An Introduction to MOVES:
National Scale

FHWA Resource Center
EPA Office of Transportation and Air Quality

EPA-420-B-09-025

MOVES

Introduction Presentation Outline

- A quick tour of the Graphical User Interface (GUI).
- Setting up a National run specification.
- Running the model.
- Discussion of output results.
- Feel free to ask questions!

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Advanced Features (not addressed)

- Alternate Vehicle & Fuels Technologies strategies panel.
- Heavy Duty Retrofit strategies panel.
- Advanced features panel.
- Using XML and batch input options.
- Using distributed processing (multiple computers).
- Using Core Model Input Tables (CMITs).
- Joining MySQL tables.

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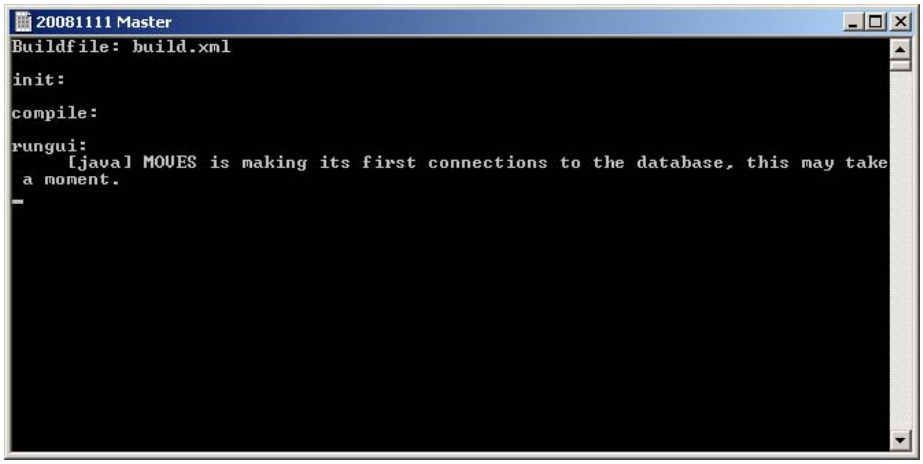
Since you will see these items as we go through the GUI, I want to warn you in advance that we do not have time to address everything that MOVES can do in this one short training session.

Start Master Using Desktop Icon

- **Start the Master using the desktop icon.**
  - Notice the console window associated with the MOVES window is started. Do not close this window.
- **Stop the Master.**
  - Note that console window automatically closed.
- **If no Worker is present, one will automatically be started.**
  - A Worker application is created to do the calculations when you execute the model.

Console Window



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The console window is automatically generated when you run MOVES. It will show you what MOVES is doing while running and will provide useful messages if there is a problem. This window automatically closes when you close the MOVES GUI screen.

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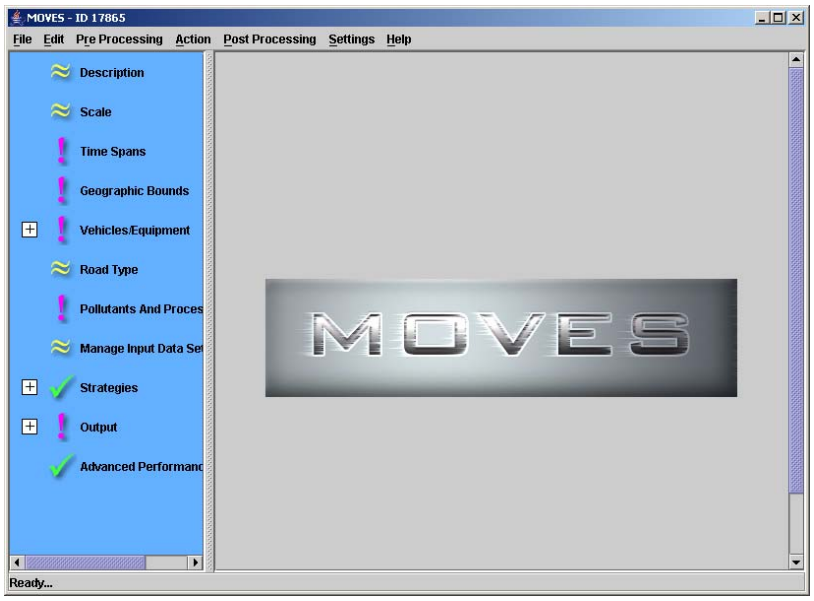
Console Window

- This Window is automatically generated when MOVES is run.
- The Window will show any error messages related to problems running the MOVES code.
- Do not manually close this Window while running MOVES.
- This Window will automatically close when you close MOVES.

Initial MOVES Screen



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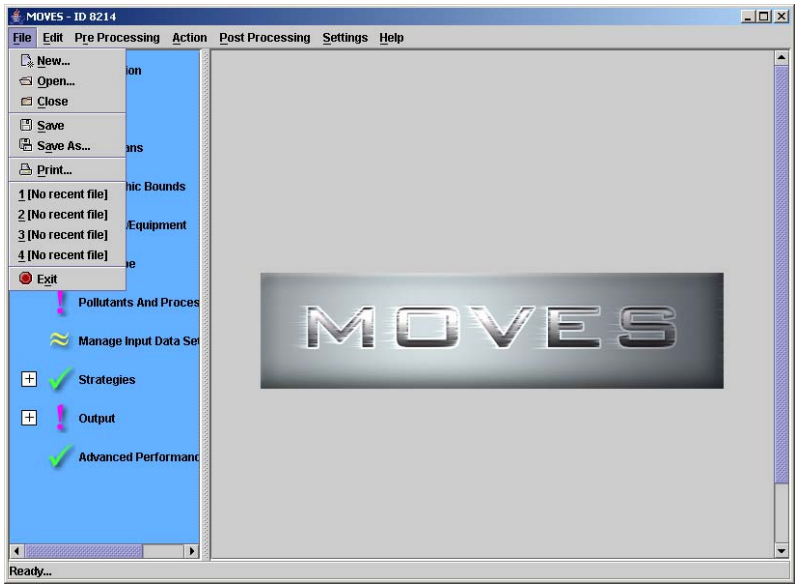
This is the initial MOVES screen when you run MOVES.

Initial MOVES Screen

- **This is also referred to as the Graphical User Interface (GUI) for MOVES.**
- **The Navigation List is in blue in the left hand side.**
  - Green check means input is ready.
  - Red exclamation indicates more information is needed.
  - Wavy lines means no input is necessary.
- **All Navigation List inputs must be green checked or wavy lines before MOVES will run.**

File Menu



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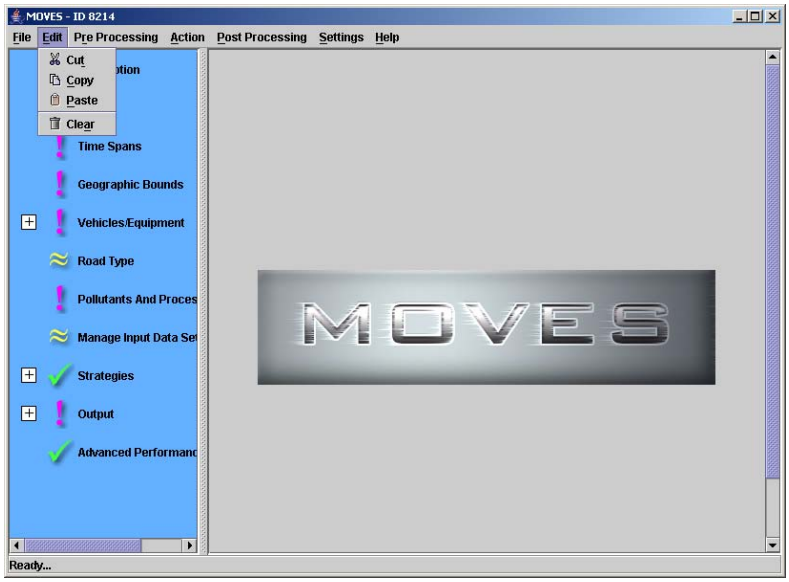
This slide shows the contents of the File pull-down menu.

MOVES

File Menu

- The File menu applies to the Run Specification (input) files used by MOVES to define a run.
- The File menu contains all of the usual options for handling these files.
- Selecting New will clear any current items selected.

Edit Menu



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This slide shows the contents of the Edit pull-down menu.

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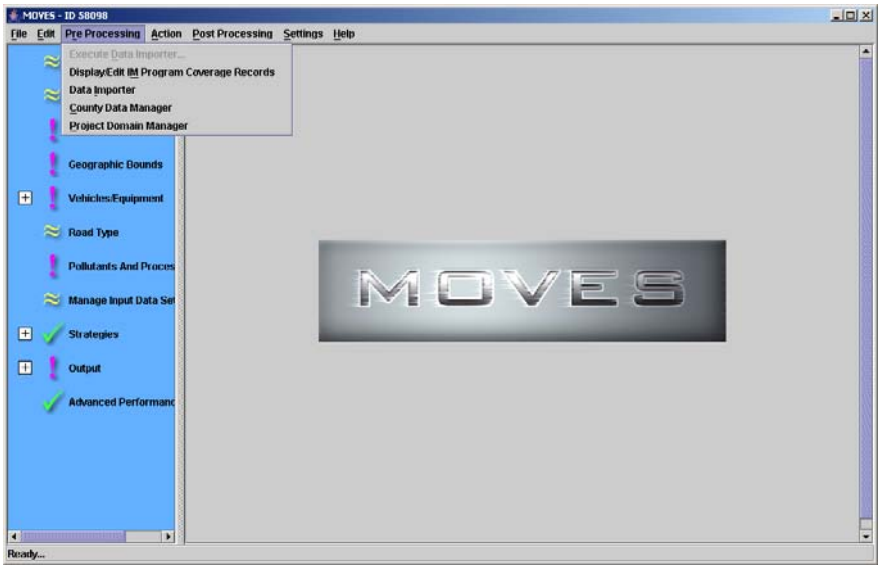
Edit Menu

- The Edit menu applies to any text selected in the GUI.
- All of the typical options are available for manipulating text.

