

Module 10

Modeling Nonroad Emissions



Module Overview

- Options for modeling nonroad emissions
- Overview of nonroad in MOVES2014b
- Hands-on demonstration of nonroad in MOVES
- Course wrap-up

Options for Modeling Nonroad Emissions

- NONROAD2008
 - Last revision of the NONROAD model
 - Can still be used for SIPs and other regulatory purposes
 - May not be fully compatible with latest operating systems
- NMIM2008
 - Last revision of NMIM, an inventory modeling “shell” for MOBILE6.2 and NONROAD2008
 - Includes some features that may make it easier to use than NONROAD2008
 - Nonroad portion only can still be used for SIPs and other regulatory purposes
 - Can model air toxics
 - May not be fully compatible with latest operating systems

Options for Modeling Nonroad Emissions

- MOVES2014
 - Incorporates existing NONROAD2008 into MOVES framework
 - No changes to basic model design or data
 - Same results as NONROAD2008 and NMIM2008
 - More limited output options than other two models
 - Compatible with latest operating systems
- MOVES2014a
 - Adds VOC, TOG, NMHC, NMOG, plus about 60 air toxics
 - Adds more output aggregation options to give flexibility similar to NONROAD and NMIM
 - Includes updated gasoline fuels
 - May be used for SIPs and other regulatory purposes

Options for Modeling Nonroad Emissions

- MOVES2014b
 - Updates equipment growth estimates for every sector
 - Updates diesel Tier 4 emission rates
 - Improves post processing scripts
 - May be used for SIPs and other regulatory purposes

Nonroad Guidance

Which model should I use?

- Recommend using MOVES2014b for nonroad inventory development
 - NONROAD2008 and NMIM2008 no longer supported by EPA
 - MOVES2014b has improved default activity estimates and the latest emission factors
 - This is in addition to all of the MOVES2014a improvements (updated fuels, more pollutant options, and more flexible output)

What data should I use?

- It is acceptable to use default nonroad fleet and activity data for SIPs and other regulatory submissions
- You can use local fleet and activity data for any of these models
 - Contact us at mobile@epa.gov with questions about how to do this in MOVES2014b.

Future of Nonroad Modeling

- Adding nonroad to MOVES2014 and the improvements in MOVES2014a and MOVES2014b are the first steps toward major revisions to the nonroad modeling process
- Those revisions may include:
 - New emissions, activity, and fleet data
 - New algorithms for calculating emissions
 - New design
- Still in the early planning stages for additional revisions
 - Timetable is not yet determined
- Goal is for MOVES to be a comprehensive model that covers most types of mobile sources in a consistent way

Overview of Nonroad in MOVES

- Heavy reliance on national defaults applied at the county level
 - Local activity and fleet data can be hard to develop
 - MOVES uses surrogates (construction activity, acreage farmed, etc.) to allocate national data to the county level
- MOVES produces inventory output
 - Emission rates can be derived using post-processing scripts
- MOVES does not account for hourly activity patterns or aggregate emissions for more than 1 day
 - MOVES Nonroad inventory output is for a single day with no hourly detail

Overview of Nonroad in MOVES

- Nonroad equipment divided into 12 sectors with 91 equipment types
 - Not included are locomotives, commercial marine, and aircraft
- Pollutants and Processes detail more limited than for onroad

Hands-On Demonstration: Estimating Nonroad Emissions



Scale

- Nonroad sectors can be modeled by selecting “Nonroad” in the Scale panel
- “National” is only option for scale
 - Refers to national default database
 - Individual counties can be selected in Geographic Bounds panel
- “Inventory” is only option for Calculation Type
 - Several scripts are available in the Post Processing menu to calculate emission factors from inventory results

Scale

MOVES - ID 2214896263202995615

File Edit Pre Processing Action Post Processing Tools Settings Help

≈ Description

✓ Scale

! Time Spans

! Geographic Bounds

+ ! Vehicles/Equipment

! Road Type

! Pollutants And Processes

≈ Manage Input Data Sets

+ ✓ Strategies

+ ! Output

✓ Advanced Performance Features

Model

☐ Onroad

☒ Nonroad

Domain/Scale

☒ National

☐ County

☐ Project

Calculation Type

☒ Inventory Mass and/or Energy within a region and time span.

☐ Emission Rates Mass and/or Energy per unit of activity.

MOVESScenarioID:

Caution: Changing these selections changes the contents of other input panels. These changes may include losing previous data contents.

Ready...

Time Spans

- Nonroad emissions in MOVES are calculated on a daily basis
- No options for specifying Time Aggregation Level or Hours
- Select:
 - 2015
 - July
 - Weekdays

Time Spans

MOVES - ID 2214896263202995615

File Edit Pre Processing Action Post Processing Tools Settings Help

Description

Scale

Time Spans

Geographic Bounds

Vehicles/Equipment

Road Type

Pollutants And Processes

Manage Input Data Sets

Strategies

Output

Advanced Performance Features

Time Aggregation Level

☐ Year ☐ Month ☐ Day ☒ Hour

Years

Select Year: 2015 Add

Years:

Remove

Months

☐ January ☒ July

☐ February ☐ August

☐ March ☐ September

☐ April ☐ October

☐ May ☐ November

☐ June ☐ December

Select All Clear All

Days

☐ Weekend

☒ Weekdays

Select All Clear All

Hours

Start Hour: End Hour:

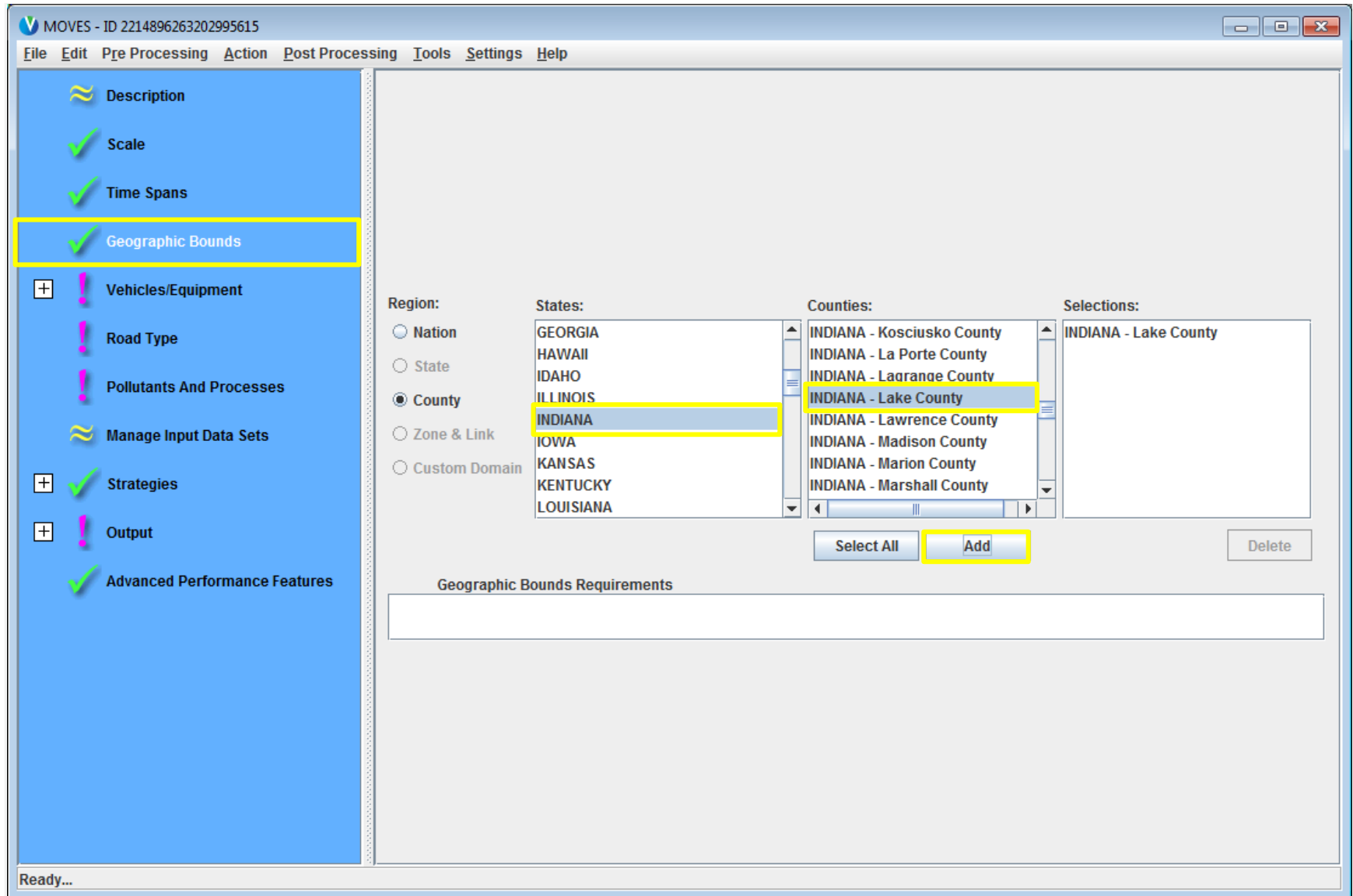
Select All Clear All

Ready...

Geographic Bounds

- Can select Nation or County
- Can run multiple counties in a single run
- Select:
 - Indiana
 - Lake County

