23155 2008
   UAIRDATA 23230 2008
   PROFBASE 0.0
ME FINISHED
```

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Constructing an Input File – AERMOD

```
OU STARTING
   RECTABLE 24 1ST
   MAXTABLE 24 50
   POSTFILE 24 ALL PLOT 5yrAvg24hr.plt
   POSTFILE ANNUAL ALL PLOT 5yrAvgAnnual.plt
OU FINISHED
```

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Output File Structure – AERMOD

- In-class Demonstration

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CAL3QHCRi – Improvements to EPA's CAL3QHCR Model

- Improvements were made to CAL3QHCR to enhance its use for highway air quality analyses as described in:
  - Guideline on Air Quality Models (Title 40 of the Code of Federal Regulations, Part 51, Appendix W)
    - Subsection 4.2.2c – Refined analytical techniques for other special modeling applications involving highways
    - Subsection 5.2.2.2b – Source-specific analysis of complicated sources for PM_{10} as specified in Subsection 4.2.2
    - Subsection 5.2.3a – CO impacts at roadway intersections
    - Subsection 5.2.4f – Localized NO_2 concentrations due to mobile sources
    - Subsection 5.2.5b – Effects of roadways and highways on Pb air quality

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CAL3QHCRi – Improvements to EPA's CAL3QHCR Model

- Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas
  - Highways and intersections for $PM_{2.5}$ and PM_{10}
- Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Evaluating Indirect Sources
  - Parking areas and similar types of indirect sources
- Near-road NO_2 Monitoring Technical Assistance Document (Draft)
  - Deleted from the final document

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Need for CAL3QHCR Improvements

- CAL3QHCR remains the model of choice by many State Departments of Transportation for several reasons
  - Familiarity with CALINE3 and CAL3QHC
  - Consistency with other dispersion modeling conducted in the highway air quality analysis
    - There is no AERMOD alternative to CALINE3 or CAL3QHC
  - Computational efficiency of CAL3QHCR over AERMOD
    - CAL3QHCR runs approximately 6 times faster
  - CAL3QHCR may provide lower results than AERMOD
    - A factor of 2 for some applications

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Need for CAL3QHCR Improvements

- Continue technical support
  - EPA's version of the CAL3QHCR model can be obtained through their SCRAM website
  - CAL3QHCR is not maintained by EPA and is no longer updated; therefore, technical support for the model code is not available through OAQPS

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CAL3QHCRi Improvements

- Simplify and update the input file structure
- Computer processing enhancements
- Advanced function to account for the variability of emissions, traffic, and signalization (ETS) patterns
- Add the capability to process multiple years of meteorology in a single simulation
- Update the output file structure

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CAL3QHCRi Improvements

- Improvements were made without affecting the concentration estimates produced
  - Consequently, ***the preferred status of the model is unchanged*** (40 CFR 51 Appendix W, Section 3.1.2b)

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Concentration Estimates Produced by CAL3QHCRi Versus CAL3QHCR

	CAL3QHCRi					U.S. EPA CAL3QHCR 13196				
Year:	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Max 1-hr Avg	9.33193	10.3298	9.16412	9.77849	10.0959	9.3319	10.3298	9.1641	9.7785	10.0959
Receptor	117	117	117	117	117	117	117	117	117	117
Wind Direction	300	314	298	305	320	300	314	298	305	320
Julian Day	65	14	84	30	34	65	14	84	30	34
Hour	7	8	8	8	7	7	8	8	8	7
Max 24-hr Avg	3.04114	2.83805	2.43740	2.85348	2.67140	3.0411	2.8380	2.4374	2.8535	2.6714
Receptor	294	294	117	294	85	294	294	117	294	85
Julian Day	38	5	83	75	16	38	5	83	75	16
No. of Calms	4	6	0	7	5	4	6	0	7	5
2nd Max 24-hr Avg	2.93632	2.56604	2.22876	2.45291	2.51026	2.9363	2.5660	2.2288	2.4529	2.5103
Receptor	117	294	294	294	294	117	294	294	294	294
Julian Day	37	32	27	11	6	37	32	27	11	6
No. of Calms	0	0	6	1	5	0	0	6	1	5
Max Annual Avg	0.97561	0.95755	0.88528	0.83420	0.95140	0.9756	0.9576	0.8853	0.8342	0.9514
Receptor	294	294	294	294	294	294	294	294	294	294
No. of Calms	658	966	902	867	1037	658	966	902	867	1037
Max 5-yr Qtr 24-hr	2.69811	Q1				2.6981	Q1			
Receptor	294					294				
Max 5-yr Avg	0.92081					0.9209				
Receptor	294					294				
No. of Calms	4430					4430				

Streamlined Management of Input Files

- A single input data file along with a single meteorological data file are required to complete a simulation with multiple (e.g., 5) years of meteorology
- Contrast this to EPA's version of CAL3QHCR for a $PM_{2.5}$ simulation, which requires 60 files:
  - 20 input data files (4 quarterly files for each of 5 years);
  - 20 meteorological data files; and
  - 20 control files

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Streamlined Management of Output Files

- Output files produced
  - One descriptive output file
  - One Emissions, Traffic, Signalization (ETS) file
  - One message file
  - Two two post files
  - Two plot files
- The output files simplify the process of completing design value computations for highway air quality analyses

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Streamlined Management of Output Files

- Contrast this to EPA's version of CAL3QHCR for a $PM_{2.5}$ simulation, which produces 100 files
  - 20 descriptive output files
  - 20 et1 files – intermediate computation file for processing ETS data
  - 20 et2 files – intermediate computation file for processing ETS data
  - 20 message files
  - 20 plot files

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Input File Structure – CAL3QHCRi

- A CAL3QHCRi input file is organized into six groupings
  1. File management
  2. Program controls and site variables
  3. Receptor locations
  4. ETS patterns
  5. Background concentrations
  6. Link configurations

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Input File Structure – CAL3QHCRi

- Each line of data in the input file has a specific structure, generally consisting of:
  – A five character pathway label in columns 1 through 5
  – A parameter list (data values) in columns 6 through 132, as necessary
    - Data values for a record cannot be continued on the next line
  – Example
    - #1: 'CAL3QHCR Example Analysis - PM2.5',60,175,0,0,1,0.3048,1
- Data values are entered in free format (i.e., at least one space or a single comma is required to delimit the fields)

Input File Structure – CAL3QHCRi

- No space is required between the pathway label and parameter list
- Any number of spaces can separate data values in the parameter list
- Only a single comma may be used as a delimiter
- Do not use the tab key
- End the line after the last data value using the enter key with no extra spaces
- The order of data values is important

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Input File Structure – CAL3QHCRi

- A five character pathway label for data records is incorporated
  - Its function is to provide a means to distinguish each data record or record type in an input file
  - Any five character combination can be used as a descriptor
    - Avoid using two asterisks or two blanks as the first two characters of a pathway label or the data record provided will be ignored
  - All fields in a data record must contain a valid entry or the model will fail to complete its execution

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Input File Structure – CAL3QHCRi

- Comment lines and blank lines can be effectively used to annotate an input file
  - If the first two characters on a line contain two asterisks or two spaces, then any subsequent information provided on the line is ignored by the program
  - Blank lines can be used to separate the groupings of data
  - Comment lines can be used to document information and as column headings to label input data values

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Input File Structure – CAL3QHCRi

- Numerical format of data fields in a record

Format Type	Description
Character	A string of alphanumeric characters that are bracketed by single quotes (e.g., 'SR 1 – NB Lanes')
Integer	A number with no decimal point (e.g., 12)
Real	A number with a decimal point separating the whole number portion from the fractional number portion (e.g., 234.16)

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Records for File Management

Parameter	Format	Description
MET:	-	Pathway label
'*.met'	Character	Name of file containing preprocessed meteorology[a]
OUT:	-	Pathway label
'*.out'	Character	Name of file containing model printout[b]
ETS:	-	Pathway label
'*.ets'	Character	Name of file containing ETS data[b]
MSG:	-	Pathway label
'*.msg'	Character	Name of file containing simulation errors and other messages[b]
PST1	-	Pathway label
'*.pst'	Character	Name of file containing concurrent model results in post format of 24-hour averages for PM2.5, PM-10, and OTHER or 1-hour averages for CO and NO2[b]
PST2	-	Pathway label
'*.pst'	Character	Name of file containing concurrent model results in post format of annual averages for PM2.5, PM-10, NO2, and OTHER or 8-hour averages for CO[b]
PLT1	-	Pathway label
'*.plt'	Character	Name of file containing high value model results in plot format of average quarterly 24-hour for PM2.5; 6th highest 24-hour for PM-10; 24-hour for OTHER; 2nd highest 1-hour for CO; or average 8th highest 1-hour for NO2[b]
PLT2	-	Pathway label
'*.plt'	Character	Name of file containing high value model results in plot format of average annual for PM2.5, PM-10, NO2, and OTHER or 2nd highest 8-hour for CO[b]

[a]User-created file; [b]CAL3QHCRi-generated file

Records for Program Control & Site Variables

Parameter	Format	Description
#1:	-	Pathway label
'JOB'	Character	Job title/description, up to 40 characters
ATIM	Real	Run averaging time (min)
Z0	Real	Surface roughness (or roughness length) (cm)
VS	Real	Settling velocity (cm/s)
VD	Real	Deposition velocity (cm/s)
NR	Integer	Number of receptors
SCAL	Real	Scale conversion factor, user units to meters
IOPT	Integer	Output units, 1 = feet; 0 = meters
#2:	-	Pathway label
'RUN'	Character	Run title/description, up to 40 characters
NL	Integer	Number of links
JTIER	Integer	Tier approach, 1 = Tier I; 2 = Tier II
'MODE'	Character	Pollutant (units), 'CO' = CO (ppm); 'PM2.5' = PM2.5 (µg/m^3); 'PM-10' = PM-10 (µg/m^3); 'NO2' = NO2 (ppb); 'OTHER' = OTHER (µg/m^3)
FLINK	Integer	Print link contributions, 1 = YES; 0 = NO
FAMB	Integer	Include background concentrations in results, 1 = YES; 0 = NO
'RU'	Character	Land use selection, 'R' = Rural; 'U' = Urban
#3:	-	Pathway label
STRMO	Integer	Processing start month
STRDY	Integer	Processing start day
STRYR	Integer	Processing start year
ENDMO	Integer	Processing end month
ENDDY	Integer	Processing end day
ENDYR	Integer	Processing end year

Records for Program Control & Site Variables – Notes

- Pathway #1
  - Averaging time should be 60 min, since predictions are performed for a 1-hour period
  - Surface roughness should be within the range of 3 cm to 400 cm
  - If gravitational settling is negligible, the settling velocity should be 0 cm/s
  - If deposition effects are negligible, the deposition velocity should be 0 cm/s
- Pathway #2
  - To account for hourly variations in emissions and meteorology, specify a Tier II approach (JTIER = 2)
  - The MODE parameter may be a pollutant name of up to five characters. Designations that currently control the pollutant label, format, and averaging time of the results are 'CO', 'PM2.5', 'PM-10', 'NO2', and 'OTHER'. Additional designations are used as the pollutant label; the format and averaging time are as provided for MODE = 'OTHER'.
  - Typically, do not include background concentrations in the model run by entering values of 0.0. Background concentrations are usually determined separately and added to model results to calculate design values.
  - For determining whether land use is rural or urban, refer to EPA's Guideline on Air Quality Models, section 7.2.3
- Pathway #3
  - Processing start and end dates should match the start and end dates of the preprocessed meteorology
  - Typically, the start month and day are January 1 (01,01) and the end month and day are December 31 (12,31)
  - 5 years of off-site meteorology are generally required, which can be processed in a single simulation, e.g., 01,01,06,12,31,10
  - If available, use met files prepared for regulatory applications by the governing air agency
  - Wind speeds should be at least 1 m/s

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Records for Receptor Locations

Parameter	Format	Description
#4:	-	Pathway label
'RCP'	Character	Receptor name, up to 20 characters
XR	Real	X-coordinate of receptor (user units)
YR	Real	Y-coordinate of receptor (user units)
ZR	Real	Z-coordinate of receptor (user units)
*** Repeat in succession for each Receptor = 1 to NR ***		

NOTES:

- Pathway #4
  - User units are defined by the SCAL parameter entered on the Pathway #1 record
  - Receptors should always be located outside of the mixing zone (link width)
  - Receptor height should represent the typical ground-level breathing height of 1.8 m (5.9 ft) or less

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Records for Emissions, Traffic, & Signalization Patterns

Parameter	Format	Description
#5:	-	Pathway label
PMOY1 to PMOY12	Integer	Month of year patterns for ETS values; assigned in the order: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec An example distinguishing four seasonal patterns by quarter: 1,1,1,2,2,2,3,3,3,4,4,4 Up to 12 monthly patterns may be assigned
#6:	-	Pathway label
PHOD1 to PHOD24	Integer	Ending hour of day patterns for ETS values; assigned in the order: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 An example distinguishing four hourly patterns to represent the morning peak, midday, afternoon peak, and overnight: 1,1,1,1,1,1,2,2,2,3,3,3,3,3,3,3,4,4,4,1,1,1,1,1 Up to 24 hourly patterns may be assigned.
#7:	-	Pathway label
PDOW1 to PDOW7	Integer	Day of week patterns for ETS values; assigned in the order: Mon Tue Wed Thu Fri Sat Sun An example distinguishing weekday and weekend travel: 1,1,1,1,1,2,2 Up to 7 daily patterns may be assigned.

NOTES:
- Pathways #5, 6, and 7
  - The emissions, traffic, and signalization data reflected in the MOVES modeling should be assigned to the relevant months, hours, and/or days using appropriate month of year, hour of day, and day of week ETS patterns

Records for Background Concentrations

Parameter	Format	Description
#8:	-	Pathway label
BKG	Real	Hourly ambient background concentrations (ppm for CO; ppb for NO_2; μg/m^3 for PM2.5, PM-10, and OTHER) for each month of year ETS pattern
		*** Repeat in succession for each of hour of day ETS pattern, then for each day of week ETS pattern ***

NOTES:
- Pathway #8
  - Typically, hourly ambient background concentration will be set to zero. Background concentrations are usually determined separately and added to model results to calculate design values.

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Records for Link Configurations

Parameter	Format	Description
#9:	-	Pathway label
'LNK'	Character	Link name, up to 20 characters
'IQ'	Character	Traffic flow, 'F' = free-flow link; 'Q' = queue link
'TYP'	Character	Link type, 'AG' = at-grade; 'FL' = fill; 'BR' = bridge; and 'DP' = depressed
XL1	Real	Link X-coordinate start point (user units)
YL1	Real	Link Y-coordinate start point (user units)
XL2	Real	Link X-coordinate end point (user units)
YL2	Real	Link Y-coordinate end point (user units)
SH	Real	Source height (user units)
WL	Real	Mixing zone width (user units)
NLANES	Integer	Number of travel lanes for queue link (required only if IQ = 'Q')
NL	Integer	Number of links

- Pathway #9:
  - A new link is required when there is a change in link width, link orientation, traffic volume, travel speed, or emission factor
  - For a succession of links, the start coordinates of the next link usually equals the end coordinates of the prior link, i.e., no gaps or overlaps
  - In most cases, a link type of at-grade ('AG') and a source height of 0 m should be used
  - Source height should be within ± 10 m (± 32 ft)
  - Mixing zone width is defined as the width of the travelled roadway plus 3 m (10 ft) on either side
  - Link length must always be greater than the mixing zone width

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Records for Link Configurations

Parameter	Format	Description
#10:	-	Pathway label
VPHL	Real	Hourly traffic volume (veh/hr) for each month of year ETS pattern
EFL	Real	Hourly emission factor (g/veh-mi) for each month of ETS pattern
		*** Repeat in succession for each of hour of day ETS pattern, then for each day of week ETS pattern ***
#11:	-	Pathway label (required only if IQ = 'Q')
CAVG	Real	Average total signal cycle length (s) for each month of year ETS pattern
RAVG	Real	Average red signal cycle length (s) for each month of ETS pattern
YFAC	Real	Clearance lost time (s) for each month of ETS pattern
		*** Repeat in succession for each of hour of day ETS pattern, then for each day of week ETS pattern ***
#12:	-	Pathway label (required only if IQ = 'Q')
SFR	Real	Saturation flow rate (vphpl) for each month of year ETS pattern
ST	Real	Signal type for each month of ETS pattern, 1 = pre-timed; 2 = average; and 3 = semi-actuated
AT	Real	Arrival rate for each month of ETS pattern, 1 = worst; 2 = below average; 3 = average; 4 = above average; and 5 = best
		*** Repeat in succession for each of hour of day ETS pattern, then for each day of week ETS pattern ***

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Records for Link Configurations – Notes

- Pathway #10:
  - Hourly traffic volume and emission factors are applied uniformly to the entire link length
  - Emission factors are defined as g/veh-mi
    - Use the latest version of MOVES; may chose the "Emission Rates" option
  - All relevant pollutants and processes should be summed for a single "rateperdistance" emission factor per link
    - MOVES post-processing scripts are available to complete this step
- Pathway #11:
  - For clearance lost time, a default value of 2 s may be used in the absence of locally derived values
- Pathway #12:
  - For saturation flow rate, a default value of ~1800 vehicles per hour, which is representative of an urban intersection, may be used in the absence of locally derived values
  - For signal type, a default value of 1 (pre-timed) may be used in the absence of locally derived values
  - For arrival rate, a default value of 3 (average progression) may be used in the absence of locally derived values

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Constructing an Input File – CAL3QHCRi