Pre-Processing Menu



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This slide shows the contents of the Pre-Processing pull-down menu.

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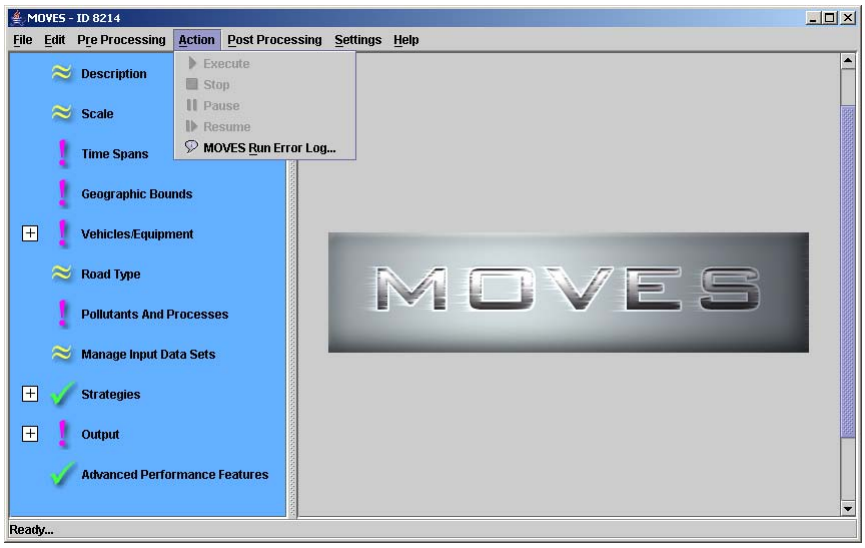
Pre-Processing Menu

- These items are used to create your own custom inputs to represent your location and time.
- Edit Inspection & Maintenance (I/M) data.
- Update default data values.
- Import county specific data.
- Create project level inputs.

Action Menu



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This slide shows the contents of the Action pull-down menu.

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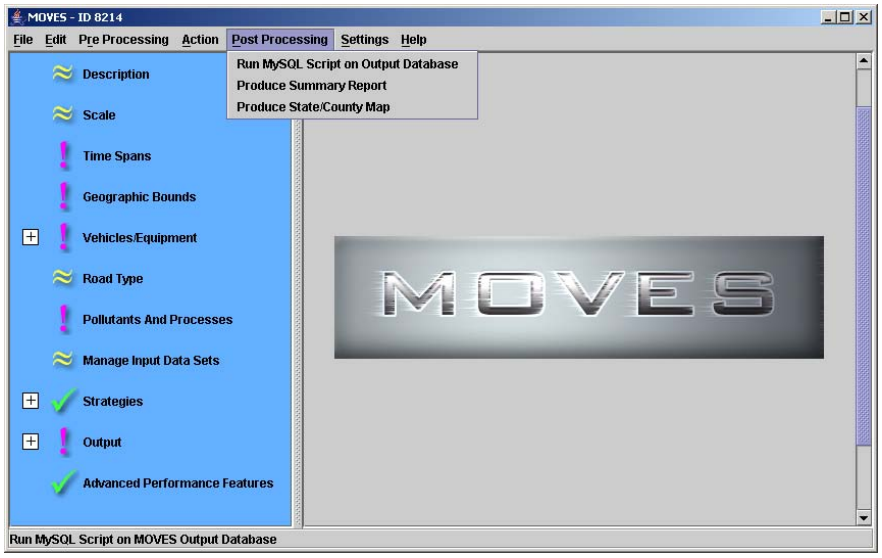
Action Menu

- Use this menu to initiate a MOVES run.
- Options to pause, resume and stop your run.
- Once a run is completed, you can review any error messages that were generated during the run.

Post-Processing Menu



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This slide shows the contents of the Post-Processing pull-down menu.

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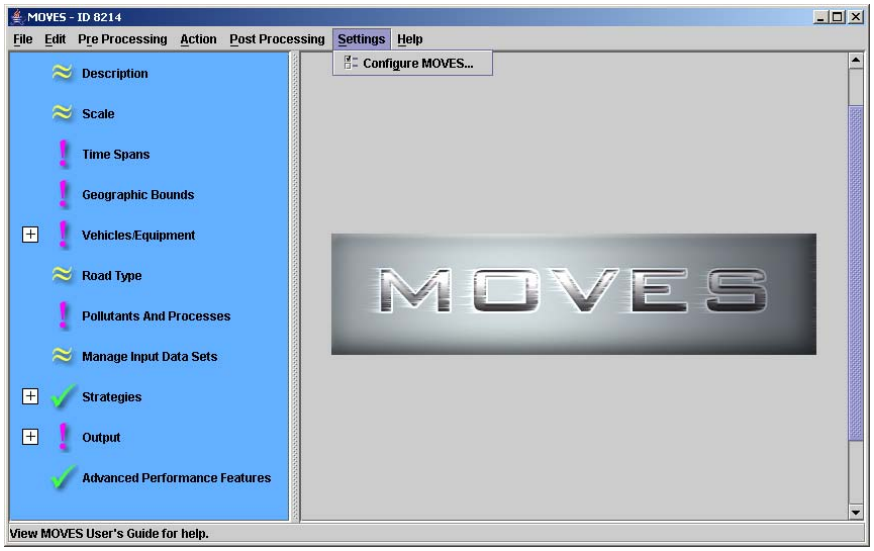
Post-Processing Menu

- **Use this menu once you have results.**
- **You must select an existing output database.**
- **Options for processing output include:**
  - Execute existing MySQL scripts.
  - Summarize results into text files.
  - Graphically represent results in a county map.

Settings Menu



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This slide shows the contents of the Settings pull-down menu.

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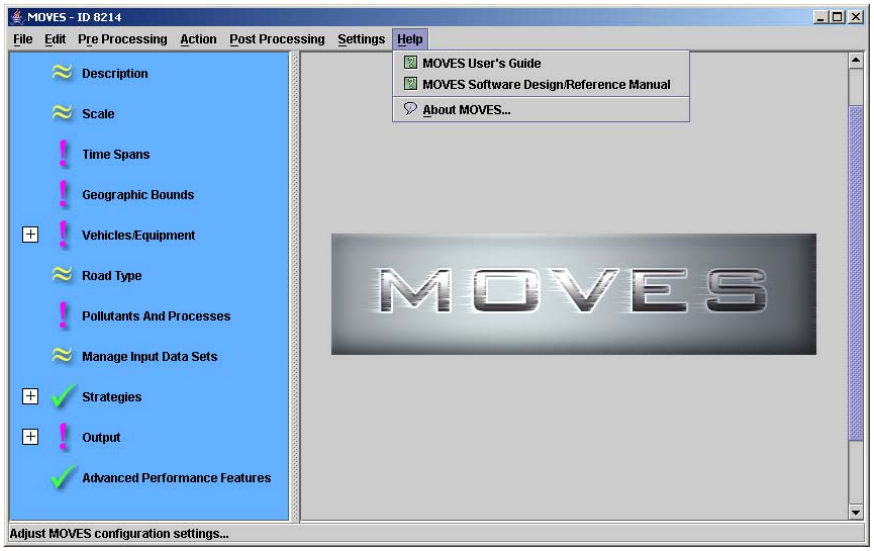
Settings Menu

- **Use this menu to configure MOVES:**
  - Select default database.
  - Select shared working folder.
- **This is an advanced feature. Normally no changes are needed.**
- **Improper configuration may cause MOVES to stop running.**

Help Menu



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This slide shows the contents of the Help pull-down menu.

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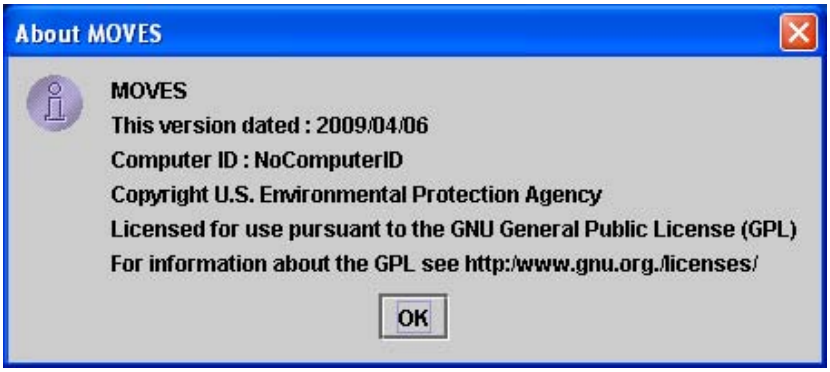
Help Menu

- **Access to the User Guide.**
- **Access to the Software Design and Reference Manual (SDRM).**
  - Detailed description of calculation steps.
  - Detailed description of calculations.
- **Display the MOVES version information.**

Help Menu: About MOVES



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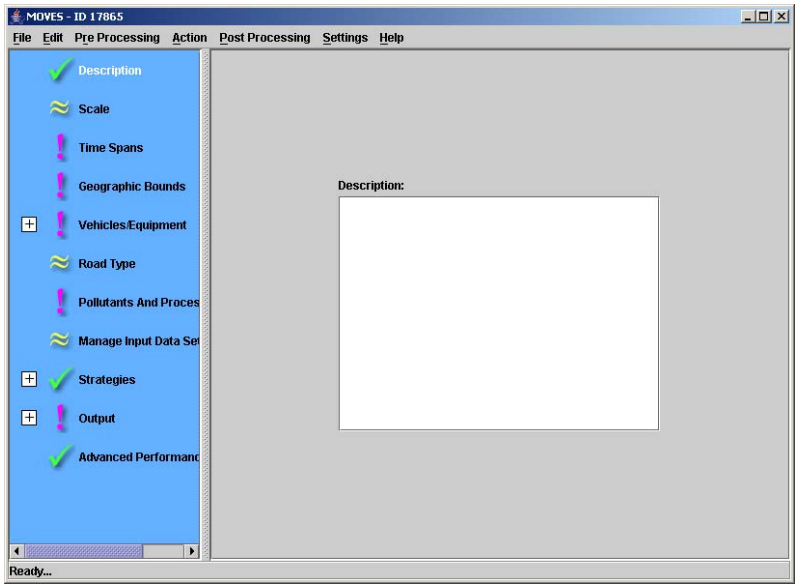
This is example content of the About MOVES option from the Help pull-down menu.