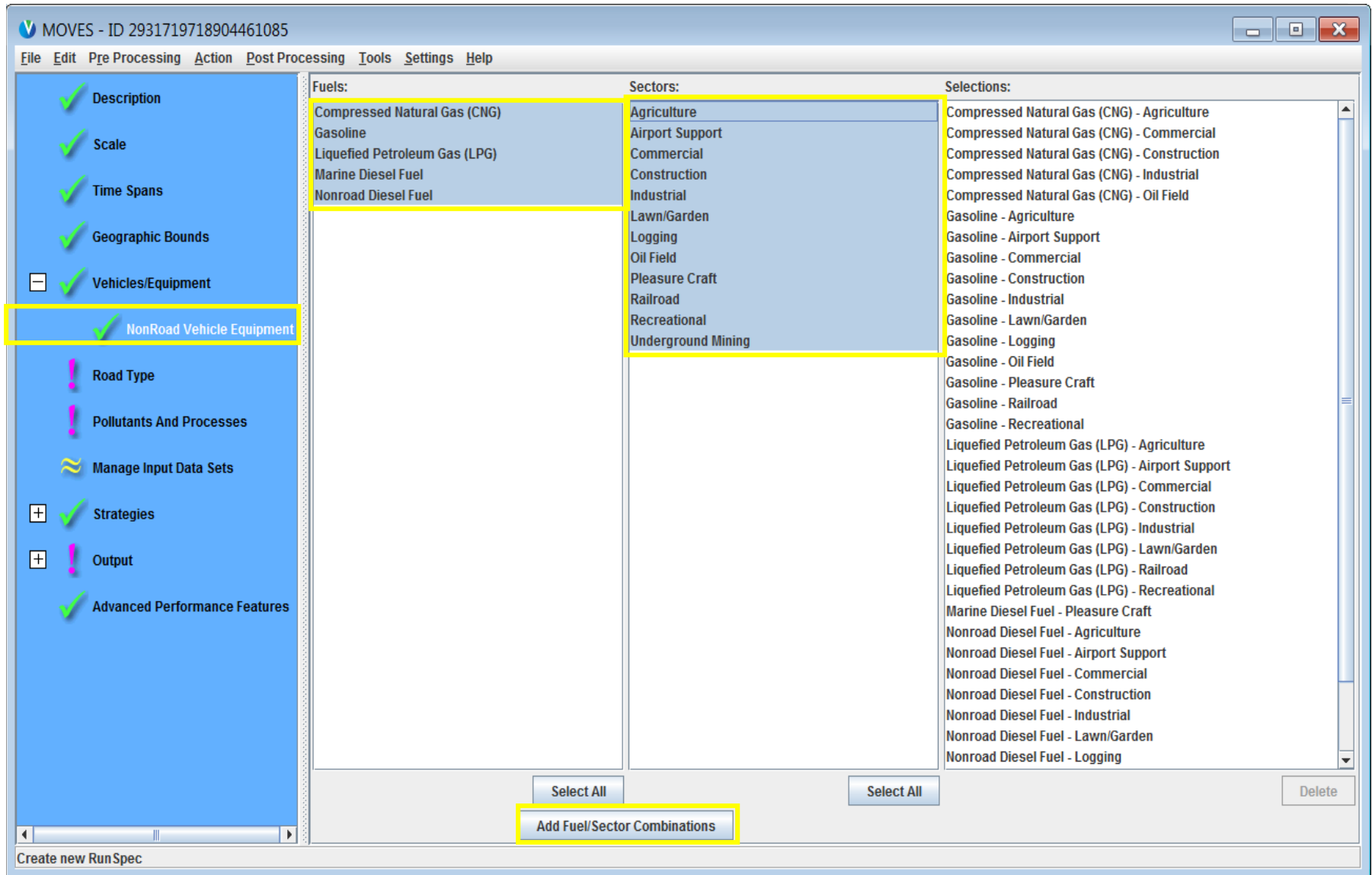
Geographic Bounds



Nonroad Vehicle Equipment

- Select these fuel types:
 - Compressed Natural Gas (CNG)
 - Diesel
 - Gasoline
 - Liquefied Petroleum Gas (LPG)
- Best to select all 12 sectors
 - MOVES allocates activity to each sector in a county based on various surrogates:
 - Farmed acreage for agriculture, construction starts for construction, etc.

Nonroad Vehicle Equipment



Road Type

- Doesn't apply to nonroad
- Click on Road Type in navigation panel to get green check

Pollutants and Processes

- All needed criteria pollutants are included
 - Less speciation detail than for onroad
 - Less differentiation by process than for onroad
- MOVES2014a added about 60 toxics
- Select:
 - Total Gaseous HC
 - Oxides of Nitrogen
 - Primary Exhaust PM_{2.5}