```
     FILE MANAGEMENT
**** Meteorology File
MET: 'CAL3QHCR5yr.met'
**** Output File
OUT: 'CAL3QHCR.out'
**** ETS File
ETS: 'CAL3QHCR.ets'
**** Message File
MSG: 'CAL3QHCR.msg'
**** Post File - Concurrent 24-hr averages
PST1 'CAL3QHCR24hr.pst'
**** Post File - Concurrent annual averages
PST2 'CAL3QHCRAnnual.pst'
**** Plot File - Highest 5-yr average 24-hr by quarter
PLT1 'CAL3QHCR5yrAvg24hr.plt'
**** Plot File - 5-yr average annual
PLT2 'CAL3QHCR5yrAvgAnnual.plt'
```

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Constructing an Input File – CAL3QHCRi

```
     PROGRAM CONTROL & SITE VARIABLES
**** 'JOB',ATIM,ZO,VS,VD,NR,SCAL,IOPT
 #1: 'CAL3QHCR Example Analysis - PM2.5',60,175,0,0,1,0.3048,1
**** 'RUN',NL,JTIER,'MODE',FLINK,FAMB,'RU'
 #2: '2006-2010 Annual Meteorology',1,2,'PM2.5',0,0,'U'
**** STARTMO,STARTDY,STARTYR,ENDMO,ENDDY,ENDYR
 #3: 1,1,6,12,31,10

     RECEPTOR LOCATIONS
**** [ Repeat in succession for each Receptor = 1 to NR ]
**** 'RCP',XR,YR,ZR
 #4: '1',29.5,698.2,5.0
```

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Constructing an Input File – CAL3QHCRi

```
     ETS PATTERNS
**** PMOY1,PMOY2,PMOY3, . . . ,PMOY11,PMOY12
 #5: 1,1,1,2,2,2,3,3,3,4,4,4
**** PHOD1,PHOD2,PHOD3, . . . ,PHOD23,PHOD24
 #6: 1,1,1,1,1,1,2,2,2,3,3,3,3,3,3,3,4,4,4,1,1,1,1,1
**** PDOW1,PDOW2,PDOW3,PDOW4,PDOW5,PDOW6,PDOW7
 #7: 1,1,1,1,1,1,1

     BACKGROUND CONCENTRATIONS
**** [ Repeat in succession for each hour of day ETS pattern,
****   then for each day of week ETS pattern ]
**** PDOW1 for PHOD1 to PHOD4:  BKG -
**** PMOY1,PMOY2,PMOY3,PMOY4
 #8: 0,0,0,0
 #8: 0,0,0,0
 #8: 0,0,0,0
 #8: 0,0,0,0
```

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Constructing an Input File – CAL3QHCRi

```
     LINK CONFIGURATIONS
**** [ Repeat #9 and #10 in succession for each
****   Link = 1 to NL ]
**** [ Repeat #10 in succession for each hour of day ETS
****   pattern, then for each day of week ETS pattern ]
**** 'LNK','IQ','TYP',X1,Y1,X2,Y2,SH,WL,(for,IQ='F')
 #9: 'NW ramp','F','AG',957.4,2236.4,1150.7,1971.4,0.0,43.7
**** PDOW1 for PHOD1 to PHOD4:  VPHL - | EFL -
**** PMOY1,PMOY2,PMOY3,PMOY4,PMOY1,PMOY2,PMOY3,PMOY4
#10: 186,186,186,186,0.057850,0.040397,0.031504,0.038953
#10: 404,404,404,404,0.062932,0.043161,0.032228,0.041529
#10: 186,186,186,186,0.054575,0.036239,0.030592,0.035091
#10: 404,404,404,404,0.050415,0.034508,0.030593,0.033955
```

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Output File Structure – CAL3QHCRi

ExampleAnalysisPM25.out

```
7692
7693      Design Values - Project Contributions:
7694      -------------------------------------
7695
7696   5-YEAR AVERAGE HIGH QUARTERLY 24-HOUR PM2.5 CONCENTRATIONS IN UG/M**3
7697                  FOR MET DATA YEARS:  2006-2010
7698           EXCLUDING AMBIENT BACKGROUND CONCENTRATIONS.
7699
```

Line	Receptor Number	Quarter1 Conc	Quarter 2 Conc	Quarter 3 Conc	Quarter 4 Conc
7702	1	0.41650	0.27233	0.26424	0.31863
7703	2	0.45964	0.30880	0.29488	0.35012
7704	3	0.51440	0.35384	0.33481	0.38641
.	.				
.	.				
.	.				
8073	294	2.69811*	1.95892*	1.84787*	2.01432*
.	.				
.	.				
.	.				
8111	319	1.55289	1.08285	1.02109	1.11396
8112	320	1.11343	0.79660	0.73284	0.82467
8113	321	0.78302	0.59265	0.53724	0.61956

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Output File Structure – CAL3QHCRi

ExampleAnalysisPM25.out

```

   5-YEAR AVERAGE ANNUAL PM2.5 CONCENTRATIONS IN UG/M**3
               FOR MET DATA YEARS:  2006-2010
        EXCLUDING AMBIENT BACKGROUND CONCENTRATIONS.

           Receptor      Average     Number   Calm
            Number         Conc     of Days   Hours
                 1       0.07873     1826     C4430
                 2       0.09139     1826     C4430
                 3       0.10572     1826     C4430
                 .
                 .
                 .
               294       0.92081*    1826     C4430
                 .
                 .
                 .
               319       0.49616     1826     C4430
               320       0.34497     1826     C4430
               321       0.24701     1826     C4430