Description Panel



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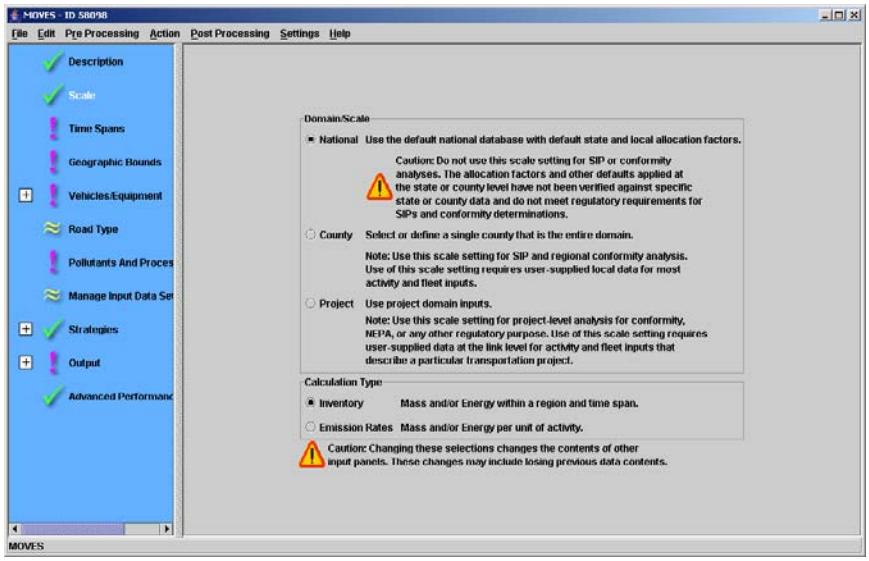
Description Panel

- The description should be used to help you remember the purpose of your run.
- This description will be stored in the Run Specification file.
- This description will also be stored in the MOVESRun table in the output database.

Scale Panel


MOVES - ID 58098
File Edit Pre Processing Action Post Processing Settings Help
Description
Scale
Time Spans
Geographic Bounds
Vehicles/Equipment
Road Type
Pollutants And Proces
Manage Input Data Set
Strategies
Output
Advanced Performanc
Domain/Scale
National Use the default national database with default state and local allocation factors.
Caution: Do not use this scale setting for SIP or conformity analyses. The allocation factors and other defaults applied at the state or county level have not been verified against specific state or county data and do not meet regulatory requirements for SIPs and conformity determinations.
County Select or define a single county that is the entire domain.
Note: Use this scale setting for SIP and regional conformity analysis. Use of this scale setting requires user-supplied local data for most activity and fleet inputs.
Project Use project domain inputs.
Note: Use this scale setting for project-level analysis for conformity, NEPA, or any other regulatory purpose. Use of this scale setting requires user-supplied data at the link level for activity and fleet inputs that describe a particular transportation project.
Calculation Type
Inventory Mass and/or Energy within a region and time span.
Emission Rates Mass and/or Energy per unit of activity.
Caution: Changing these selections changes the contents of other input panels. These changes may include losing previous data contents.
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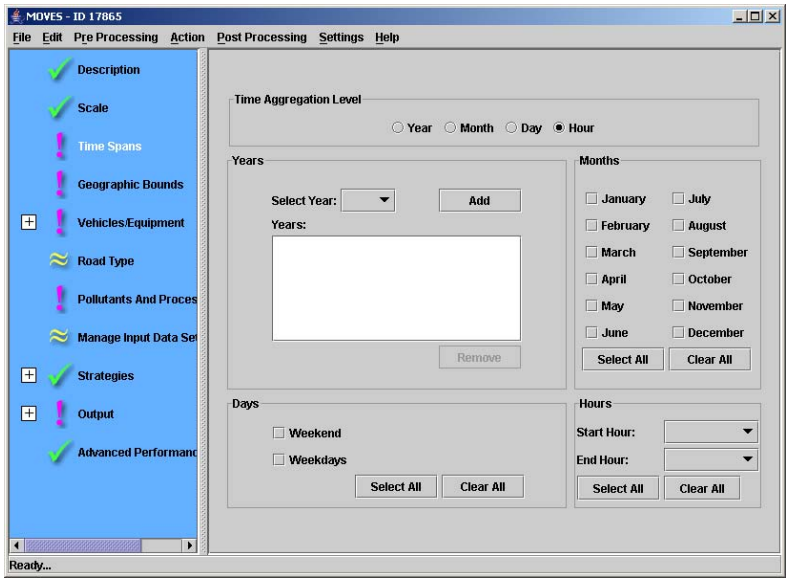
Scale Panel

- **Three scale options:**
  - National: Using default values.
  - County: Using user supplied local values.
  - Project: Link level analysis.
- **Two result options:**
  - Inventory: Results in tons (or grams).
  - Emission Rates: Results in grams per mile.
- **Make these decisions first.**
- **Your choice here will affect other panels.**

Time Span Panel



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Time Span Panel

- **Choose the time period to be modeled.**
- **Choose the level of detail of the calculations.**
- **Years: 1990, 1999-2050.**
- **Choose a range of hours of interest.**
- **Weekday or weekend days.**
  - Different activity on each day type.
  - Both types needed for weeks, months or years.
- **If you chose County scale, you may only choose one Year.**
- **If you chose the Project Level scale, you may only choose one Year and one Hour.**

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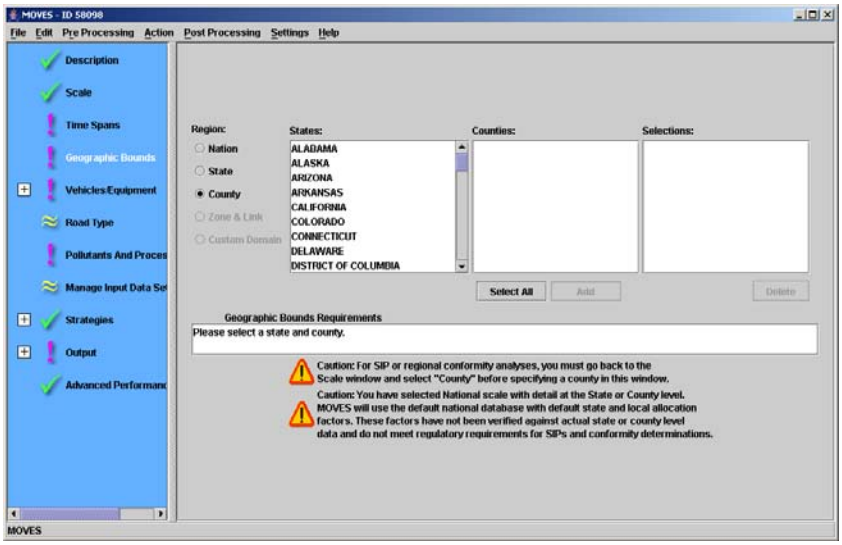
Geographic Bounds Panel



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Geographic Bounds Panel

- **Select the location(s) you wish to model:**
  - county (counties) of interest, or
  - state of interest (all counties together), or
  - Select the nation (all 50 states and DC).
- **If you selected the County or Project Level scale, you may select only a single county.**
- **You can model a multi-county domain if you select the Custom Domain option.**

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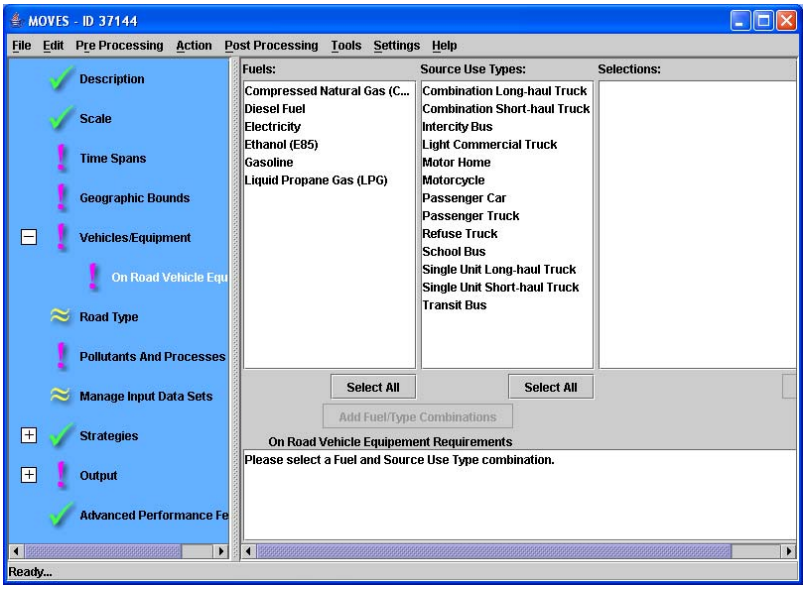
A domain is an area where various parameters are shared.

On Road Vehicle Panel



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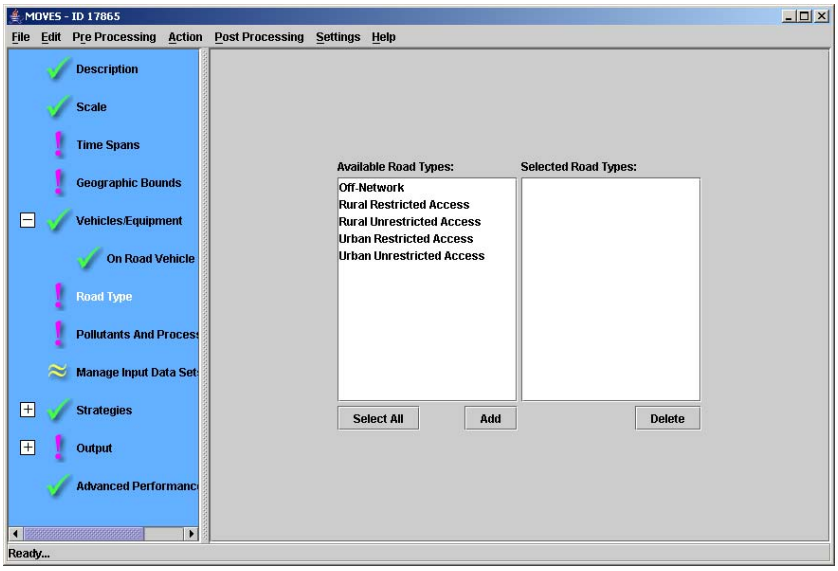
On-Road Vehicle Panel

- Select fuel types of interest.
- Select the vehicle categories.
- Add the combinations.
- Warnings will appear for invalid combinations.
- Warnings will *not* affect the results.