Pollutants and Processes

MOVES - ID 2931719718904461085

File Edit Pre Processing Action Post Processing Tools Settings Help

✓ Description

✓ Scale

✓ Time Spans

✓ Geographic Bounds

[-] ✓ Vehicles/Equipment

✓ NonRoad Vehicle Equipment

✓ Road Type

✓ Pollutants And Processes

⋈ Manage Input Data Sets

[+] ✓ Strategies

[+] ! Output

✓ Advanced Performance Features

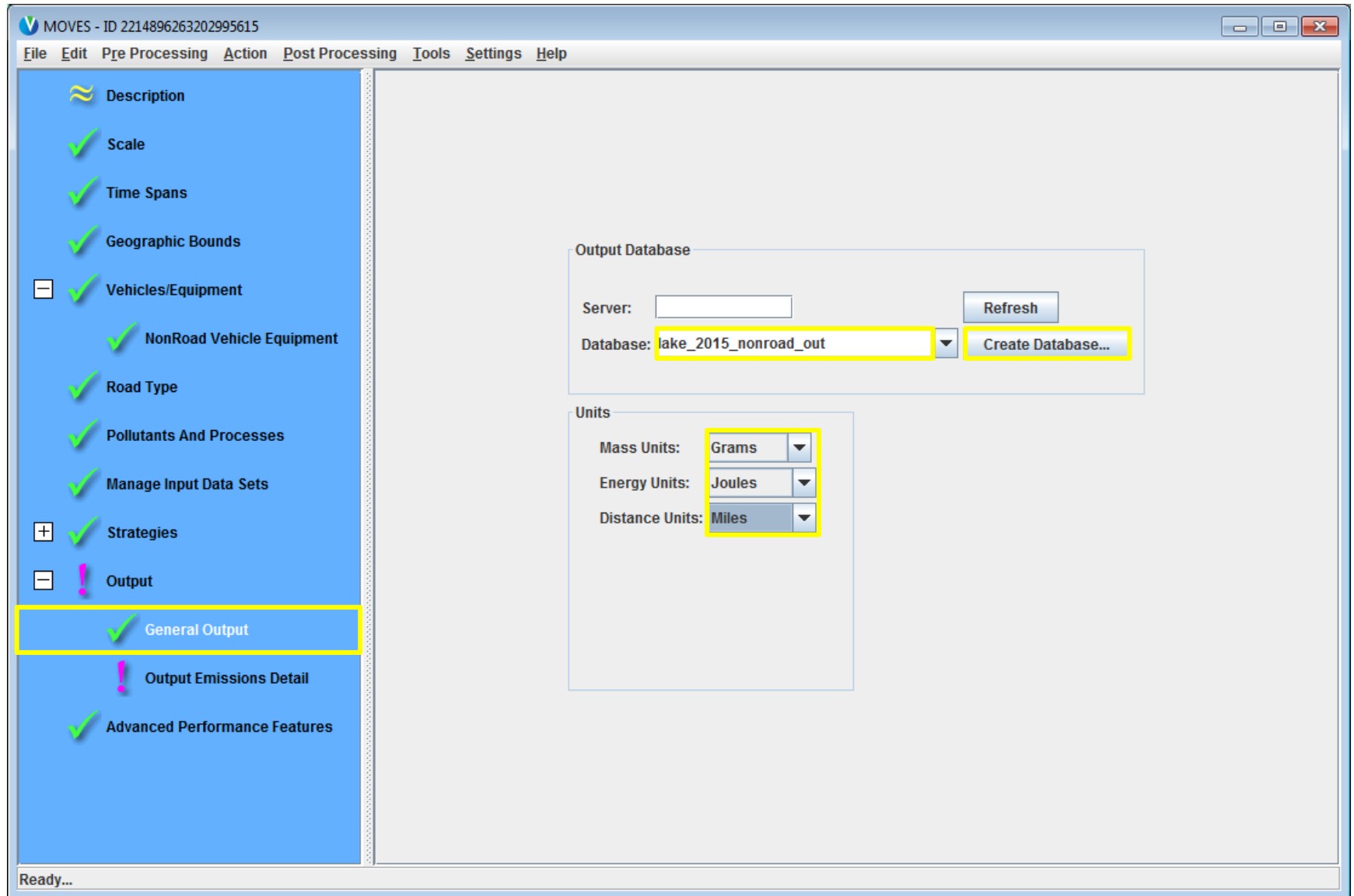
| | Running Exhaust | Crankcase Running Exhaust | Refueling Displacement Vapor Loss | Refuel |
|---|-------------------------------------|-------------------------------------|-------------------------------------|--------|
| <input checked="" type="checkbox"/> Total Gaseous Hydrocarbons | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | |
| <input type="checkbox"/> Non-Methane Hydrocarbons | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Non-Methane Organic Gases | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Total Organic Gases | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Volatile Organic Compounds | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Methane (CH4) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Carbon Monoxide (CO) | <input type="checkbox"/> | | | |
| <input checked="" type="checkbox"/> Oxides of Nitrogen (NOx) | <input checked="" type="checkbox"/> | | | |
| <input type="checkbox"/> Ammonia (NH3) | <input type="checkbox"/> | | | |
| <input checked="" type="checkbox"/> Primary Exhaust PM2.5 - Total | <input checked="" type="checkbox"/> | | | |
| <input type="checkbox"/> Primary Exhaust PM10 - Total | <input type="checkbox"/> | | | |
| <input type="checkbox"/> Sulfur Dioxide (SO2) | <input type="checkbox"/> | | | |
| <input type="checkbox"/> Brake Specific Fuel Consumption (BSFC) | <input type="checkbox"/> | | | |
| <input type="checkbox"/> Atmospheric CO2 | <input type="checkbox"/> | | | |
| <input type="checkbox"/> Benzene | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> Ethanol | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> MTBE | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> 1,3-Butadiene | <input type="checkbox"/> | <input type="checkbox"/> | | |
| <input type="checkbox"/> Formaldehyde | <input type="checkbox"/> | <input type="checkbox"/> | | |
| <input type="checkbox"/> Acetaldehyde | <input type="checkbox"/> | <input type="checkbox"/> | | |
| <input type="checkbox"/> Acrolein | <input type="checkbox"/> | <input type="checkbox"/> | | |
| <input type="checkbox"/> [+] Additional Air Toxics | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> [+] Polycyclic Aromatic Hydrocarbons (PAH) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| <input type="checkbox"/> [+] Metals | <input type="checkbox"/> | | | |
| <input type="checkbox"/> [+] Dioxins and Furans | <input type="checkbox"/> | | | |
| <input type="checkbox"/> NonHAPTOG | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

Select Prerequisites

Clear All

Create new RunSpec

Output – General Output



Output – Output Emissions Detail

- All output will be for a 24-hour day
- Currently MOVES nonroad output can be broken down by:
 - Model year
 - Fuel type
 - Fuel subtype
 - Emission process
 - SCC
 - Sector
 - Engine technology
 - Horsepower class
- If you select all of these, output table is very large: 312,642 rows for this run
- Select SCC for an inventory at the equipment type level