    Program terminated normally
```

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Met Data Processing Steps

- Step 1 – Surface Meteorology can be obtained from a variety of sources
- Data should be selected based on its spatial and temporal representativeness with respect to the transport and dispersion conditions of the project area considering:
  - Proximity of the met monitoring site to the project area;
  - Complexity of the terrain;
  - Exposure of the met monitoring site; and
  - Period of time during which data are collected

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Met Data Processing Steps

1. **Obtain Surface Meteorology**
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
5. Process Surface and Upper Air Data to Obtain Met Files

- The most predominant source of surface data is the National Weather Service (NWS) National Climatic Data Center (NCDC)
  - Recent data from the Automated Surface Observation System (ASOS) are collected in rolling averages stored every minute
    - AERMINUTE averages minute-by-minute wind measurements over an hour
  - Conventional, human observations are based on a single 2-minute average taken during the hour to represent the hour

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Met Data Processing Steps

1. **Obtain Surface Meteorology**
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
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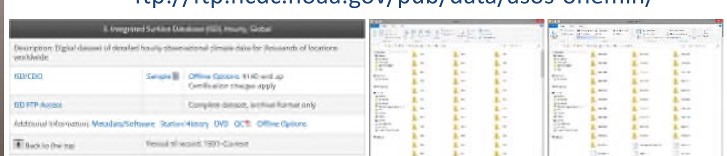
- National Climatic Data Center
  - Free data access
    - http://www.ncdc.noaa.gov/data-access/quick-links#dsi-3505
  - Integrated Surface Hourly Database (ISHD)
    - ftp://ftp.ncdc.noaa.gov/pub/data/noaa/
  - ASOS1-minute data
    - ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/



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Met Data Processing Steps

1. **Obtain Surface Meteorology**
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
5. Process Surface and Upper Air Data to Obtain Met Files

- EPA Surface Databases
  - http://www.epa.gov/ttn/scram/metobsdata_databases.htm

Met Data Processing Steps

1. Obtain Surface Meteorology
2. **Obtain Upper Air Meteorology**
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
5. Process Surface and Upper Air Data to Obtain Met Files

- Step 2 – Upper Air Meteorology can also be obtained from a variety of sources
- Chief among them is the NCDC, National Oceanic and Atmospheric Administration (NOAA)
  - If radiosonde data require processing to obtain mixing heights, process the data using EPA's Mixing Height Program
    - http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm

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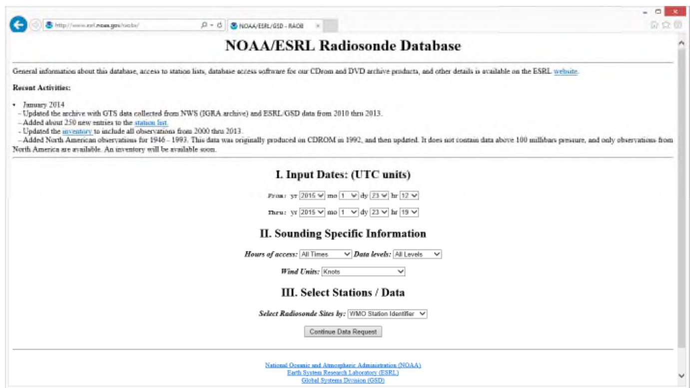
Met Data Processing Steps

1. Obtain Surface Meteorology
2. **Obtain Upper Air Meteorology**
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
5. Process Surface and Upper Air Data to Obtain Met Files

- NOAA Earth Research Laboratory (ERSL)
  - NOAA/ESRL radiosonde database
    - http://www.esrl.noaa.gov/raobs/



Met Data Processing Steps

1. Obtain Surface Meteorology
2. **Obtain Upper Air Meteorology**
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if needed
5. Process Surface and Upper Air Data to Obtain Met Files

- EPA Upper Air Databases
  - http://www.epa.gov/ttn/scram/ metobsdata_databases.htm

Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. **Quality Assurance / Quality Control**
4. Convert Surface Data to Assessable Format, if Needed
5. Process Surface and Upper Air Data to Obtain Met Files

- Step 3 – Refer to EPA's Quality Assurance / Quality Control requirements
  - "Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models"
    - http://www.epa.gov/ttn/scram/ surface/missdata.txt

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Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. **Convert Surface Data to Assessable Format, if Needed**
5. Process Surface and Upper Air Data to Obtain Met Files

- Step 4 – Convert Surface Data to an accessible format, if needed
  - Refer to Chapter 4 in "Analysis of the Affect of ASOS-Derived Meteorological Data on Refined Modeling"
    - http://www.epa.gov/ttn/scram/ /guidance/met/asos.pdf

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Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. **Process Surface and Upper Air Data to Obtain Met Files**

- Step 5 – Process Surface and Upper Air Data to obtain Meteorological Data Files
  - AERMET / MPRM
    - Stage 1: Extract and quality assurance
    - Stage 2: Merge
    - Stage 3: Process and create files for use in dispersion modeling

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Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. **Process Surface and Upper Air Data to Obtain Met Files**

- Some state and local agencies may have 5 years of preprocessed met data available
  - These are typically processed for use with AERMOD
- If using preprocessed data, determine if the data is representative of the project area following EPA guidance

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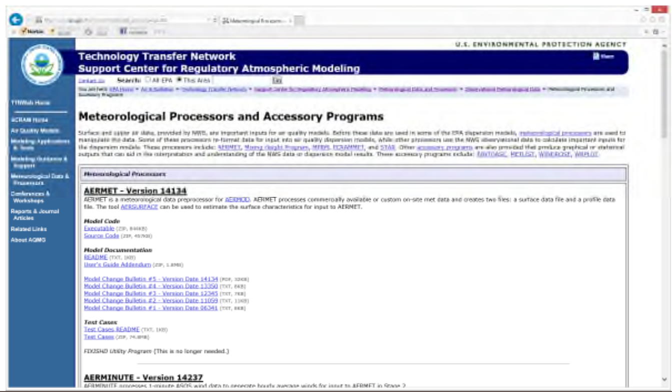
Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. **Process Surface and Upper Air Data to Obtain Met Files**

- EPA Meteorological Processors
  - http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm



Met Data Processing Steps

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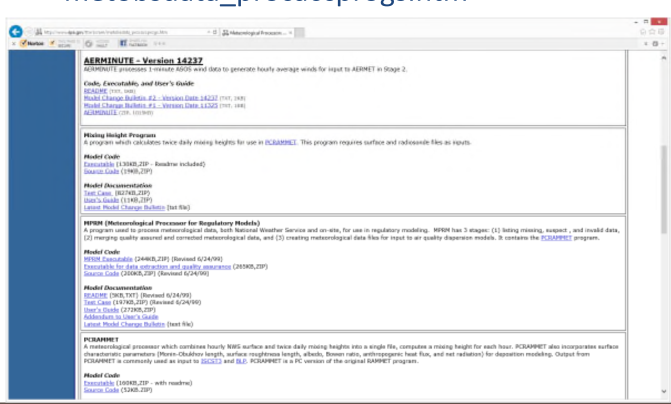
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. **Process Surface and Upper Air Data to Obtain Met Files**

- EPA Meteorological Processors
  - http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm

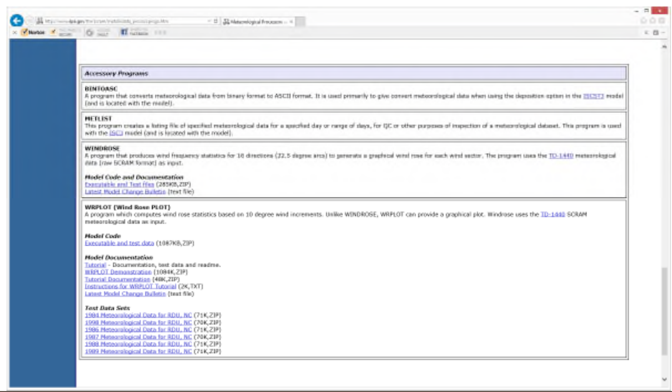


Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. **Process Surface and Upper Air Data to Obtain Met Files**

EPA Meteorological Accessory Programs

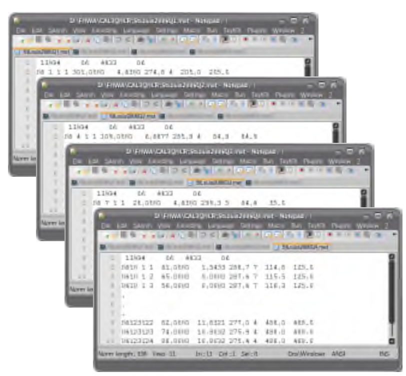
– http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm



Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance / Quality Control
4. Convert Surface Data to Assessable Format, if Needed
5. Process Surface and Upper Air Data to Obtain Met Files

- Step 6 – Add a step in processing met data files for the EPA version of CAL3QHCR* to account for seasonal variations in emissions
  – Segregate files by quarter:



*Does not apply To CAL3QHCRi

Background Concentrations

Ambient Concentration

=

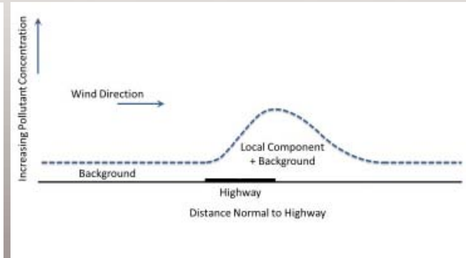
Background

+

Project (Local) Component

+

Other Nearby Sources not Reflected in Background



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Background Concentrations

- Representative background concentrations are typically evaluated and chosen through the interagency consultation process
- Usually determined based on:
  - Current data from one or more ambient air quality monitors or
  - Future predictions from a chemical transport model
- The same background concentration is applied to modeling results for all receptors for all build and no-build scenarios

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Design Values

- Ambient concentration statistic appropriate for comparison to a National Ambient Air Quality Standard (NAAQS)
- PM2.5
  - Annual – arithmetic mean, averaged over 3 years
    - 15.0 μg/m^3 (1997)
    - 12.0 μg/m^3 (2012)
  - 24-hour – 98th percentile, averaged over 3 years
    - 65 μg/m^3 (1997)
    - 35 μg/m^3 (2012)

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Design Values

- PM10
  - 24-hour – not to be exceeded more than once per year on average over 3 years
    - 150 μg/m^3
- CO
  - 8-hour – not to be exceeded more than once per year
    - 9 ppm
  - 1-hour – not to be exceeded more than once per year
    - 35 ppm

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Recommendations for Streamlining the Modeling Process

- Conduct processing steps in parallel rather than in series
  - Traffic analysis
  - Emission analysis
  - Dispersion analysis (link and receptor locations)
- Segregate Links – define highway segments with shared characteristics
- Adopt Link IDs common to each process
- Use Link IDs to merge data from each process to supply air dispersion model input templates

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Defining Links

- Traffic Analysis
  - Volume
  - Vehicle speed
  - Truck percentage
- Issues (especially for congestion mitigation projects)
  - It may be important to segregate hourly vehicle activity during peak traffic periods instead of averaging over a 3-hour period – both options available per EPA guidance
  - In general, do not rely on regional travel demand models for project scale vehicle speeds, especially near signalized intersections and other traffic controls

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Defining Links

- Emissions Analysis
  - Prepare speed look-up tables segregated by
    - Light-duty and heavy-duty vehicles (non-trucks & trucks)
    - Road type
    - Appropriate time periods (months and hours, as applicable)
    - Roadway grade
  - Project scale inputs that typically do not vary by link
    - Vehicle age distribution
    - Alternative vehicle fuels & technology
    - Fuel supply & formulation
    - Meteorology

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Defining Links

- Dispersion Analysis
  - Highway width
  - Orientation or bearing
  - Traffic activity affecting emissions
    - Volume
    - Speed
    - Truck percentage

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Dispersion Model Input File Templates – Merging Traffic Data

Segment ID	AM Pk Period 7:00-8:00			AM Pk Period 8:00-9:00			PM Pk Period 3:00-4:00			PM Pk Period 4:00-5:00			PM Pk Period 5:00-6:00		
	Speed_ mph	NonTruck_ Volume	Truck_Volu me	Speed_ mph	NonTruck_ Volume	Truck_Volu me	Speed_ mph	NonTruck_ Volume	Truck_Volu me	Speed_ mph	NonTruck_ Volume	Truck_Volu me	Speed_ mph	NonTruck_ Volume	Truck_Volu me
MS03N500a	8	787	107	8	644	88	6	593	81	5	697	95	6	593	81
MS03N1000a	45	787	107	45	644	88	45	593	81	45	697	95	45	593	81
MS03N500d	32	581	79	31	476	65	30	538	73	30	632	86	30	538	73
MS03N1000d	42	581	79	43	476	65	42	538	73	42	632	86	42	538	73
MS03S500a	2	904	123	4	739	101	6	1,125	153	5	1,322	180	6	1,125	153
MS03S1000a	5	904	123	44	739	101	45	1,125	153	45	1,322	180	45	1,125	153
MS03S500d	32	1,263	172	32	1,034	141	32	1,731	236	32	2,033	277	32	1,731	236
MS03S1000d	42	1,263	172	41	1,034	141	41	1,731	236	41	2,033	277	41	1,731	236
RH10E500a	3	2,228	304	8	1,823	249	8	2,189	299	7	2,572	351	8	2,189	299
RH10E1000a	4	2,228	304	45	1,823	249	45	2,189	299	31	2,572	351	45	2,189	299
RH11E500d	32	2,590	353	33	2,119	289	33	2,172	296	32	2,551	348	33	2,172	296
RH11E1000d	40	2,590	353	40	2,119	289	39	2,172	296	39	2,551	348	39	2,172	296
RH11W500a	8	2,314	316	9	1,894	258	10	2,416	329	8	2,837	387	10	2,416	329
RH11W1000a	45	2,314	316	45	1,894	258	45	2,416	329	45	2,837	387	45	2,416	329
RH10W500d	34	1,799	245	35	1,472	201	35	1,884	257	35	2,212	302	35	1,884	257
RH10W1000d	40	1,799	245	41	1,472	201	41	1,884	257	40	2,212	302	41	1,884	257

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Dispersion Model Input File Templates – Merging Emissions Data

				Q1 (months=1-3, monthID=1) PM2.5 MOVES2010b Emission Factor (g/VMT)							
				ON (6pm-7am, hourID=1)		AM (7am-9am, hourID=8)		MD (11am-2pm, hourID=13)		PM (3pm-6pm, hourID=17)	
CalYr	RoadTyp	Fuel	Speed	Non-Trucks	Trucks	Non-Trucks	Trucks	Non-Trucks	Trucks	Non-Trucks	Trucks
2015	4	TOT	1	0.37872959	6.06081492	0.40573674	6.07597220	0.32541208	6.03089696	0.31163611	6.02317578
2015	4	TOT	2	0.18936489	3.03040749	0.20286848	3.03799686	0.16270594	3.01544956	0.15581793	3.01158574
2015	4	TOT	3	0.13282153	2.02490634	0.14233914	2.02995804	0.11403197	2.01493302	0.10917724	2.01235423
2015	4	TOT	4	0.10668355	1.51868048	0.11459434	1.52246839	0.09106611	1.51119852	0.08703090	1.50926641
2015	4	TOT	5	0.09100085	1.22213272	0.09794756	1.22518362	0.07728661	1.21610954	0.07374320	1.21455256
2015	4	TOT	6	0.08054570	1.03830499	0.08684974	1.04088922	0.06810035	1.03320423	0.06488476	1.03188691
2015	4	TOT	7	0.07307762	0.92375062	0.07892248	0.92600096	0.06153847	0.91930627	0.05855718	0.91815900
2015	4	TOT	8	0.06874821	0.84098955	0.07424877	0.84299137	0.05788880	0.83704019	0.05508308	0.83601952
2015	4	TOT	9	0.06378697	0.77381591	0.06893825	0.77562369	0.05361721	0.77024825	0.05098961	0.76932788
2015	4	TOT	10	0.05874196	0.72007512	0.06342606	0.72172795	0.04949456	0.71681479	0.04710525	0.71597301
2015	4	TOT	11	0.05461416	0.67620476	0.05891606	0.67773342	0.04612134	0.67318244	0.04392705	0.67240169
2015	4	TOT	12	0.05117429	0.64899623	0.05515765	0.65043988	0.04331041	0.64614615	0.04127861	0.64540908
2015	4	TOT	13	0.04892944	0.62973677	0.05264314	0.63110640	0.04159759	0.62703052	0.03970324	0.62633044
2015	4	TOT	14	0.04638697	0.61169274	0.04986967	0.61300119	0.03951122	0.60911068	0.03773472	0.60844346
2015	4	TOT	15	0.04418359	0.59605555	0.04746611	0.59730951	0.03770315	0.59358256	0.03602884	0.59294133
2015	4	TOT	16	0.04215861	0.57941955	0.04528250	0.58062328	0.03599143	0.57704259	0.03439801	0.57642750
2015	4	TOT	17	0.04012111	0.56056897	0.04314778	0.56172703	0.03414601	0.55828352	0.03260221	0.55769271
2015	4	TOT	18	0.03871495	0.54481891	0.04165509	0.54593545	0.03291058	0.54261416	0.03141078	0.54204495
2015	4	TOT	19	0.03707329	0.52977364	0.03993601	0.53085318	0.03142156	0.52764092	0.02996132	0.52708927
2015	4	TOT	20	0.03559563	0.51715640	0.03838885	0.51820546	0.03008141	0.51508903	0.02865661	0.51455486

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Dispersion Model Input File Templates – Merging Link Data

Object_ID	X1	Y1	X2	Y2	Descriptor	Direction	Seg_ID	Sub_Segmen	Intersect	Length
123	6220158.52413000000	2326290.42611000000	6220167.33481000000	2326877.97217000000	24	SB	ALR04S	03		587.61212652400
122	6220147.51136000000	2325179.20917000000	6220158.52413000000	2326290.42611000000	24	SB	ALR04S	04		1111.27150767000
121	6220150.81516000000	2324160.50189000000	6220147.51136000000	2325179.20917000000	24	SB	ALR04S	05		1018.71263747000
120	6220143.65671000000	2323189.70134000000	6220150.81516000000	2324160.50189000000	12	SB	ALR04S	06		970.82694382000
119	6220129.94610000000	2322542.01923000000	6220143.65671000000	2323189.70134000000	12	SB	ALR04S	07		647.82720530300
190	6245269.55199000000	2316415.27558000000	6245266.98179000000	2315915.28216000000	36	NB	CA01E	01	1000a	500.00002857900
189	6245272.12220000000	2316915.26900000000	6245269.55199000000	2316415.27558000000	36	NB	CA01E	02	500a	500.00002857900
197	6245273.99687000000	2317279.94445000000	6245272.12810000000	2316916.40187000000	36	NB	CA01E	04	500d	363.54738309200
196	6245273.67698000000	2317415.26374000000	6245273.99687000000	2317279.94445000000	36	NB	CA01E	05	500d	135.31966124100
195	6245273.16977000000	2317629.94343000000	6245273.67698000000	2317415.26374000000	36	NB	CA01E	06	1000d	214.68028794300
194	6245279.32264000000	2317915.19679000000	6245273.16977000000	2317629.94343000000	36	NB	CA01E	07	1000d	285.31971710400
358	6245284.93746000000	2318175.50008000000	6245279.32264000000	2317915.19679000000	36	EB	CA01E	08		260.36383476100
357	6245298.16972000000	2318397.65187000000	6245284.93746000000	2318175.50008000000	36	EB	CA01E	09		222.54552106400
356	6245309.36589000000	2318465.87975000000	6245298.16972000000	2318397.65187000000	36	EB	CA01E	10		69.14042331010
344	6245324.06238000000	2318555.43764000000	6245309.36589000000	2318465.87975000000	36	EB	CA01E	11	1000a	90.75573192380
343	6245344.81234000000	2318664.06242000000	6245324.06238000000	2318555.43764000000	36	EB	CA01E	12	1000a	110.58889730200
342	6245378.37789000000	2318802.86004000000	6245344.81234000000	2318664.06242000000	36	EB	CA01E	13	1000a	142.79855105200
341	6245431.40173000000	2318949.41979000000	6245378.37789000000	2318802.86004000000	36	EB	CA01E	14	1000a	155.85662405500
347	6245471.08637000000	2319059.11019000000	6245431.40173000000	2318949.41979000000	36	EB	CA01E	15	500a	116.64841745400
346	6245572.12816000000	2319287.23506000000	6245471.08637000000	2319059.11019000000	36	EB	CA01E	16	500a	249.50030263900
345	6245633.02239000000	2319406.43266000000	6245572.12816000000	2319287.23506000000	36	EB	CA01E	17	500a	133.85131612500
350	6245579.81253000000	2319436.43752000000	6245505.18735000000	2319290.12515000000	36	WB	CA01W	01	500d	164.24441344300
351	6245505.18735000000	2319290.12515000000	6245426.81250000000	2319108.99985000000	36	WB	CA01W	02	500d	197.35498004100
352	6245426.81250000000	2319108.99985000000	6245403.37817000000	2319043.48522000000	36	WB	CA01W	03	500d	69.57970411910
353	6245403.37817000000	2319043.48522000000	6245381.57801000000	2318978.20845000000	36	WB	CA01W	04	500d	68.82080852850
346	6245381.57801000000	2318978.20845000000	6245344.06234000000	2318865.87501000000	36	WB	CA01W	05	1000d	118.43237198500
347	6245344.06234000000	2318865.87501000000	6245296.00010000000	2318675.18740000000	36	WB	CA01W	06	1000d	196.65132542200

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Dispersion Model Input File Templates – Merging Receptor Data

'RCP'	XR	YR
'1FwyROW1'	6254440.997	2303558.356
'1FwyROW3'	6254276.997	2303562.081
'1FwyROW4'	6254194.997	2303563.944
'1FwyROW5'	6254112.998	2303565.806
'1FwyROW6'	6254030.998	2303567.669
'1FwyROW8'	6253866.998	2303571.394
'1FwyROW9'	6253784.998	2303573.256
'1FwyROW11'	6253620.999	2303576.981
'1FwyROW12'	6253538.999	2303578.844
'1FwyROW13'	6253456.999	2303580.706
'2FwyROW1'	6253375.386	2303588.374
'2FwyROW2'	6253293.866	2303597.421
'2FwyROW3'	6253212.345	2303606.468
'2FwyROW4'	6253130.825	2303615.515
'2FwyROW5'	6253049.304	2303624.561
'3FwyROW1'	6252971.067	2303648.569
'3FwyROW2'	6252893.252	2303674.496
'4FwyROW1'	6252822.035	2303714.446
'5FwyROW1'	6252757.414	2303764.292
'5FwyROW2'	6252697.845	2303820.674
'6FwyROW1'	6252655.628	2303890.732
'6FwyROW2'	6252614.731	2303961.829

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Dispersion Model Input File Templates – Merging Data into AERMOD