Road Type Panel



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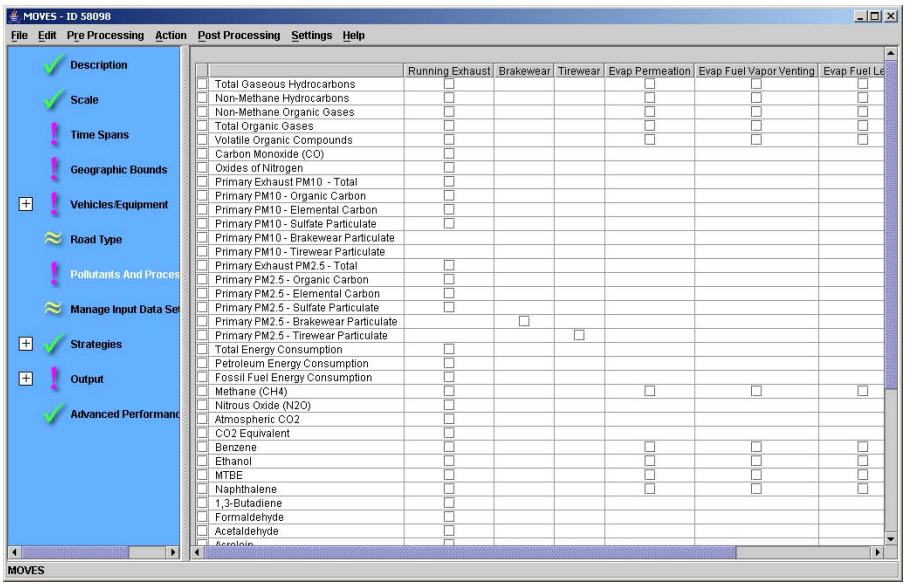
Road Type Panel

- Selecting only some road types will cause warnings.
- Rural and urban roads have different driving behavior.
- Unrestricted roadways have traffic signals.
- Restricted roadways are the interstates and freeways with entry and exit ramps.
- Engine start and some evaporative emissions are put in the off-network category.

Pollutant/Process Panel



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Pollutant & Process Panel

- Each pollutant can be generated by one or more emission processes.
- Some emission processes generate only certain pollutants.
- Be sure to check all of the emission processes (or use the check box on the left) if you want all of the emissions of that pollutant from the vehicles calculated.

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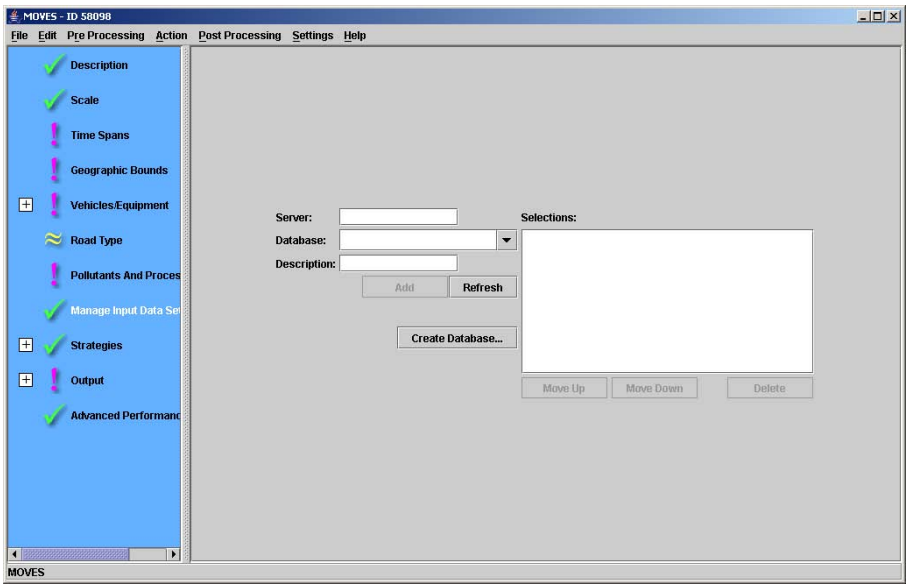
Pollutant & Process Panel

- The calculation of some pollutant/process combinations depend on other pollutant/processes and both must be chosen.
- If you need VMT results, select it here.
- Be sure to check the Pollutant/Process Requirements box for errors and warnings.
- You will likely need to scroll to see all of the pollutants and processes.

Manage Input Datasets



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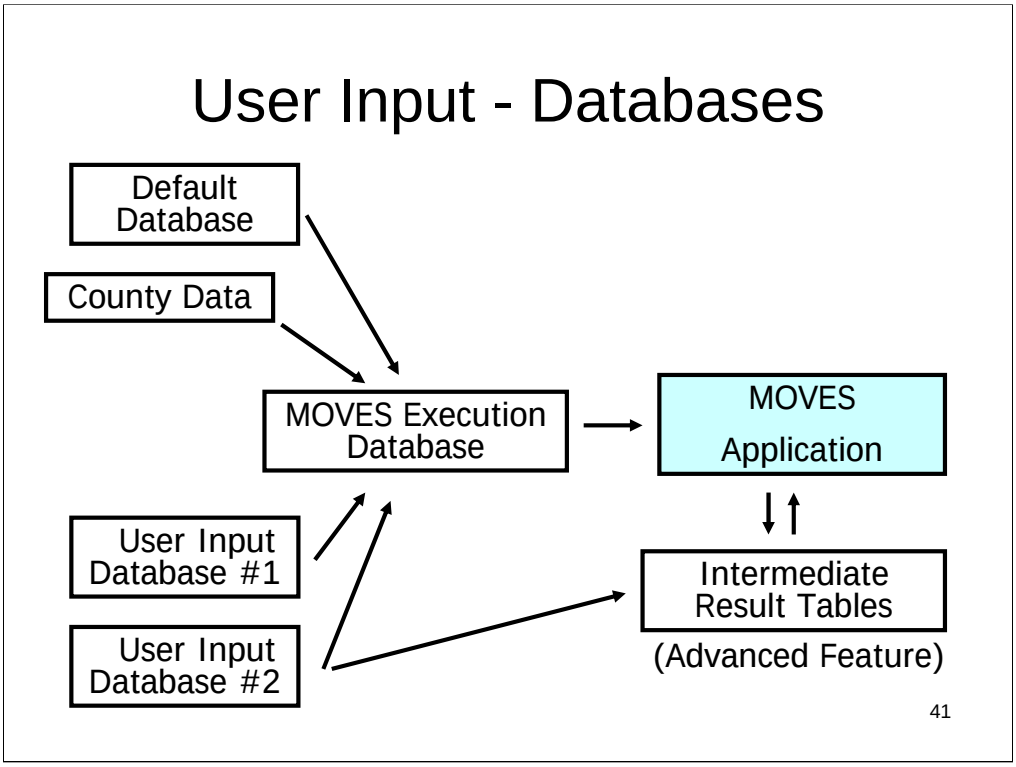
Manage Input Datasets Panel

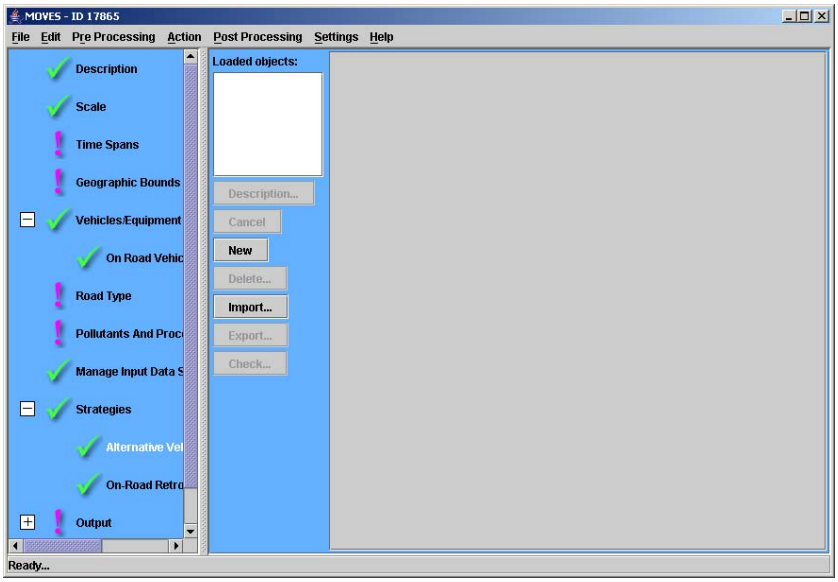
- **This where you indicate a database that replaces default data.**
- **The chosen database is assumed to contain the data you wish to use in this run.**
  - There is an option to create an empty database.
- **You may select more than one database.**
- **Conflicts are resolved by using the data from the last database selected.**
- **County specific data is usually entered using the County Data Manager.**



You can have more than one user input database.

User inputs can include intermediate result tables (Core Model Input Table, CMIT).