Output – Output Emissions Detail

MOVES - ID 2931719718904461085

File Edit Pre Processing Action Post Processing Tools Settings Help

- ✓ Description
- ✓ Scale
- ✓ Time Spans
- ✓ Geographic Bounds
- [-] ✓ Vehicles/Equipment
 - ✓ NonRoad Vehicle Equipment
 - ✓ Road Type
 - ✓ Pollutants And Processes
 - ✓ Manage Input Data Sets
- [+] ✓ Strategies
- [-] ✓ Output
 - ✓ General Output
 - ✓ **Output Emissions Detail**
 - ✓ Advanced Performance Features

Always

☒ Time 24-Hour Day

☒ Location COUNTY

☒ Pollutant

for All Vehicle/Equipment Categories

☐ Model Year

☒ Fuel Type ☐ Fuel Subtype

☐ Emission Process

☐ Estimate Uncertainty

On Road/Off Road

☒ On Road/Off Road

On and Off Road

☐ Road Type

☐ Source Use Type

☒ SCC

☐ Regulatory Class

Off Road

☒ Sector

☐ Engine Tech.

☐ HP Class

Number of iterations: 2

☐ Keep pseudo-randomly sampled input

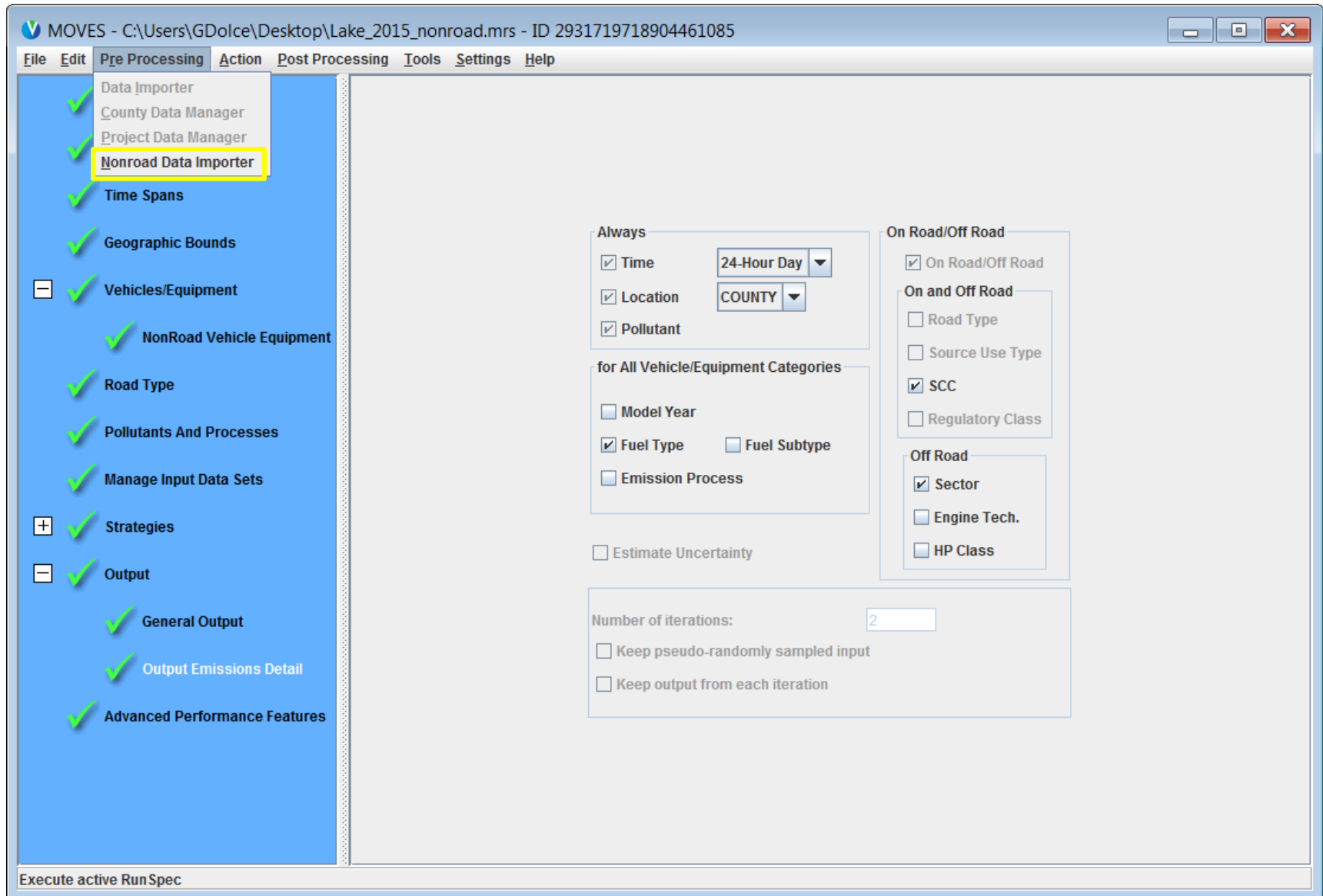
☐ Keep output from each iteration

Create new Run Spec

Using the Nonroad Data Importer

- Access from Pre-Processing menu
 - Select “Nonroad Data Importer”
 - “Data Importer” is for onroad only
- Meteorology Data
 - Nonroad in MOVES uses the same met data table as onroad
 - ZoneMonthHour
 - Use same local temperature data for nonroad and onroad
- Fuels
 - Two tables
 - nrFuelSupply
 - FuelFormulation
- Generic
 - Provides access to nonroad tables
 - All begin with “nr” (e.g. nrfuelformulation)
 - Consult with EPA before changing nonroad tables