```
CO STARTING
   TITLEONE  2015 EMFAC2011 PM2.5 Example Arterial
   TITLETWO  2008-2012 Meteorology
   MODELOPT  FLAT CONC
   AVERTIME  24 ANNUAL
   URBANOPT       2000000
   POLLUTID  PM2.5
   FLAGPOLE           1.5
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
CO FINISHED

SO STARTING
**                                     Xs1            Ys1            Xs2            Ys2
**           Scrid        Srctyp       (m)            (m)            (m)            (m)
**           -----        ------       -----------    -----------    -----------    -----------
   LOCATION          001  LINE         1899154.559    709066.640     1899156.326    709181.110
   LOCATION          062  LINE         1901374.918    709459.414     1901573.182    709456.141

** Line Source            Lnemis       Relhgt         Width          Szinit
** Parameters:            (g/s-m2)     (m)            (m)            (m)
**           -----        --------     ------         -----          ------
   SRCPARAM          001  1.0          1.3            7.315          1.2
   SRCPARAM          062  1.0          1.3            7.315          1.2

** Variable               Qflag        ON             AM1            AM2            ON
** Emission Rates:        ------       -------------- -------------  -------------  --------------
   EMISFACT          001  HROFDY       7*2.8228968E-07  6.0721223E-07  5.6048163E-07  2*2.8228968E-07
   EMISFACT          062  HROFDY       7*5.1687225E-07  1.0886432E-06  1.0034244E-06  2*5.1687225E-07
   URBANSRC  ALL
   SRCGROUP  ALL
SO FINISHED
```

program controls

highway config

emissions

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Dispersion Model Input File Templates – Merging Data into AERMOD

```
RE STARTING
**
**           Receptor Array
**
**             Xcoord       Ycoord
**              (m)          (m)
**           -----------  ----------
   DISCCART   1899132.486  709502.677
   DISCCART   1900976.584  709237.315
RE FINISHED

ME STARTING
   SURFFILE  23155_2008-2012.sfc
   PROFFILE  23155_2008-2012.pfl
   SURFDATA  23155 2008
   UAIRDATA  23230 2008
   PROFBASE            0.0
ME FINISHED

OU STARTING
   RECTABLE  24 1ST
   MAXTABLE  24 50
   POSTFILE  24 ALL PLOT 2015_EMFAC_PM25_Art_5yrAvg24hr.plt
   POSTFILE  ANNUAL ALL PLOT 2015_EMFAC_PM25_Art_5yrAvgAnnual.plt
OU FINISHED
```

receptor locations

meteor-ology

output options

RESOURCE CENTER

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Dispersion Model Input File Templates – Merging Data into CAL3QHCRi