Strategies Panel



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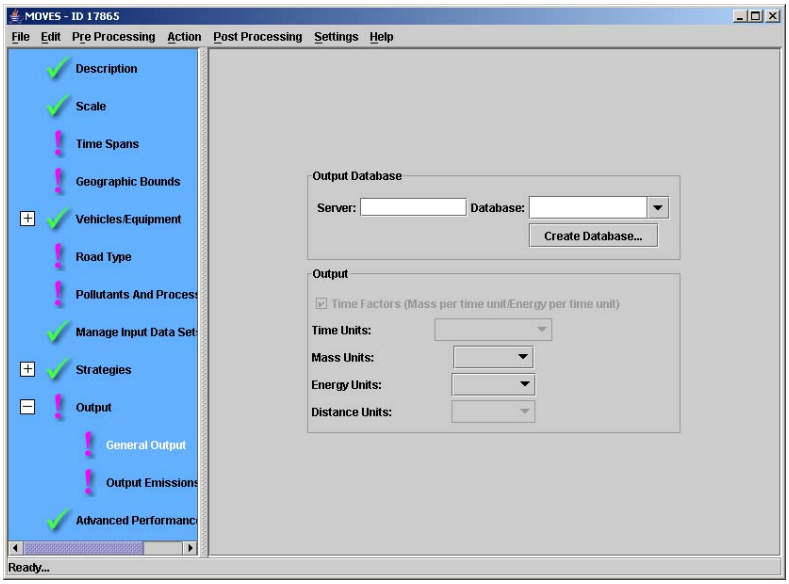
Strategies Panel

- **Alternative Vehicle Fuel and Technology (AVFT).**
  - Select the fraction of diesel vehicles in each model year.
  - Options for use of advanced technologies (i.e. hybrid).
- **On-Road Retrofit**
  - Alters the emission rates for selected vehicles.
  - Used to account for retrofit programs.

General Output Panel



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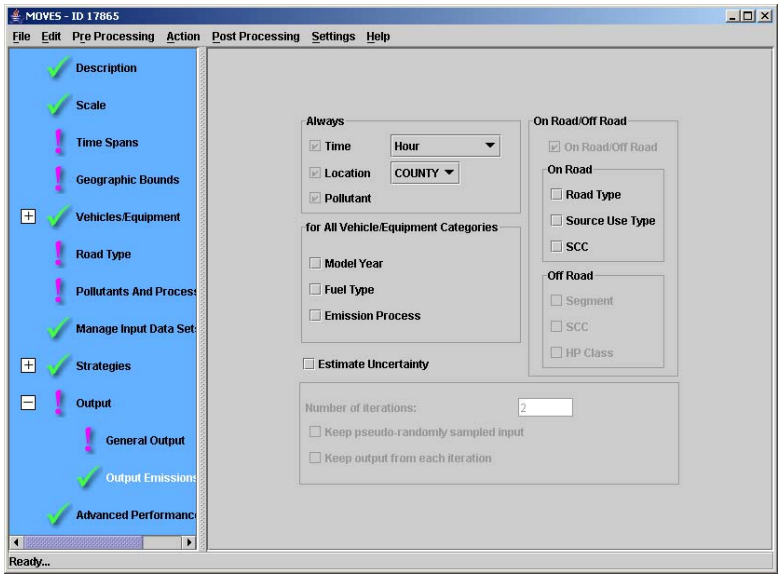
General Output Panel

- **Select a database to place the results:**
  - Create a database, or
  - Choose an existing database.
  - Multiple runs will be assigned unique run ID values.
- **Choose the units for the output values.**
- **You must choose the units for the VMT output if you have selected VMT output in the Pollutant/Process panel.**

Output Emissions Panel



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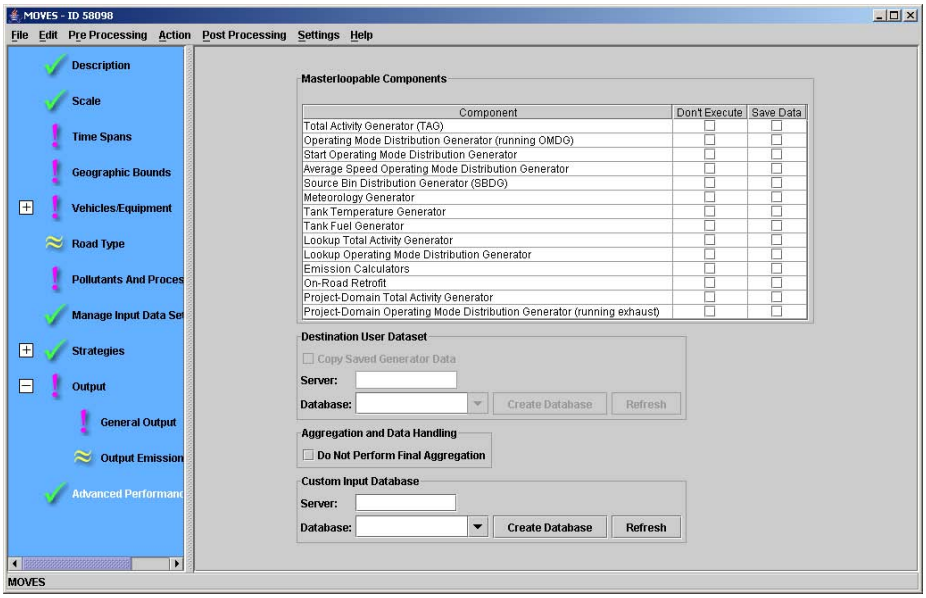
Output Emissions Panel

- This panel determines the amount of aggregation of the output.
- The amount of aggregation can only be greater than or equal to the level of aggregation chosen in the input panels.
- The default level of aggregation is by pollutant.
- Estimating Uncertainty – Not recommended.

Advanced Performance Panel



This **Navigation Panel** item invokes features which may be used to diagnose problems with the model software, or to improve the run time for long model runs by saving and reusing intermediate results. Use of these features requires knowledge of the detailed software components of the MOVES program, the inputs they require, and the outputs they produce. Users interested in these features should review the MOVES Software Design and Reference

This panel allows users save intermediate results from various portions of the model and to turn off portions of the model code.
This panel also allows the user to "turn off" final aggregation of MOVES results.
Selecting the "Do Not Perform Final Aggregation" option can reduce execution time for large runs. However, when this option is selected, the MOVES output tables may include rows with duplicate key fields. The results from these rows should be summed to produce useful output.

this panel allows users to specify the database to be used when modeling a Custom Domain. See Section 2.2.4 Geographic Bounds for additional information on the Custom Domain option.

Caution! It is possible to undo a custom database selection by hitting the “Refresh” button, which clears the selected database.

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Advanced Performance Panel

- **Advanced Performance Features**
  - This is an advanced feature primarily to reduce run time.
  - Save Data prevents MOVES from destroying intermediate result values from the MOVES execution database.
  - Don't Execute assumes that the results are already available in the input database or will not be needed for the final results.
  - Useful for diagnostics and obtaining intermediate results.
- **You can choose a custom input database to supersede the default database.**
- **Don't use these features until you understand them.**

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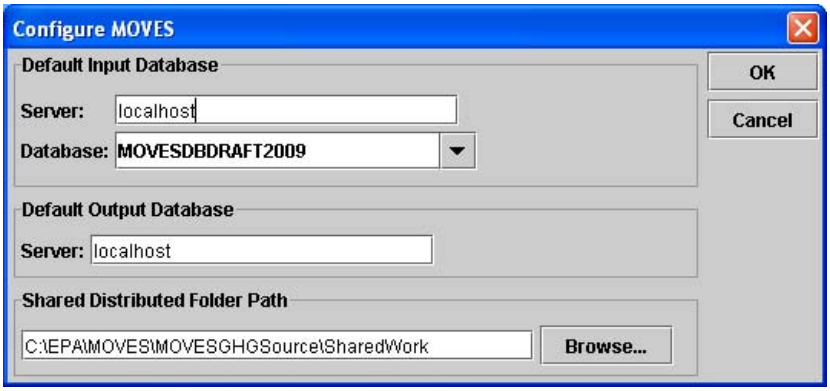
Do not press the shiny red button!

Configure MOVES Panel



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Configure MOVES Panel

- This will show you the name of the default database being used by MOVES.
- The location of the Shared Work folder is where MOVES and the Worker application share files when you run MOVES.
- Normally, you will not need to make changes in this panel.
- Changes can cause MOVES to stop working.
- Do not make changes in this panel until you understand it.

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Default National Scale

- **Uses primarily national average default values.**
- **Uses some county specific information.**
  - Temperatures and humidity.
  - Fuel properties.
- **Allocates national results to counties.**
- **Results do not meet regulatory requirements for SIP and Conformity determinations.**

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Choose National from the Scale panel.

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Setting up a Run Specification

- MOVES cannot run without a valid Run Specification (runspec).
- A runspec indicates the location, time period, alternate data and output preferences.
- Runspecs can (should) be saved and can be re-loaded to be run again and/or edited.
- The GUI panels are used to set up your runspec.

RunSpec Cautions

- Limit your run specification to just what you need.
- Organize your inputs and outputs so you don't get confused.
- Use naming conventions to help you identify files.

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Setting up a Run Specification

- **Enter a Description.**
- **Choose the National scale and Inventory calculation.**
- **Choose a single year/month/day/hour.**
  - This is the only scale where you can choose multiple years.
  - Adding more year/month/day/hour will increase the run time.
  - Do not use the Time Aggregation Level until you understand it.
- **Choose one (or more) counties.**
  - This is the only scale where you can choose multiple counties.
  - Adding more counties will increase the run time.
  - Do not use the Nation/State regions until you understand them.

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Using the Time Aggregation Level options will change the results.

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Setting up a Run Specification

- **Choose a fuel and vehicle type.**
  - Not all fuel/vehicle combinations are valid.
  - Even valid combinations may not produce results.
  - Adding combinations will increase run time.
- **Select the road types.**
- **Select a pollutant and process and VMT.**
  - Adding combinations will increase run time.
  - VMT results are selected here. This will generate a warning.
- **You currently have no user input datasets.**

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Valid combination will not produce results if the fleet mix does not include these vehicles. For example, electric cars are a valid combination, but no results will be reported if there are no electric cars in the fleet at the time and location you select.