Using the Nonroad Data Importer



Nonroad Data Importer – Create Database

The screenshot shows the 'MOVES Data Importer' application window. The 'Database' tab is selected, and the 'Fuel' sub-tab is active, indicated by a green checkmark. The main instruction reads: 'Select or create a database to hold the imported data.' Below this, there are three input fields: 'Server:' with the value 'localhost', 'Database:' with the value 'lake_2015_nonroad_in', and 'Log:' which is empty. To the right of these fields are three buttons: 'Refresh', 'Create Database', and 'Clear All Imported Data'. The 'Create Database' button is highlighted. At the bottom of the window, there is a green bar with the text 'Database' and a 'Done' button.

MOVES Data Importer

RunSpec Summary Database Fuel Meteorology Data Generic Tools

Select or create a database to hold the imported data.

Server: localhost Refresh

Database: lake_2015_nonroad_in Create Database

Log: Clear All Imported Data

Database

Done

Nonroad Data Importer – Meteorology

The screenshot shows the 'MOVES Data Importer' application window with the 'Meteorology Data' tab selected. The window has a standard Windows-style title bar and a tabbed interface. The 'Fuel' tab is also visible and marked with a green checkmark. The main area is divided into several sections: a 'Description of Imported Data' text area, a 'zoneMonthHour Data Source' section with a 'File: (please select a file)' label and a 'Browse...' button, and a section with 'Clear Imported Data' and 'Create Template...' buttons. Below these is an 'Import' button. At the bottom, there are 'Export Default Data' and 'Export Imported Data' buttons. A green bar at the very bottom contains the text 'Meteorology Data' and a 'Done' button.

MOVES Data Importer

RunSpec Summary Database ☒ Fuel Meteorology Data Generic Tools

Description of Imported Data:

zoneMonthHour Data Source:

File: (please select a file)

Browse...

Clear Imported Data Create Template...

Import

Messages:

Export Default Data Export Imported Data

Meteorology Data

Done

Data Importer – Fuel

The screenshot shows the 'MOVES Data Importer' application window with the 'Fuel' tab selected. The interface includes a 'Description of Imported Data' section with a 'Fuels Wizard' button. Below this are two sections for data sources: 'nrFuelSupply Data Source' and 'FuelFormulation Data Source', each with a 'File: (please select a file)' label, a 'Browse...' button, and 'Clear Imported Data' and 'Create Template...' buttons. An 'Import' button is located below these sections. A 'Messages:' section is at the bottom left. At the bottom, there are 'Export Default Data' and 'Export Imported Data' buttons. A cyan bar at the bottom right contains the word 'Fuel', and a 'Done' button is at the bottom right corner.

MOVES Data Importer

RunSpec Summary Database **Fuel** Meteorology Data Generic Tools

Description of Imported Data:

Fuels Wizard

nrFuelSupply Data Source:

File: (please select a file) Browse...

Clear Imported Data Create Template...

FuelFormulation Data Source:

File: (please select a file) Browse...

Clear Imported Data Create Template...

Import

Messages:

Export Default Data Export Imported Data

Fuel

Done

Data Importer – Generic Tab

The screenshot shows the 'MOVES Data Importer' application window with the 'Generic' tab selected. The interface includes a tab bar at the top with 'RunSpec Summary', 'Database', 'Fuel', 'Meteorology Data', 'Generic', and 'Tools'. Below the tabs is a 'Description of Imported Data:' section. A table selection area on the left shows a list of tables, with 'nrretrofitfactors' selected and highlighted by a yellow box. To the right of the table list are buttons for 'Browse...', 'Clear Imported Data', 'Create Template...', and 'Remove previously imported data'. Below these is an 'Import' button. At the bottom, there are 'Export Default Data' and 'Export Imported Data' buttons. A pink bar at the bottom right contains the text 'Generic', and a 'Done' button is at the bottom right corner.

MOVES Data Importer

RunSpec Summary Database Fuel Meteorology Data Generic Tools

Description of Imported Data:

Table: nrretrofitfactors

File: (p

nrpahgasratio
nrpahparticleratio
nrprocessgroup
nrretrofitfactors
nrsc
nrscrappagecurve
nrsourceusetype
nrstatesurrogate

Browse...

Clear Imported Data Create Template...