```
     FILE MANAGEMENT
**** Meteorology File
MET: '23155_2008-2012.met'
**** Output File
OUT: '2015_MOVES_PM25_Fwy.out'
**** ETS File
ETS: '2015_MOVES_PM25_Fwy.ets'
**** Message File
MSG: '2015_MOVES_PM25_Fwy.msg'
**** Post File 1 - Concurrent 24-hr averages
PST1 '2015_MOVES_PM25_Fwy_24hr.pst'
**** Post File 2 - Concurrent annual averages
PST2 '2015_MOVES_PM25_Fwy_Annual.pst'
**** Plot File 1 - Highest 5-yr average 24-hr by quarter
PLT1 '2015_MOVES_PM25_Fwy_5yrAvg24hr.plt'
**** Plot File 2 - 5-yr average annual
PLT2 '2015_MOVES_PM25_Fwy_5yrAvgAnnual.plt'

     PROGRAM CONTROL & SITE VARIABLES
**** 'JOB'                                   ATIM      ZO        VS         VD         NR         SCAL       IOPT
#1:  '2015 MOVES2010b PM2.5 Example Freeway'   60       108          0          0       2976     0.3048     1
**** 'RUN'                                   NL        JTIER     'MODE'     FLINK      FAMB       'RU'
#2:  '2008-2012 Meteorology'                  127         2     'PM2.5'          0          0     'U'
**** STRMO                                   STRDY     STRYR     ENDMO      ENDDY      ENDYR
 #3:                                     01        01        08         12 31              12

                         RECEPTOR LOCATIONS
**** [ Repeat in succession for each Receptor = 1 to NR ]
**** 'RCP'                                   XR           YR           ZR
#4:  '217FwyROW          1'                  6220130.011  2317283.637   5.0
#4:  '136Fwy1640ft       3'                  6230424.330  2321606.609   5.0
```

meteor-ology

output options

program control

receptor locations

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Dispersion Model Input File Templates – Merging Data into CAL3QHCRi