Setting up a Run Specification

- **You currently have no strategy inputs.**
- **Name and create an output database.**
  - Do not name output the same as input databases.
  - Use naming conventions:
    - Input – name_in
    - Output – name_out
- **Choose time/mass/distance units.**
- **Choose output granularity.**

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Using consistent naming conventions will avoid confusion later.

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Output Emission Detail

- This panel determines the granularity of the output.
- By default, all results are aggregated by:
  - Time
  - Location
  - Pollutant
- Time and location can be further aggregated.
- More detailed output can be obtained.
- Source Classification Code (SCC) is a special case.
- Do <u>not</u> select uncertainty until you understand it.

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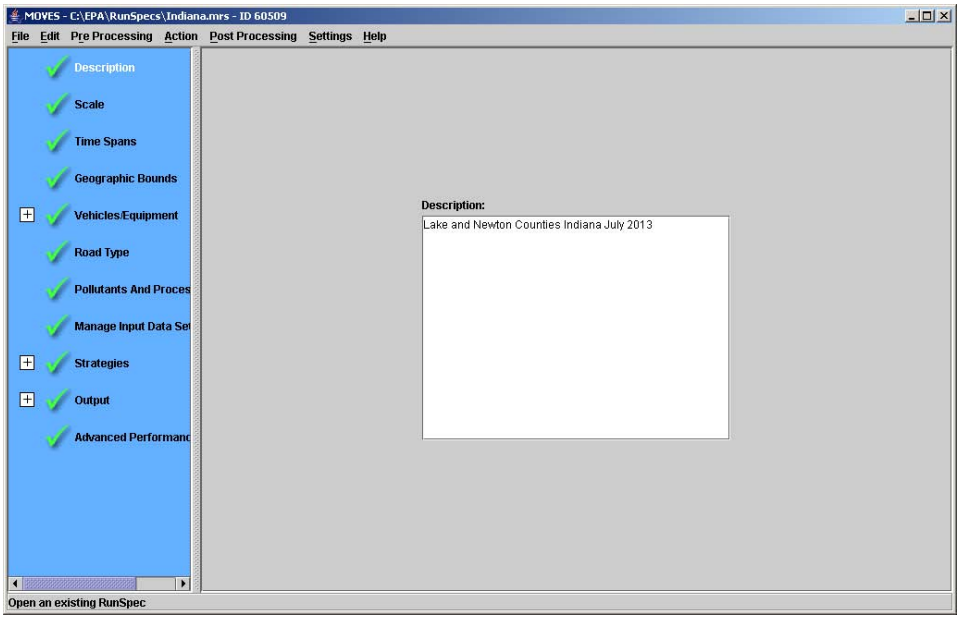
MOVES Exercise



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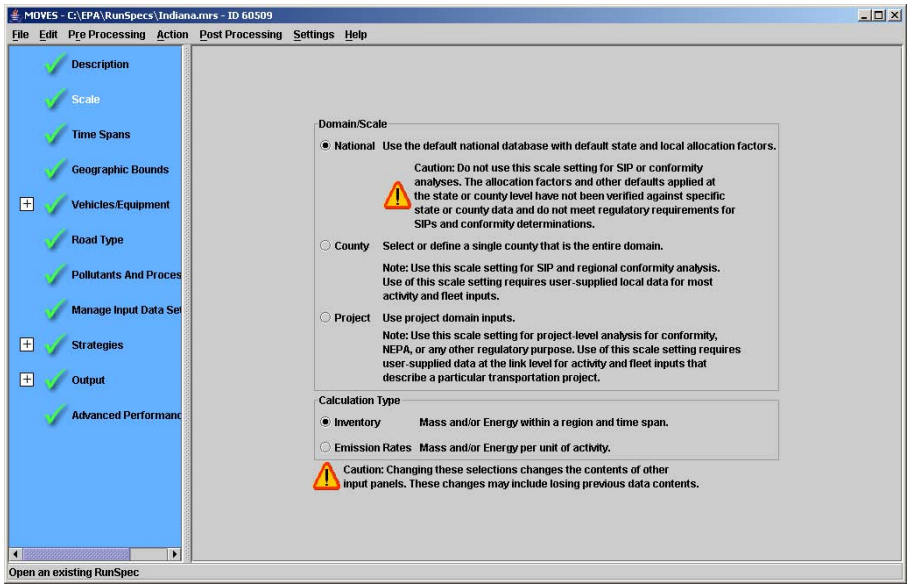
This panel shows where you can describe your analysis.

A good description will help you keep track of your results.



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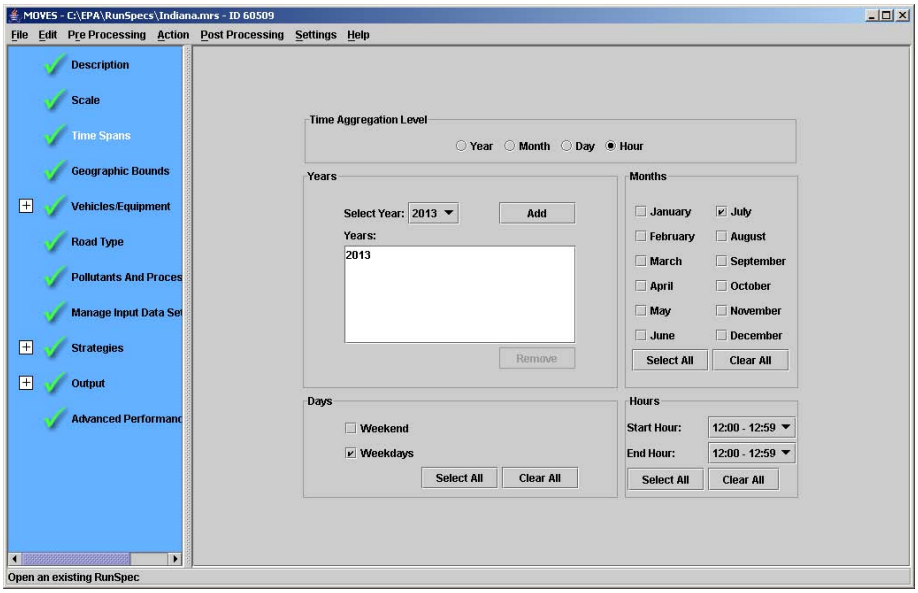
Choose Domain Scale of National. Choose Calculation Type of Inventory. (We will discuss Emission Rates later.)

This option allows you to access all of the default data stored in MOVES for the individual counties.



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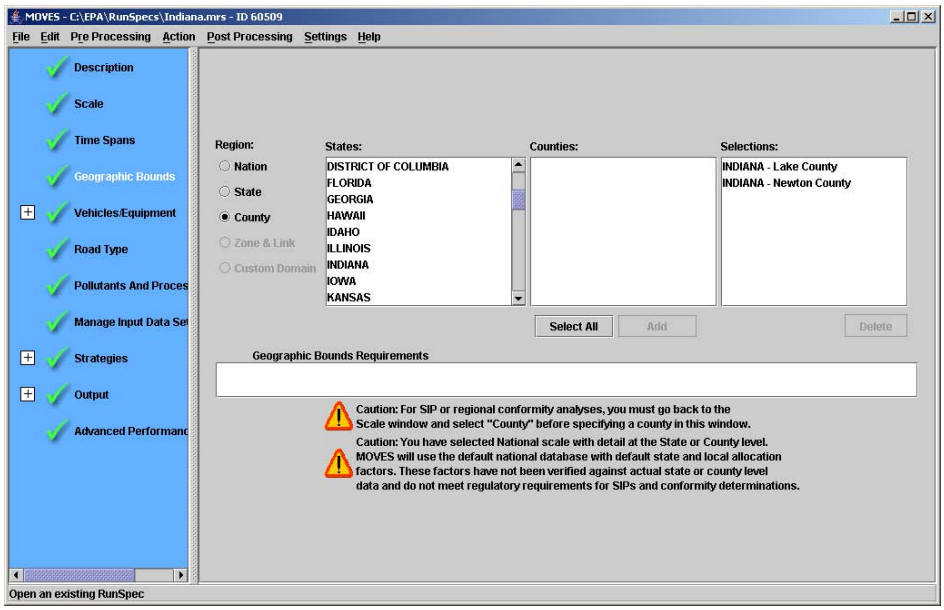
Remember not to mess with the Time Aggregation Level until you understand what it does.



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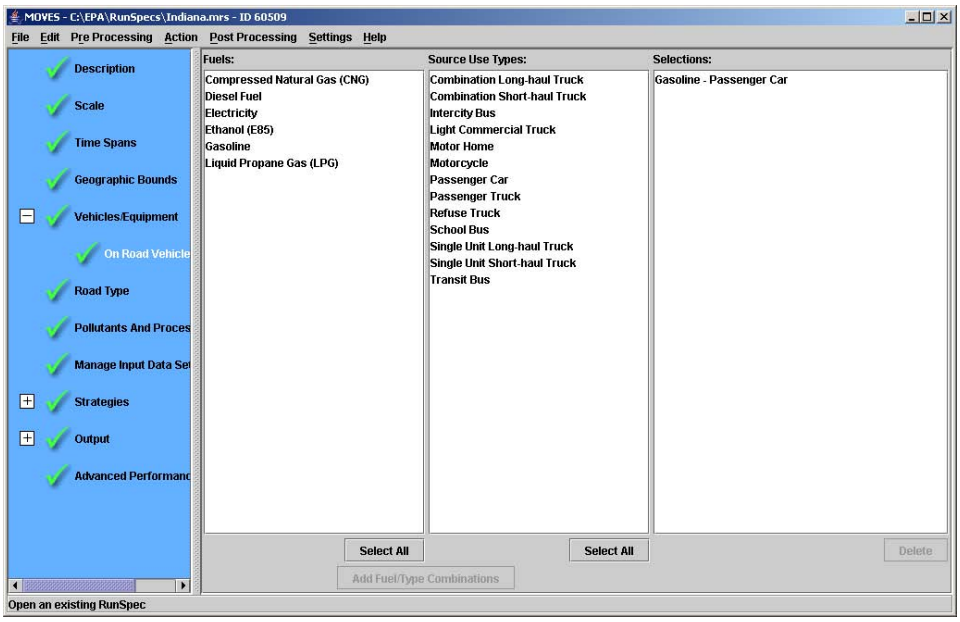
I've picked two counties in Indiana, one with an I/M program and one without.