Remove previously imported data

Import

Messages:

Export Default Data Export Imported Data

Generic

Done

Using Post Processing Scripts

- Post-processing menu contains scripts to process nonroad output into different forms
- 6 Inventory scripts
 - By county, by equipment type, by sector
 - Output Emissions Detail panel replaces most of these scripts used to consolidate inventory output
- 1 Population script
 - By sector and SCC
- 10 Emission factor scripts
 - Per horsepower-hour, per operating hour, and per vehicle
 - Use these to produce emission factors that can be multiplied by locally derived activity
 - Produces emission factors are specific to year, month, and day type

Using Post Processing Scripts: Emission Factors

| Script Title | Description | Select in Output Emissions Detail Panel | To Calculate an Inventory |
|--|--|---|--|
| EmissionFactors_per_hphr_by_Equipment.sql | Produces an output table which reports the emission results in g/hp-hour for each <i>equipment type</i> | SCC | Multiply emission factors produced by script by total hp-hours for appropriate equipment type |
| EmissionFactors_per_hphr_by_Equipment_and_Horsepower.sql | Produces an output table which reports the emission results in g/hp-hour for each <i>equipment type and horsepower class</i> | SCC, HP Class | Multiply emission factors produced by script by total hp-hours for appropriate equipment type and horsepower class |
| EmissionFactors_per_hphr_by_SCC.sql | Produces an output table which reports the emission results in g/hp-hour for each <i>SCC</i> | SCC | Multiply emission factors produced by script by total hp-hours for appropriate SCC |
| EmissionFactors_per_hphr_by_SCC_and_ModelYear.sql | Produces an output table which reports the emission results in g/hp-hour for each <i>SCC, horsepower class, and model year</i> | SCC, HP Class, Model Year | Multiply emission factors produced by script by total hp-hours for appropriate SCC, horsepower class, and model year |

Note: In general, hp-hours = rated horsepower × load factor × total hours per equipment × number of equipment operating

Default load factor assumptions are available in Appendix A of the *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling* technical report: <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10081RV.pdf>.

Sales-weighted mean rated horsepower values for each equipment by type/horsepower category are available in Appendix A of the *Nonroad Engine Population Estimates* technical report: <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10081T6.pdf>.

Using Post Processing Scripts: Emission Factors

| Script Title | Description | Select in Output Emissions Detail Panel | To Calculate an Inventory |
|---|---|---|---|
| EmissionFactors_per_OperatingHour_by_Equipment.sql | Produces an output table which reports the emission results in g/hour for each <i>equipment type</i> | SCC | Multiply emission factors produced by script by total hours of operation (i.e., operating hours) for appropriate equipment type |
| EmissionFactors_per_OperatingHour_by_Equipment_and_Horsepower.sql | Produces an output table which reports the emission results in g/hour for each <i>equipment type and horsepower class</i> | SCC, HP Class | Multiply emission factors produced by script by total hours of operation for appropriate equipment type and horsepower class |
| EmissionFactors_per_OperatingHour_by_SCC.sql | Produces an output table which reports the emission results in g/hour for each SCC | SCC | Multiply emission factors produced by script by total hours of operation for appropriate SCC |

Note: To calculate activity in operating hours, the following equation can be used:

$$\text{operating hours} = \text{hours of operation per equipment} \times \text{number of equipment operating}$$

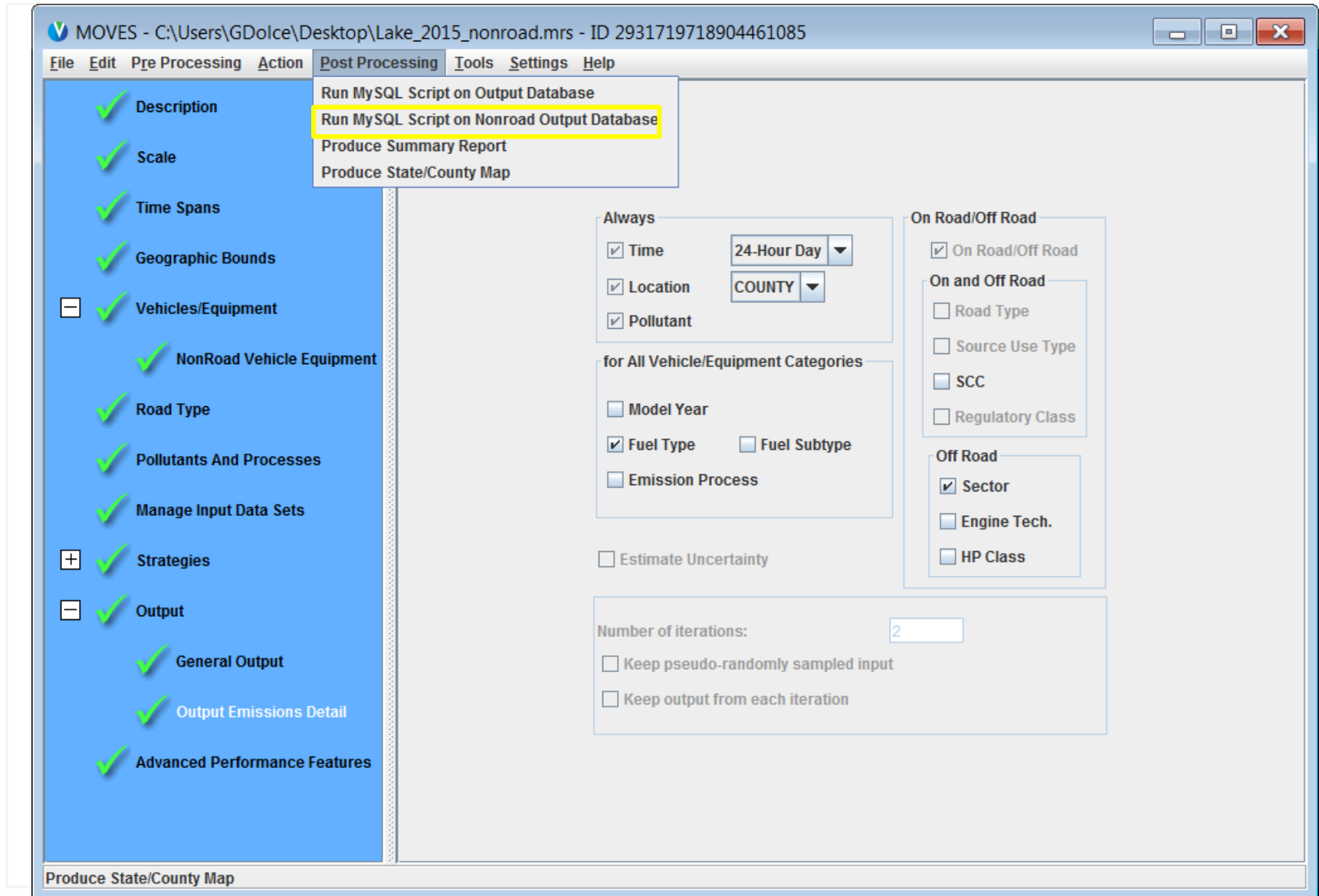
Using Post Processing Scripts: Emission Factors