```
     ETS PATTERNS
**** PMOY1                PMOY2  PMOY3  PMOY4  PMOY5  PMOY6  PMOY7  PMOY8  PMOY9
#5:                  1        1      1      1      1      1      1      1      1
**** PHOD1                PHOD2  PHOD3  PHOD4  PHOD5  PHOD6  PHOD7  PHOD8  PHOD9
#6:                  1        1      1      1      1      1      1      2      3
**** PDOW1                PDOW2  PDOW3  PDOW4  PDOW5  PDOW6  PDOW7
#7:                  1        1      1      1      1      1      1
     BACKGROUND CONCENTRATIONS
**** [ Repeat in succession for each hour of day ETS pattern, then for each day of week ETS pattern ]
**** PDOW1 for PHOD1 to PHOD9:
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
#8:                0.0
     LINK CONFIGURATIONS (for IQ = 'F')
**** [ Repeat #9 and #10 in succession for each Link = 1 to NL ]
**** [ Repeat #10 in succession for each hour of day ETS pattern, then for each day of week ETS pattern ]
**** 'LNK'         'IQ'  'TYP'  X1             Y1             X2             Y2             SH  WL
#9:  'ALR02N-02'   'F'   'AG'   6220106.76308  2317212.91867  6220104.31262  2318042.50002  0   44
**** PDOW1 for PHOD1 to PHOD9:
**** VPHL          EFL-Q1      EFL-Q2      EFL-Q3      EFL-Q4
#10:          603  0.04671531  0.03760705  0.03215120  0.03675570
#10:         1544  0.06177186  0.04960248  0.04267969  0.04918735
#10:         1426  0.06180129  0.04963263  0.04271025  0.04921753
#10:         1174  0.04410638  0.03637412  0.03459958  0.03563338
#10:         1174  0.04410638  0.03637412  0.03459958  0.03563338
#10:         1174  0.04410638  0.03637412  0.03459958  0.03563338
#10:         1494  0.05030649  0.04320159  0.04199898  0.04269584
#10:         1608  0.05009104  0.04298312  0.04177997  0.04247715
#10:         1494  0.05030649  0.04320159  0.04199898  0.04269584
```

highway config

emissions

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Receptor / Volume-source Spacing Utility Program

- Procedure based on highway right-of-way configuration
- Receptor spacing utility program application
- A similar utility program has been developed to establish volume source spacing based on highway centerline coordinates

RESOURCE CENTER

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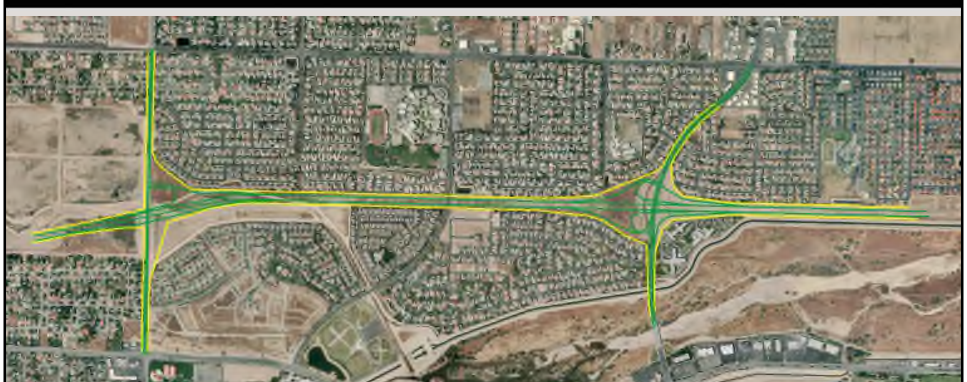
Freeway Links and Right-of Way



RESOURCE CENTER

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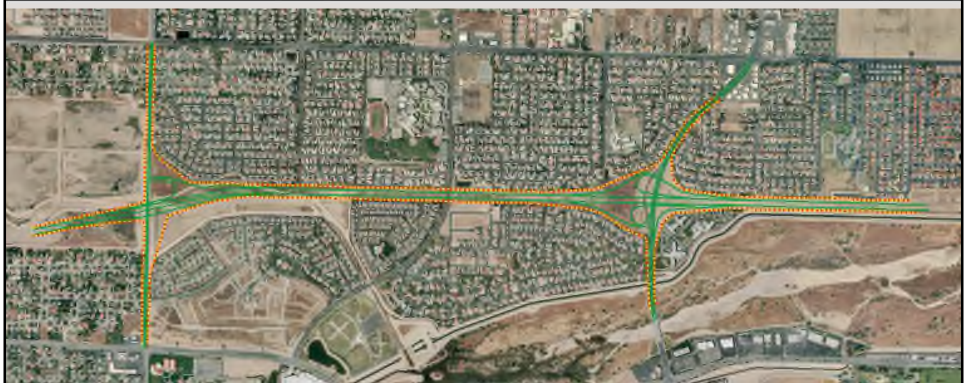
Freeway Links and Right-of Way Receptors



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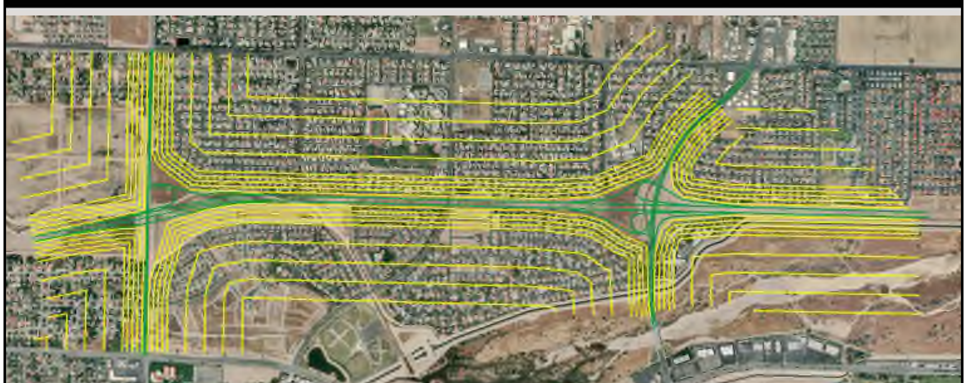
Freeway Links and Receptor Lines



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Freeway Links and Receptor Network

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Arterial Links

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Arterial Links and Receptor Network

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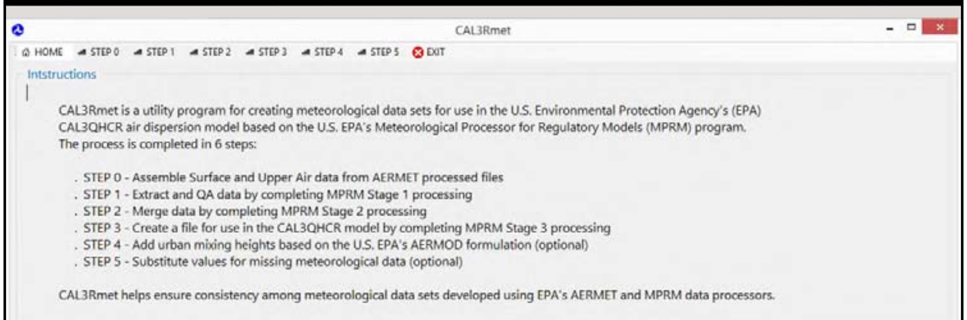
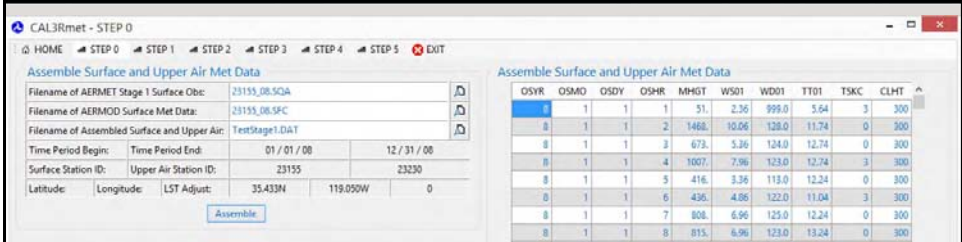
Processing CAL3QHCR Met Data – CAL3Rmet



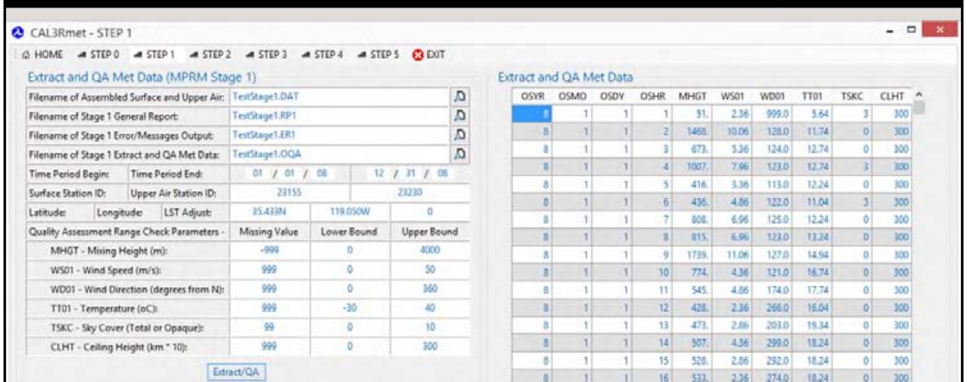
168

Processing CAL3QHCR Met Data – CAL3Rmet



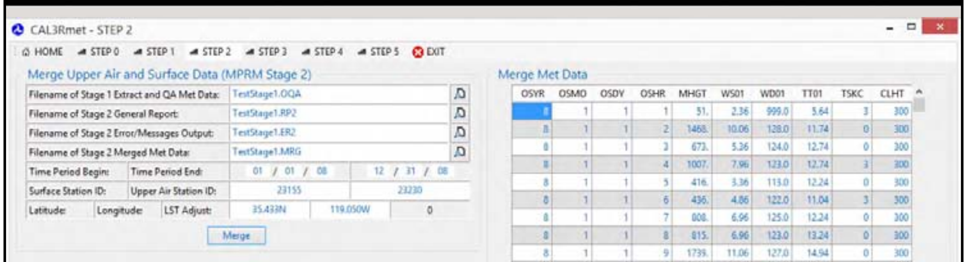
169

Processing CAL3QHCR Met Data – CAL3Rmet



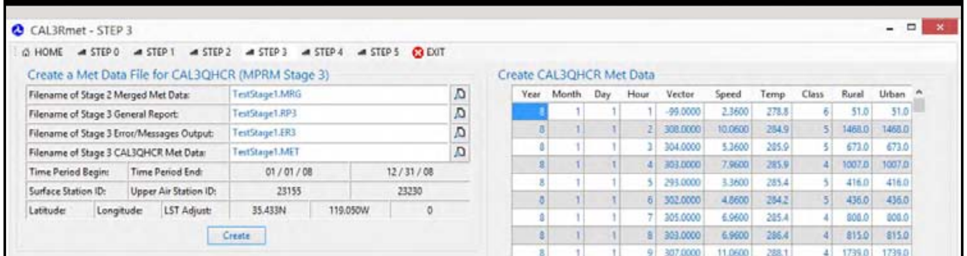
170

Processing CAL3QHCR Met Data – CAL3Rmet



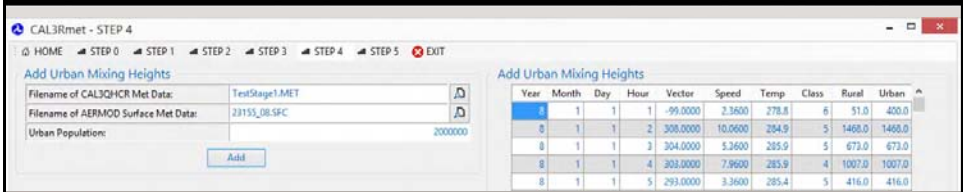
171

Processing CAL3QHCR Met Data – CAL3Rmet



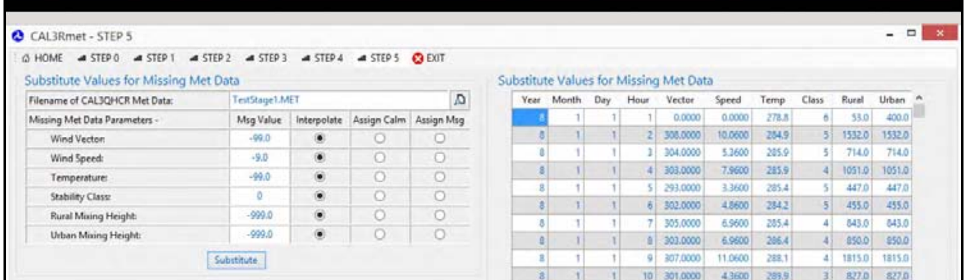
172

Processing CAL3QHCR Met Data – CAL3Rmet



Year	Month	Day	Hour	Vector	Speed	Temp	Class	Rural	Urban
8	1	1	1	-99.0000	2.3600	278.8	6	51.0	400.0
8	1	1	2	308.0000	10.0600	284.9	5	1468.0	1468.0
8	1	1	3	304.0000	5.3600	285.9	5	673.0	673.0
8	1	1	4	303.0000	7.9600	285.9	4	1007.0	1007.0
8	1	1	5	293.0000	3.3600	285.4	5	416.0	416.0

Processing CAL3QHCR Met Data – CAL3Rmet



Missing Met Data Parameters -	Msg Value	Interpolate	Assign Calm	Assign Msg
Wind Vector:	-99.0	●	○	○
Wind Speed:	-9.0	●	○	○
Temperature:	-99.0	●	○	○
Stability Class:	0	●	○	○
Rural Mixing Height:	-999.0	●	○	○
Urban Mixing Height:	-999.0	●	○	○

Year	Month	Day	Hour	Vector	Speed	Temp	Class	Rural	Urban
8	1	1	1	0.0000	0.0000	278.8	6	53.0	400.0
8	1	1	2	308.0000	10.0600	284.9	5	1532.0	1532.0
8	1	1	3	304.0000	5.3600	285.9	5	714.0	714.0
8	1	1	4	303.0000	7.9600	285.9	4	1051.0	1051.0
8	1	1	5	293.0000	3.3600	285.4	5	447.0	447.0
8	1	1	6	302.0000	4.8600	284.2	5	455.0	455.0