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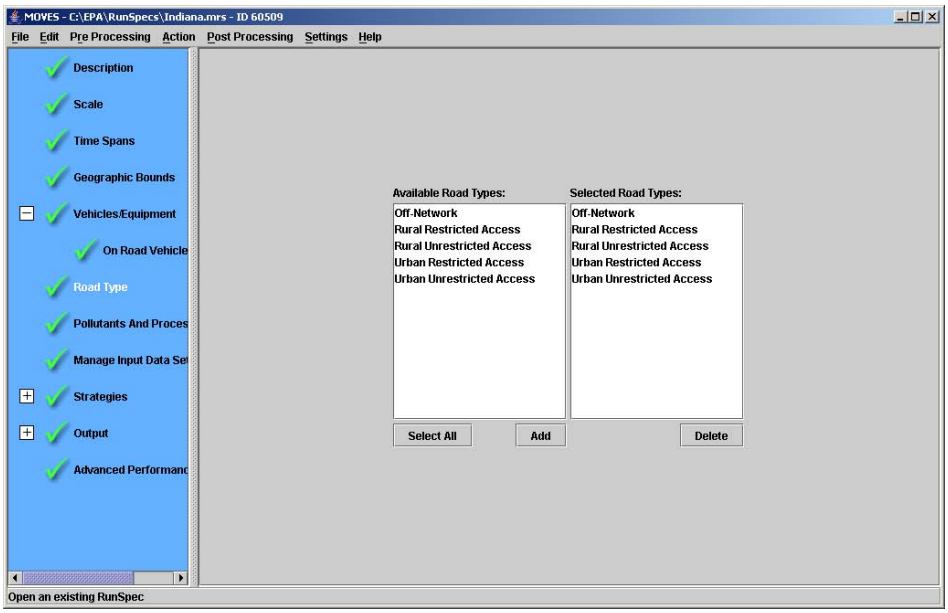
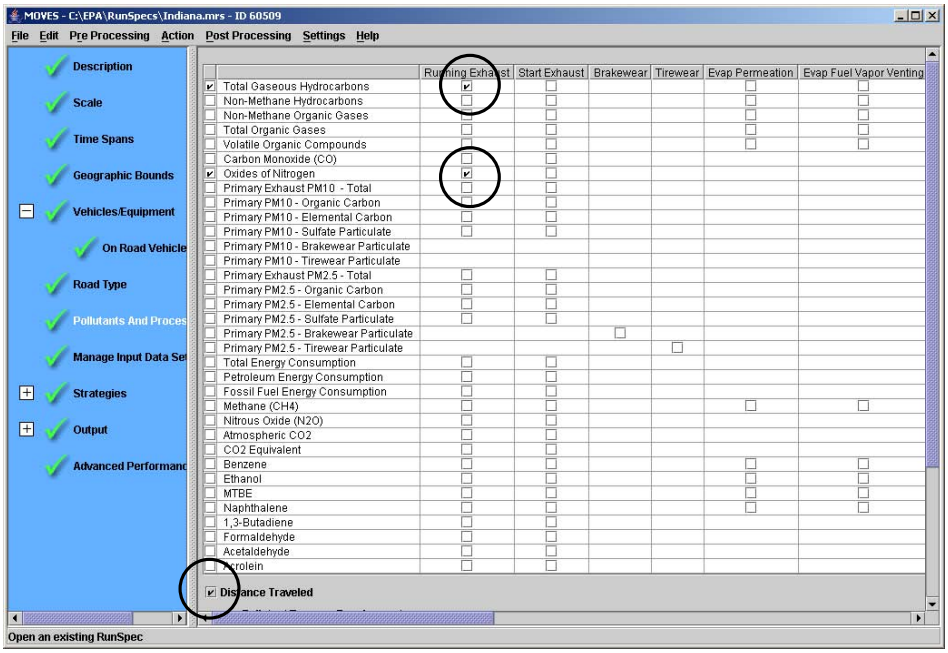
The more fuel type / vehicle type combinations you choose, the longer the run will take.



65

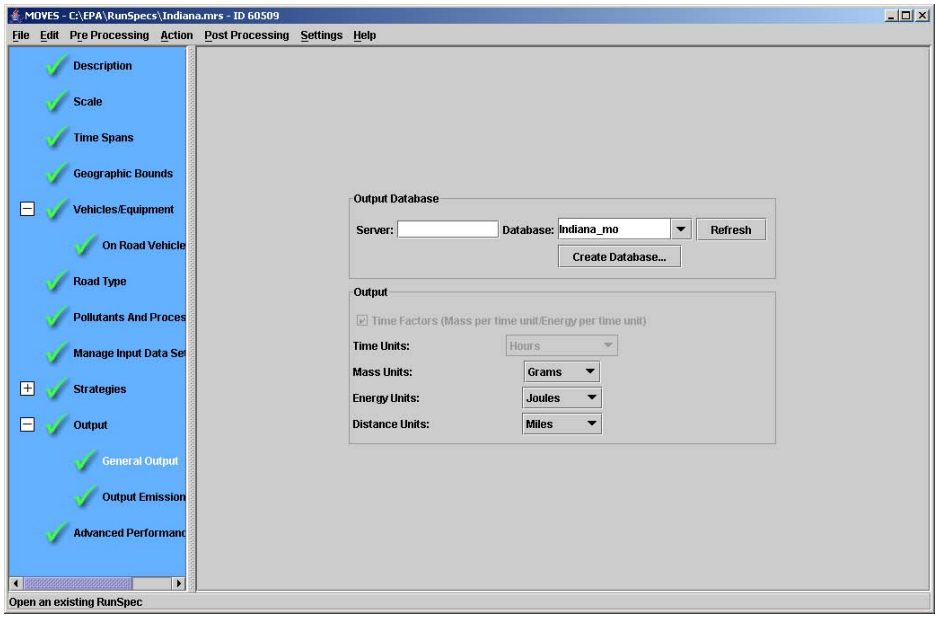
I chose all of the road types to make sure I get all of the activity. Some activity occurs off of the highways (such as engine starts and some evaporative emissions) and will be omitted from the results unless the Off-Network road type is selected.



66

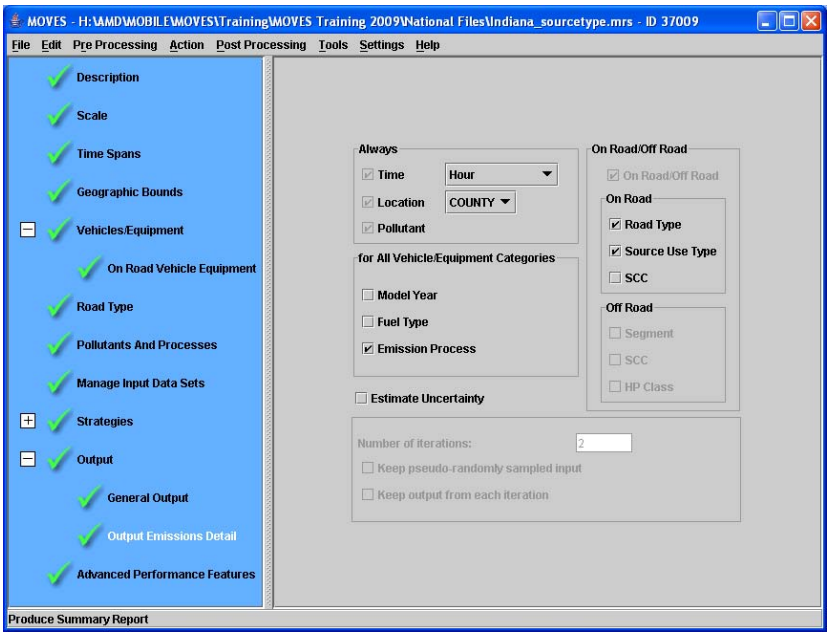
I chose only pollutants from the Running Exhaust process. Choosing more pollutants and processes will increase the time for the run.

This is where you can select output of the vehicle miles traveled (VMT). This will cause a warning that you must set the units for distance on the General Output panel.



67

You cannot select the units for distance unless you selected distance output on the Pollutants and Processes panel.



68

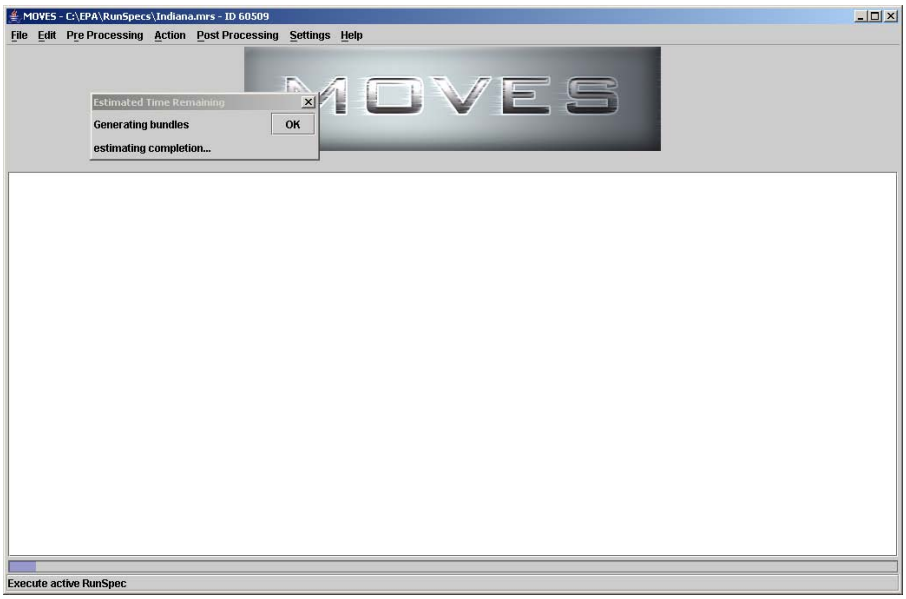
I will not be getting output by model year or fuel type. I have only chosen one emission process so selecting it will not differentiate any output, but by checking this box, the emission process field will be labeled (same for source use type). I will not be getting output by SCC. These choices will not affect the time it takes to run the model, but can increase (or decrease) the size of the output table and the amount of time for post-aggregation. You cannot disaggregate your output file once the run has been completed, so generally choose the most disaggregated scenario that you might ever need unless you are certain you do not need some detail. Results can always be aggregated later (with some effort).