| Script Title | Description | Select in Output Emissions Detail Panel | To Calculate an Inventory |
|---|--|---|--|
| EmissionFactors_per_Vehicle_by_Equipment.sql | Produces an output table which reports the emission results in g/vehicle per day for each <i>equipment type</i> | SCC | Multiply emission factors produced by script by total number of vehicle-days for appropriate equipment type |
| EmissionFactors_per_Vehicle_by_Equipment_and_Horsepower.sql | Produces an output table which reports the emission results in g/vehicle per day for each <i>equipment type and horsepower class</i> | SCC, HP Class | Multiply emission factors produced by script by total number of vehicle-days for appropriate equipment type and horsepower class |
| EmissionFactors_per_Vehicle_by_SCC.sql | Produces an output table which reports the emission results in g/vehicle per day for each <i>SCC</i> | SCC | Multiply emission factors produced by script by total number of vehicle-days for appropriate SCC |

Note: To calculate activity in vehicle-days, the following equation can be used:

$$\text{vehicle-days} = \text{number of equipment operating} \times \text{number of days of operation}$$

Using Post Processing Scripts



Using Post Processing Scripts

- Emission factor scripts can have very long run times depending on the size of the output database
- If you need emission factors:
 - Reduce the size of your output database by choosing just the amount of detail you need in the Output Emissions Detail panel
 - Only select sectors for which you have appropriate activity data
 - Delete equipment types for which you don't have activity information from the output file before running the script

Using Post Processing Scripts

- MySQL can be used to manually delete equipment types.
- For example, if you only had activity data for Pavers (NREquipTypeID=6) and Rollers (NREquipTypeID=9) in the Construction sector, the following script could be run on your output database in MySQL to reduce output to only Pavers and Rollers before running an emission factors script:

Should match the name of
your output database

```
delete output_database.movesoutput from output_database.movesoutput
inner join movesdb20161117.nrscc using(SCC)
inner join movesdb20161117.nrequipmenttype using(NREquipTypeID)
where NREquipTypeID not in (6, 9);
```

Using Post Processing Scripts

- We suggest making a copy of your original movesoutput table before deleting records:

```
create table output_database.movesoutput_copy  
select * from output_database.movesoutput;
```

- Note: To use the 'delete' function, 'Safe Updates' must be unchecked in the 'Edit → Preferences → SQL Editor' panel in MySQL.

Produce Summary Report: Nonroad Output

- MOVES' Post Processing 'Produce Summary Report' feature can be used to report *inventory* output only, for selected emission processes and pollutants, by the following categories:
 - Fuel type
 - Model year
 - SCC
 - MOVES run
 - Day type
 - Time/location identifiers (month, state, county)
- Feature covered in detail in Module 2

Questions?



Course Wrap-up



Environmental Topics

Laws & Regulations

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MOVES and Other Mobile Source Emissions Models

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MOTOR Vehicle Emission Simulator (MOVES)

[Latest version of MOVES](#)

EPA's Motor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.

Visit:
www.epa.gov/moves

Using MOVES

- [Latest MOVES Model](#)
- [MOVES Limited Use Models](#)
- [Tools to Develop or Convert MOVES Inputs](#)
- [MOVES Training Sessions](#)
- [Methods to Produce Emission Inventories](#)

Understanding Algorithms & Default Data

- [MOVES Algorithms](#)
- [MOVES Technical Reports](#)
- [NONROAD Technical Reports](#)
- [Presentations and Workshops on MOVES Data](#)
- [MOVES Model Review Work Group](#)
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Older Models

- [Previous MOVES Versions](#)
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- [NONROAD Model](#)
- [NMIM \(National Mobile Inventory Model\)](#)

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Course Wrap-up

- To join the MOVES listserv, go to:
www.epa.gov/moves/forms/epa-mobilenews-listserv
- Questions?
 - Check out our FAQ page: <https://movesepa.zendesk.com/hc/en-us>
 - Contact us:
MOBILE@epa.gov
www.epa.gov/moves
- Please turn in your course evaluations! We use them to improve the course.

Thank You