8	1	1	7	305.0000	6.9600	285.4	4	843.0	843.0
8	1	1	8	303.0000	6.9600	286.4	4	850.0	850.0
8	1	1	9	307.0000	11.0600	288.1	4	1815.0	1815.0
8	1	1	10	301.0000	4.3600	289.9	3	827.0	827.0

Agency Experiences in Conducting PM Dispersion Modeling

- AERMOD area sources versus CAL3QHCR line sources
  - Lin and Vallamsundar (IL DOT study) observed 2.1 times higher predictions of annual average concentrations of $PM_{2.5}$ for highways configured as AERMOD area sources versus CAL3QHCR line sources for a freeway interchange in Joliet, Illinois
- AERMOD area sources versus AREMOD volume sources
  - Schewe reported 1.8 to 3.8 times higher concentration predictions for highways configured as AERMOD volume sources versus AERMOD area sources

RESOURCE CENTER

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Agency Experiences in Conducting PM Dispersion Modeling

- AERMOD area sources versus AERMOD volume sources
  - Pasch, et al. (Caltrans study) found that the differences in peak concentrations predicted for highways configured as AERMOD area sources versus AERMOD volume sources narrowed by increasing the number of volume sources used in the simulation
  - Using modeling results for a hypothetical 1.1 mile freeway widening project, the study showed that
    - AERMOD produced 2.6 times higher concentrations for area sources versus a few (i.e., 22) large volume sources; whereas,
    - the concentration difference was only 10% higher for area sources versus many (i.e., 968) small volume sources

RESOURCE CENTER

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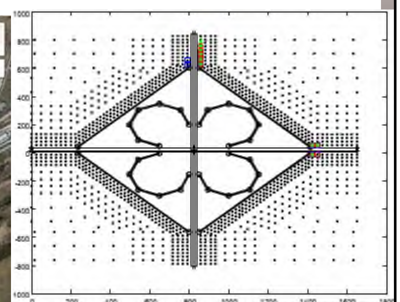
Agency Experiences in Conducting PM Dispersion Modeling – IL DOT Study

- IL DOT Study I-80 and I-55 Interchange near Joliet, Illinois
  - For an analysis year of 2015, the highest annual $PM_{2.5}$ concentration obtained from CAL3QHCR without the background was 2.7 µg/m^3 in the NE quadrant
  - This contrasts with the 5.8 µg/m^3 estimated with AERMOD



Agency Experiences in Conducting PM Dispersion Modeling – IL DOT Study

- IL DOT Study – Poplar Street Bridge, East St. Louis, Illinois
  - The highest annual $PM_{2.5}$ concentration obtained from CAL3QHCR without the background was 3.1 µg/m^3 for 2015

Agency Experiences in Conducting PM Dispersion Modeling – IL DOT Study

- IL DOT Study – Intersection of Algonquin and IL 53, Chicago
  - The highest annual PM2.5 concentration obtained from CAL3QHCR without the background was 2.6 μg/m^3 for 2015

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Agency Experiences in Conducting PM Dispersion Modeling – IL DOT Study

- IL DOT Study – Intersection of IL 3 and Piasa Lane, East St. Louis, Illinois
  - The highest annual $PM_{2.5}$ concentration obtained from CAL3QHCR without the background was 1.1 μg/m^3 for 2015

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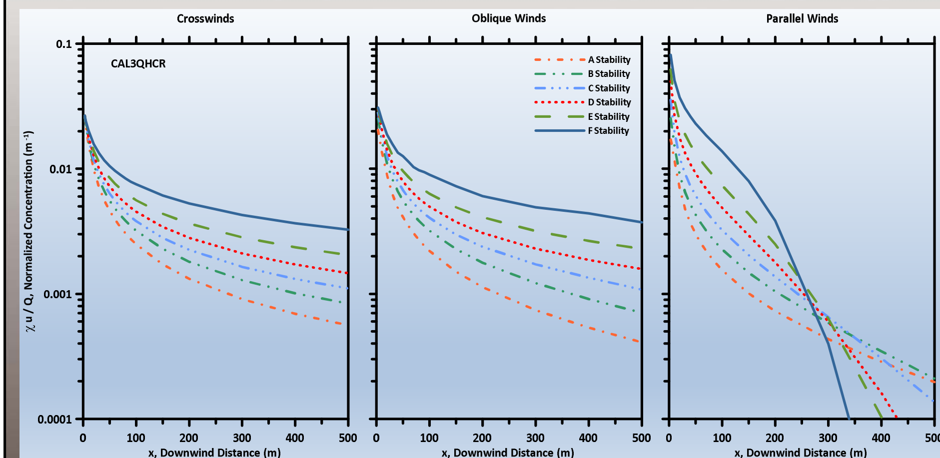
Agency Experiences in Conducting PM Dispersion Modeling – FHWA Study



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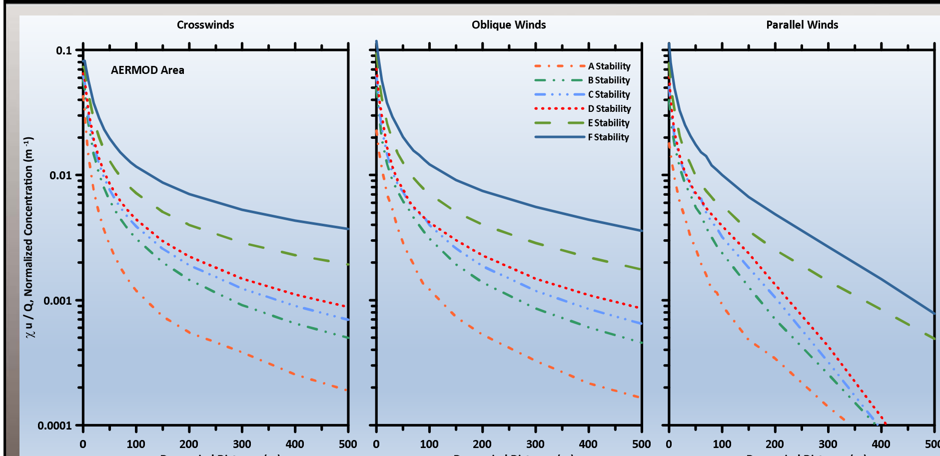
Agency Experiences in Conducting PM Dispersion Modeling – FHWA Study



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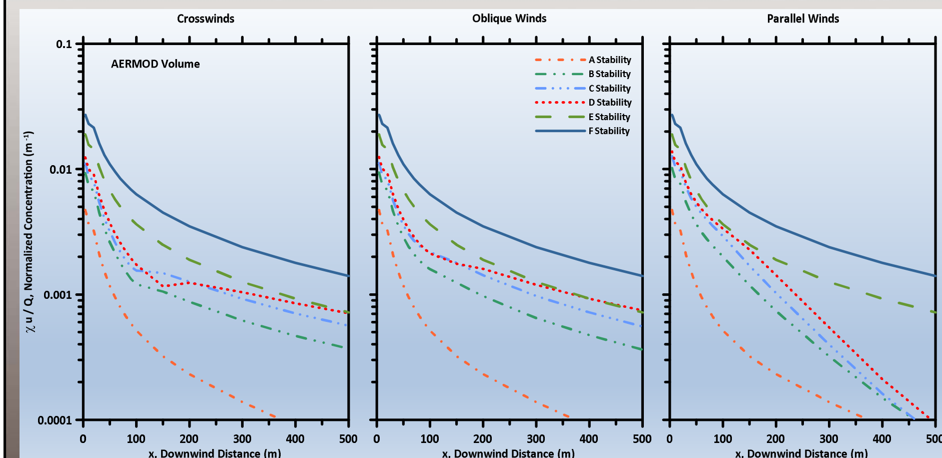
Agency Experiences in Conducting PM Dispersion Modeling – FHWA Study



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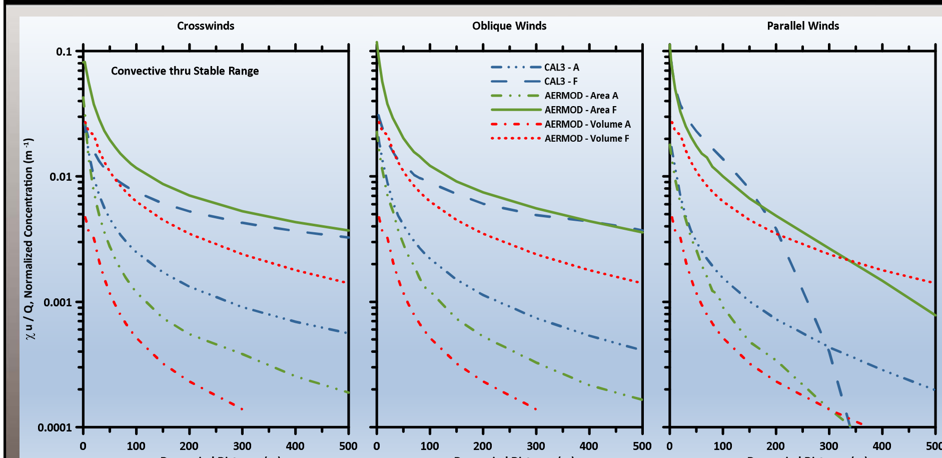
Agency Experiences in Conducting PM Dispersion Modeling – FHWA Study



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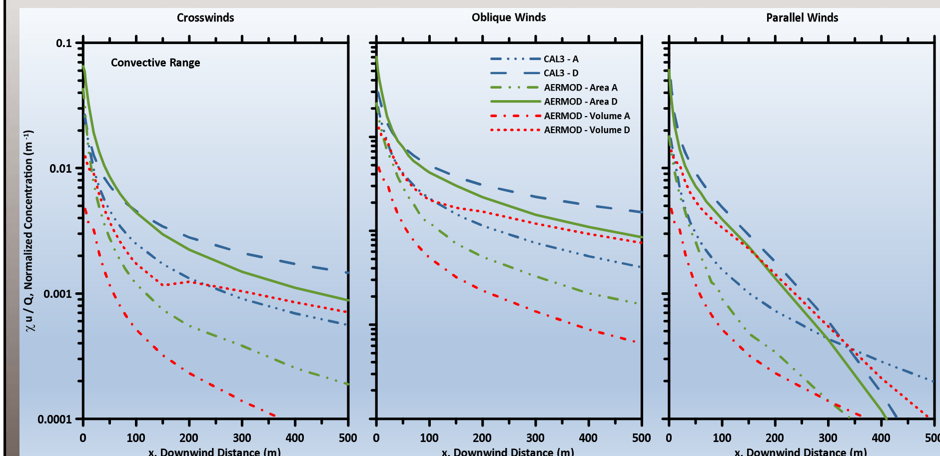
Agency Experiences in Conducting PM Dispersion Modeling – FHWA Study



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Generalized Case Studies of Project Scale PM Hot-spot Modeling

- Highway Configurations
  - Arterial intersection
  - Arterial midblock
  - Freeway interchange
  - Freeway mainline
- Emissions Models
  - MOVES2014
  - EMFAC2011
- Analysis Years
  - 2017 and 2037

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Generalized Case Studies of Project Scale PM Hot-spot Modeling

- Emission Components
  - Vehicle exhaust
    - Vehicle type (non-trucks and trucks)
  - Brake wear
  - Tire wear
  - Re-entrained road dust
  - Combined total
- Air Dispersion Models
  - AERMOD volume sources
  - AERMOD area sources
  - CAL3QHCR line sources