See what happens when you choose SCC, but change your selection back to what is shown above.

Action: Execute

69

One last chance to make changes or otherwise stop the run.

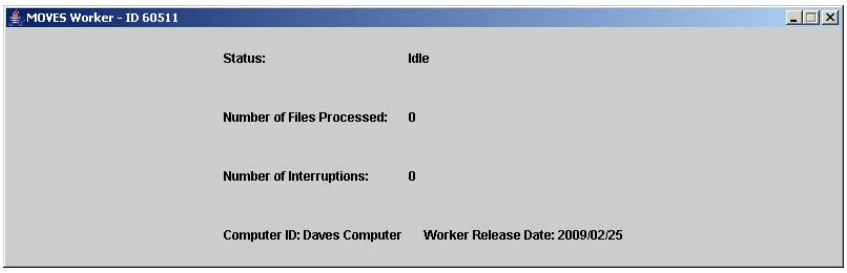


70

When running this screen will appear.

The time to completion estimates are very bad. The execution progress bar is also not a good indicator as to how much time remains in the run.

MOVES Worker

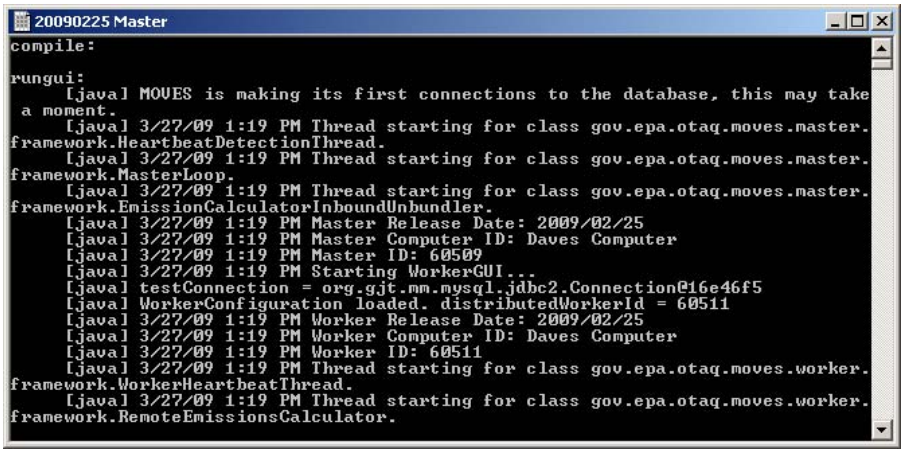


71

When you run MOVES, a worker will automatically be launched and generate this window.

This window will automatically close when the run is completed.

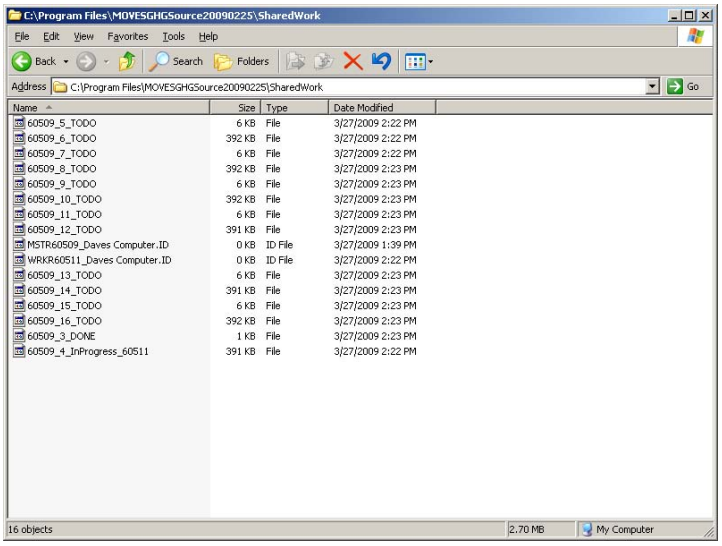
MOVES Console Window



72

The MOVES console window shows you what MOVES is doing and will report problems.

MOVES Shared Work Folder



73

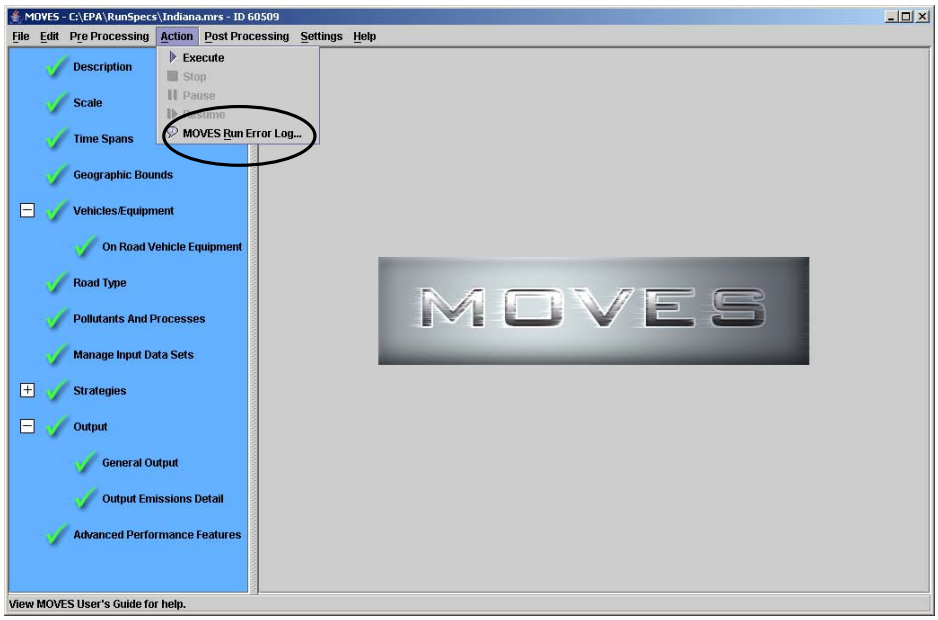
The Shared Work folder is a subdirectory of the MOVES folder in the Program Files directory. It shows you the ID of the Master and Worker and you can see the intermediate products (todo files, inprogress files and done files).

When a run is completed, the Worker ID file and all of the intermediate files will be gone.

Run Completion

74

MOVES will generate this window to inform you that the run has completed.



75

The Action menu has an option for MOVES Run Error Log that you can use to review any error or warning messages generated during your run.

You can also use this option to review error or warning messages generated during previous runs (by run ID) stored in the output database indicated in the loaded run specification.

Error Log Window

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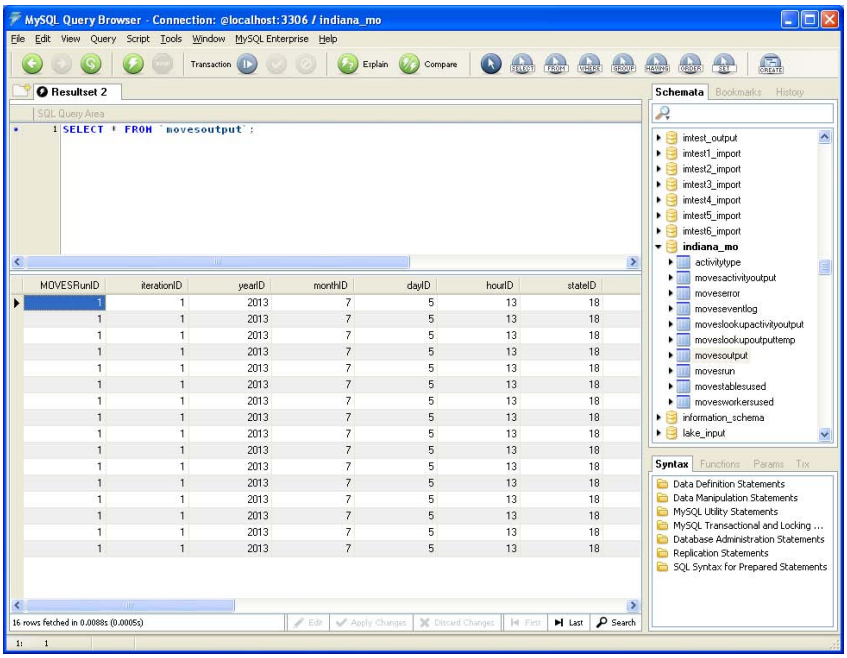
This is what an Error Log Window looks like. You can select the Run ID if more than one run is stored in the output database.



77

This slide shows the 10 output tables created by MOVES in the indiana_mo database using the MySQL Query Browser software. The movesoutput table is shown.

MOVES Output

- All results are stored in MySQL tables.
- There are various options for viewing, exporting or processing the output.
- We will discuss handling output next.

MOVES

Concepts: Aggregation

- **Aggregation of input:**
  - Reduces run time
  - Changes the results.
- **Aggregation of output:**
  - reduces the size of the output table.
  - Permanently eliminates more detailed results.
- **Don't aggregate input until you understand it.**
- **Generally: Perform any aggregation of output as a post-processing step.**

MOVES

Aggregation

- **Input aggregation:**
  - Time Aggregation Level in the Time Spans panel.
  - Region in the Geographic Bounds panel.
  - These choices will affect your output aggregation options.
- **Output aggregation:**
  - Located in the Output Emissions Panel.
  - By default, all output is already aggregated to time, location and pollutant.
  - You must choose to get more detailed output by model year, fuel type, emission process, road type or vehicle class.
  - You can also choose further aggregation of time and location.