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Preliminary Results for Generalized Cases – CAL3QHCR

Analysis Year	Generalized Case	Annual $PM_{2.5}$	24-hr $PM_{2.5}$
2015	MOVES Arterial	2.5 µg/m³	6 µg/m³
	MOVES Freeway	1.7 µg/m³	3 µg/m³
	EMFAC Arterial	0.8 µg/m³	2 µg/m³
	EMFAC Freeway	1.1 µg/m³	2 µg/m³
2035	EMFAC Arterial	0.7 µg/m³	2 µg/m³
	EMFAC Freeway	1.0 µg/m³	2 µg/m³
	Note: These results are subject to change		

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Graphical User Interfaces – FHWA's CAL3i

- Integrates EPA's CALINE3, CAL3QHC, and CAL3QHCR models into one computer program package
- Provides interactive graphical forms for entering data
- Extends the utility of the models
- Facilitates model operation in a Microsoft® Windows® environment

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Regulatory Applicability

- CO Hotspot Analysis
  - CALINE3
    - Highways with freely flowing traffic
  - CAL3QHC
    - Highways with freely flowing traffic
    - Signalized intersections
  - CAL3QHCR
    - Tier I: account for hourly variations in transport meteorology over an annual data record
    - Tier II: account for hourly variations in emissions (traffic volumes and emission factors) and transport meteorology over a year

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Regulatory Applicability

- PM Hotspot Analysis
  - CAL3QHCR
    - Tier II: account for hourly variations in emissions (traffic volumes and emission factors) and transport meteorology over a year

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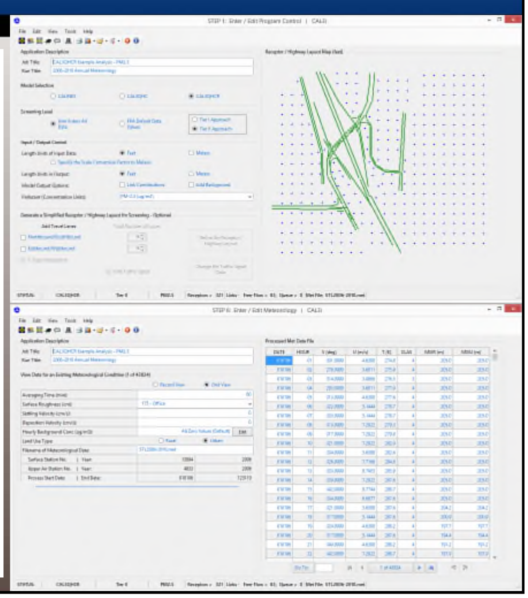
Data Forms

- Data entered via forms organized by:
  - Program control
  - Receptors
  - Links
  - Emissions
  - Meteorology



Extended Functionality

- Offers two screening options:
  - User enters all data required
  - Interface supplies EPA-recommended default data values
- Incorporates a utility for generating a simplified receptor / highway layout, allowing changes to:
  - Default configuration data
  - Default signal data
- Conducts data quality assurance/quality control checks
  - Missing data
  - Valid number verification
  - Out of range values

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Extended Functionality

- Substantially increases the capacity for receptor and link analysis
  - No preset limits on the numbers of receptors and links – arrays allocated at runtime
    - Up from 20 receptors / 20 links for CALINE3
    - Up from 60 receptors / 120 links for CAL3QHC
    - Up from 60 receptors / 120 links for CAL3QHCR
- Provides screening results for multiple averaging times
  - 1-hour and 8-hour CO concentrations

RESOURCE CENTER

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Windows® Operation

- Constructing input files
- Program execution
- Displaying results
  - Summary table
  - Bar chart
  - Model printout

RESOURCE CENTER

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Windows® Operation

- Data file operations
  - Open and save data files
  - Import receptor, link, emissions, and/or meteorological data
  - Save results table and/or model output
  - Print data forms, data files, summary table, bar chart, and model output
  - Built-in tools for plotting wind roses, comparing build vs. no-build results, and summarizing emissions

RESOURCE CENTER

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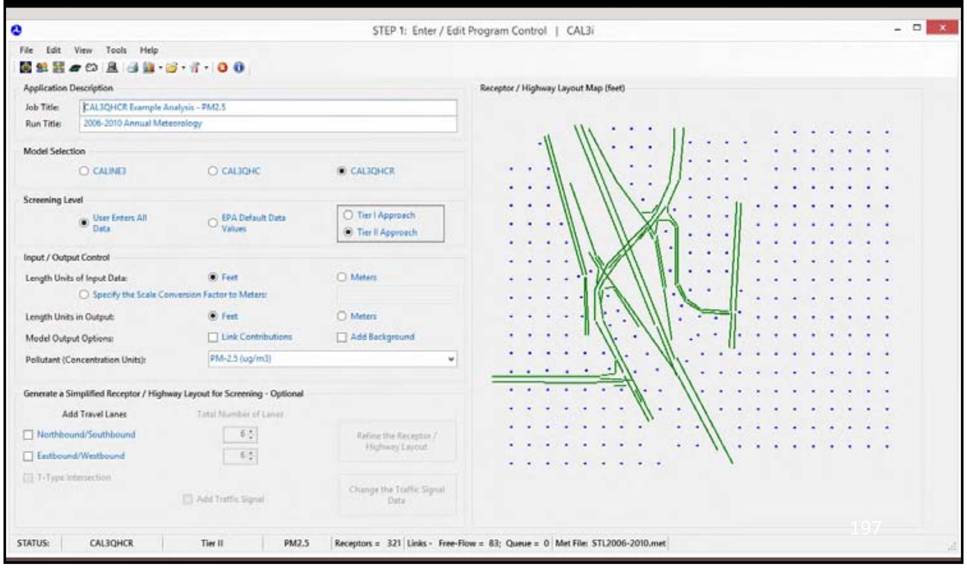
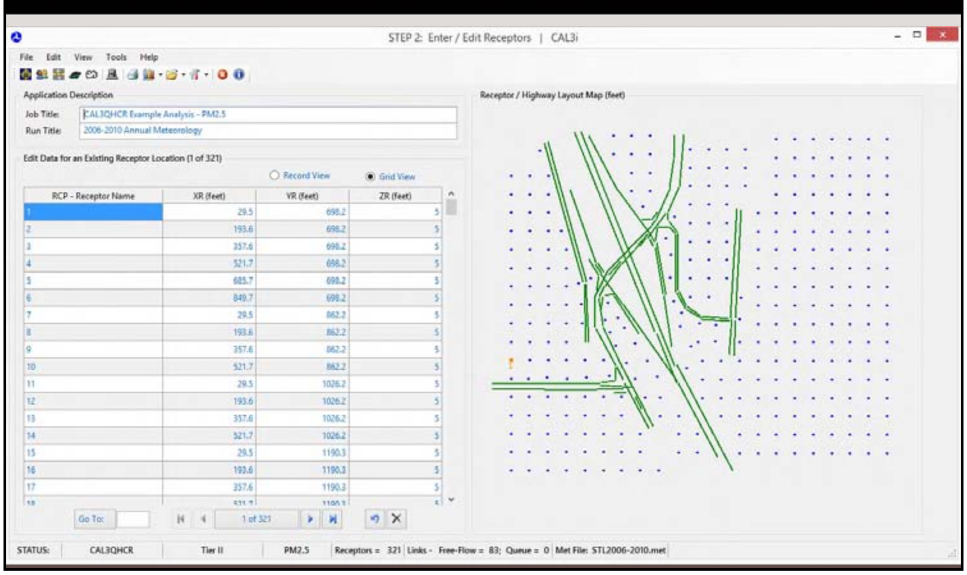
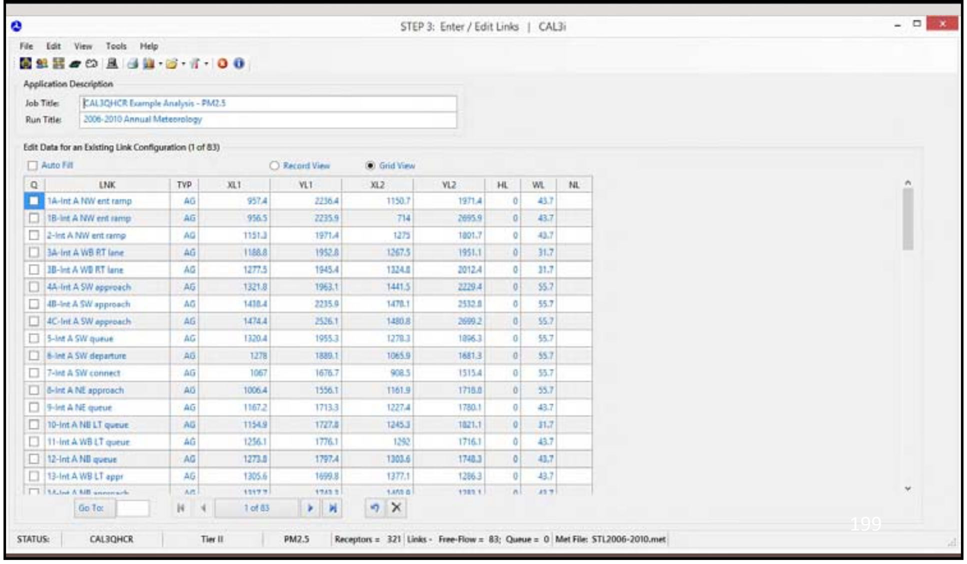
Enter / Edit Program Control



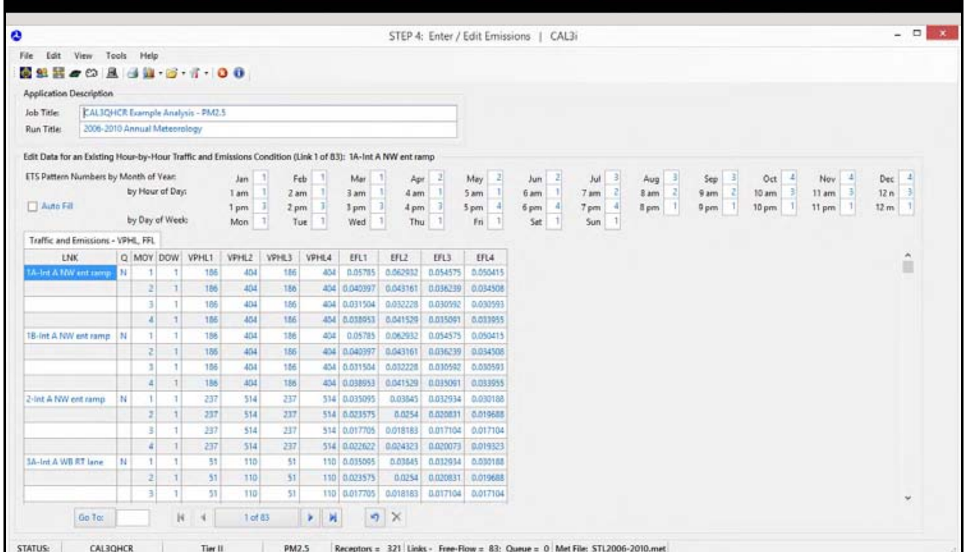
Enter / Edit Receptors



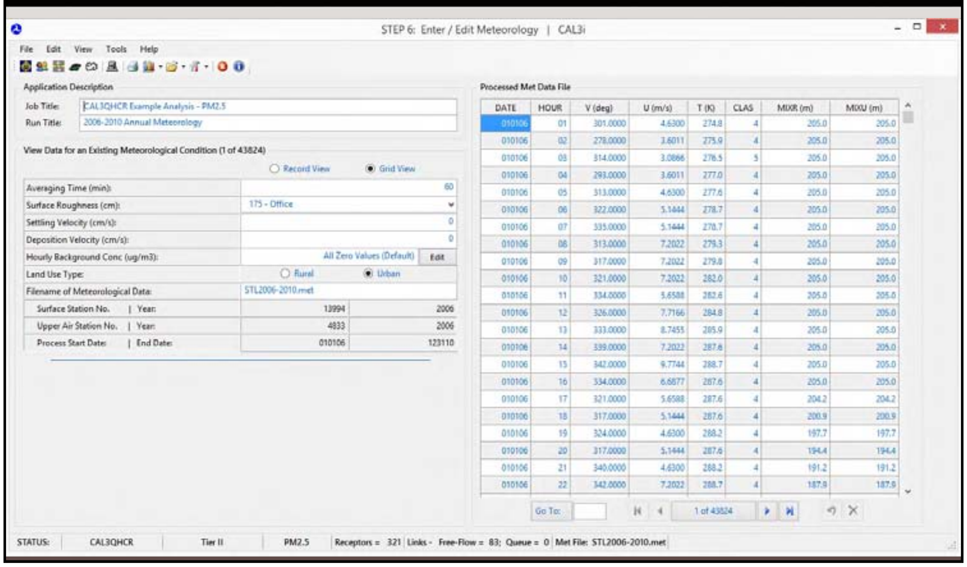
Enter / Edit Links



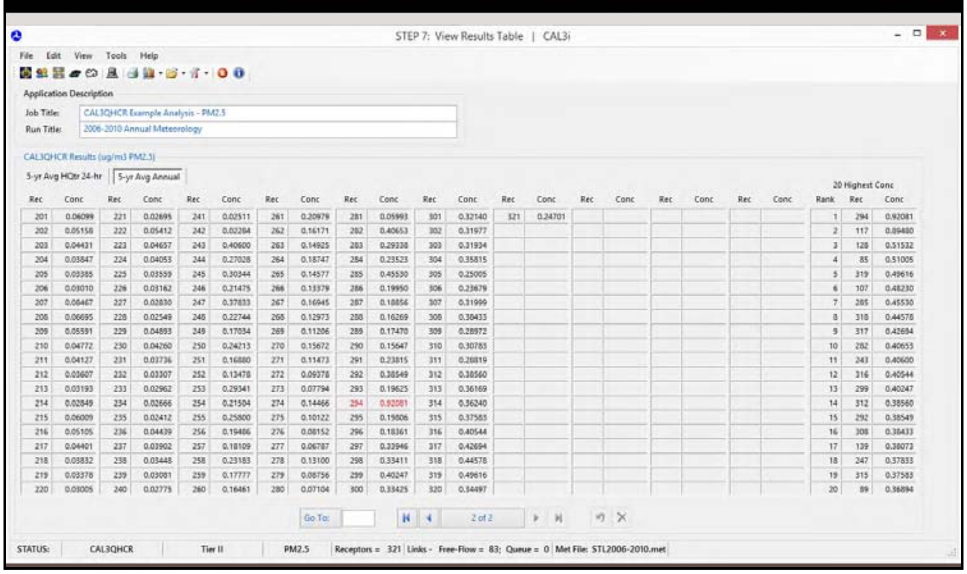
Enter / Edit Traffic and Emissions – VPHL, EFL



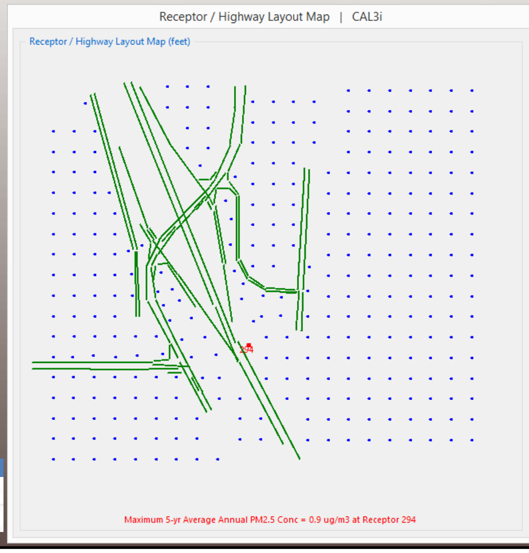
Enter / Edit Meteorology



Model Results – Summary Table



Model Results – Layout Map



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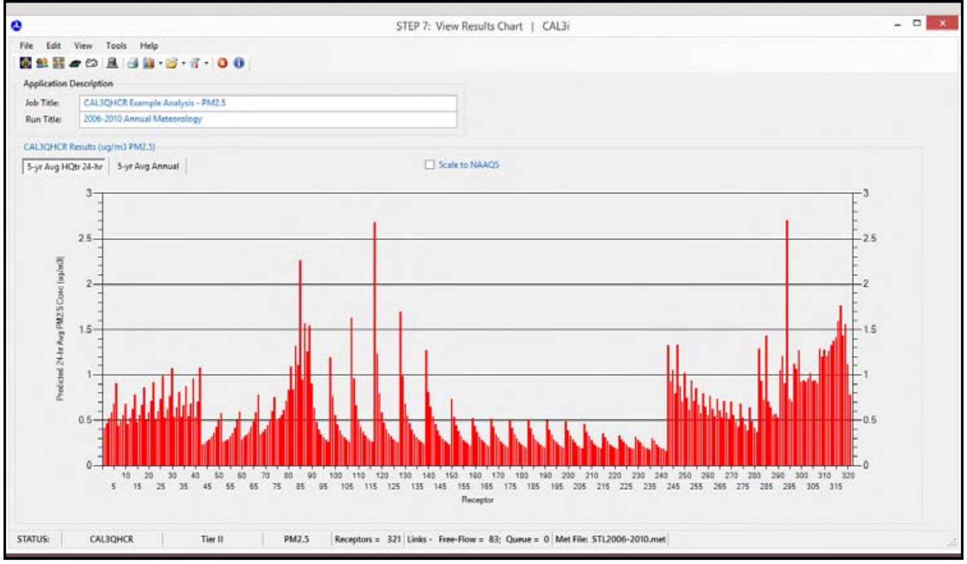
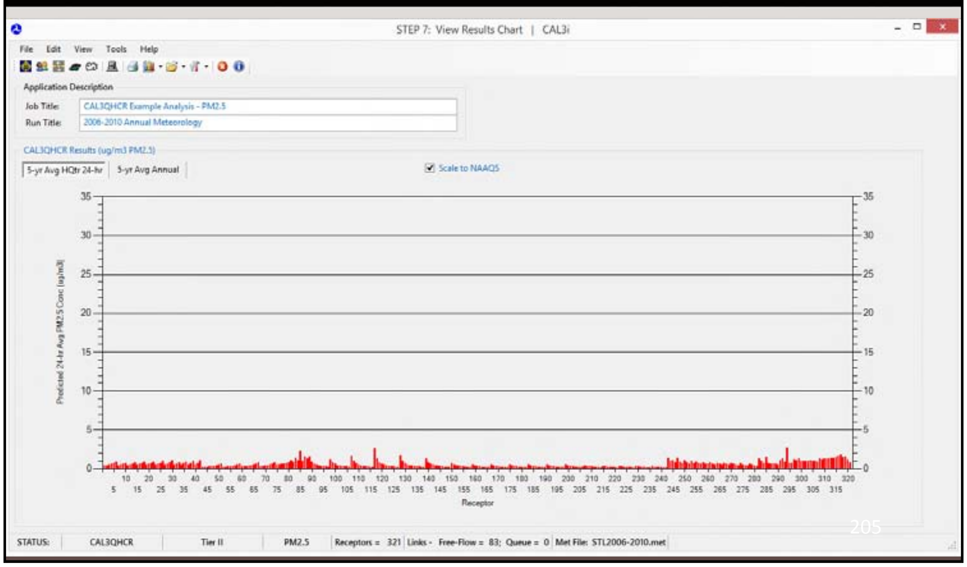
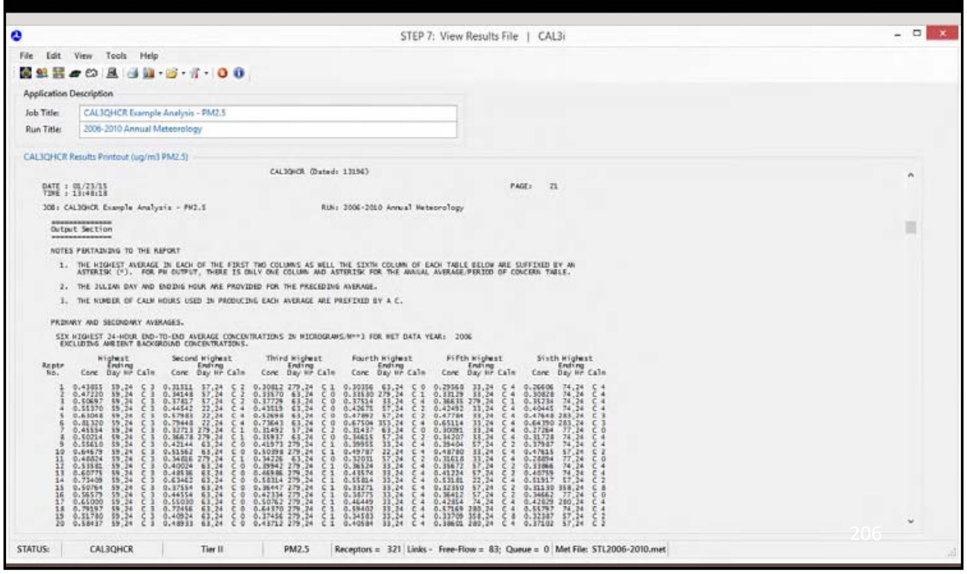
Model Results – Chart



Model Results - Chart



Model Results - Printout



Additional Tools Planned

- Construct Wind Roses
  - Tables
  - Graphs
- Compute Design Values
  - Local component plus background
- Import MOVES Link Tables

Class Exercises – AERMOD and CAL3QHCRi

- Refer to the Class Exercise Instructions