Module 8
Project-Scale Analyses

Module Overview

- Introduction to Project Scale Analyses
  - Project Scale RunSpec
  - What is a MOVES link?
- Project Scale Class Demonstration
  - Defining the Project
  - Creating the MOVES Project Scale RunSpec
  - Creating an Project Scale Input Database
  - Options for On-Road Activity
  - Project Level Outputs in MySQL

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Introduction to Project Scale

- The National Academy of Sciences suggested that EPA add a 'microscale' modeling domain to its emission modeling 'toolkit'
- Project Scale allows MOVES modeling at the 'Link' level
  - Roadway links
  - Off-network link
- Project Scale models the 'average' conditions on one or more links.
  - However, it is not a traffic simulation model

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Summary: MOVES Three Scales

	National	County	Project
Geographic area covered	• Entire nation • One or more states • One or more counties	• One county • A multi-county area	An individual transportation project (e.g., a highway, intersection, or transit project)
Purpose	Non-regulatory only	Required for SIP and regional conformity analyses	Required for project-level conformity analyses
Input database	User does not need to create, use of Data Importer is optional*	User creates with local data, through the County Data Manager	User creates with local data, through the Project Data Manager
Default data	Used unless overridden	Access to default data is limited	Access to default data is limited

* User cannot provide information for certain inputs at the National scale

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MOVES Project Scale

- Project scale is appropriate for:
  - CO and PM “Hot-spot” analyses for project conformity
  - National Environmental Policy Act (NEPA) Environmental Impact Statements (EISs)
  - Roadway/Intersection level energy and Greenhouse Gas analysis
- Link-specific data must be entered if the Project scale is selected
- Data can be exported or imported using the Project Data Manager (PDM)
  - NOTE: Access to default data is limited

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Project v. National and County Scales

- Project scale utilizes the same MOVES emission rates and correction factors as county and national scale
- Project scale does NOT utilize the default MOVES growth, VMT or population data
  - This data must be supplied by the user.
- Project scale allows the user to model a only one hour:

  In RunSpec, make <u>one</u> selection for each of the following:
  - County
  - Year
  - Month
  - Day type
  - Hour

  e.g. Washtenaw County, Michigan in January 2010, weekday at 8:00am

NOTE: Because only a single hour is selectable, you cannot use Project Scale to evaluate evaporative processes

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Project Scale Guidance

- EPA has developed guidance for:
  - Quantitative PM hot-spot analyses for transportation conformity (includes PM project scale MOVES guidance)
  - Using MOVES for CO project scale analyses
  - Both documents located here:

  www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses

- NOTE: This module is not intended to reflect technical or policy guidance but provide an overview and illustrative example of MOVES capabilities at the project scale.

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Hot-spot Training Course

- Additionally, the EPA and US DOT have developed a 3-day training course specific to the PM hot-spot requirement in the conformity rule
  - The training covers how to us MOVES consistent with EPA guidance
  - Also covers air quality modeling, background concentrations, design values, and other topics
- For training materials and updated training dates/locations, see EPA's website: https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses

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Project Scale for Regulatory Purposes

- When using MOVES at the project scale for regulatory purposes, more than one hour is needed to capture variability over time
  - E.g., activity and temperature will vary

- Each hour modeled will need a unique
  - RunSpec
  - Input database

- See EPA guidance mentioned above for more information

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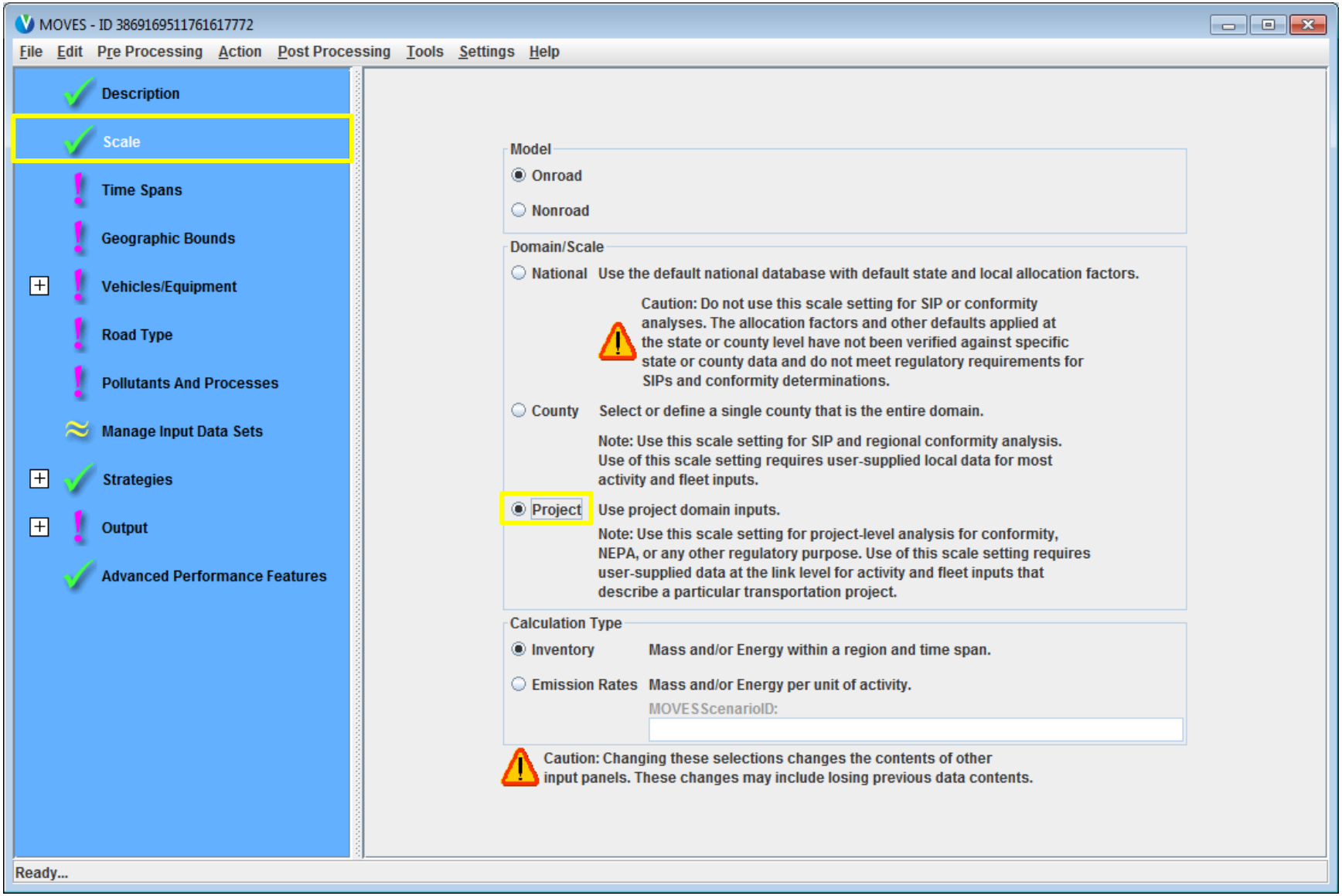
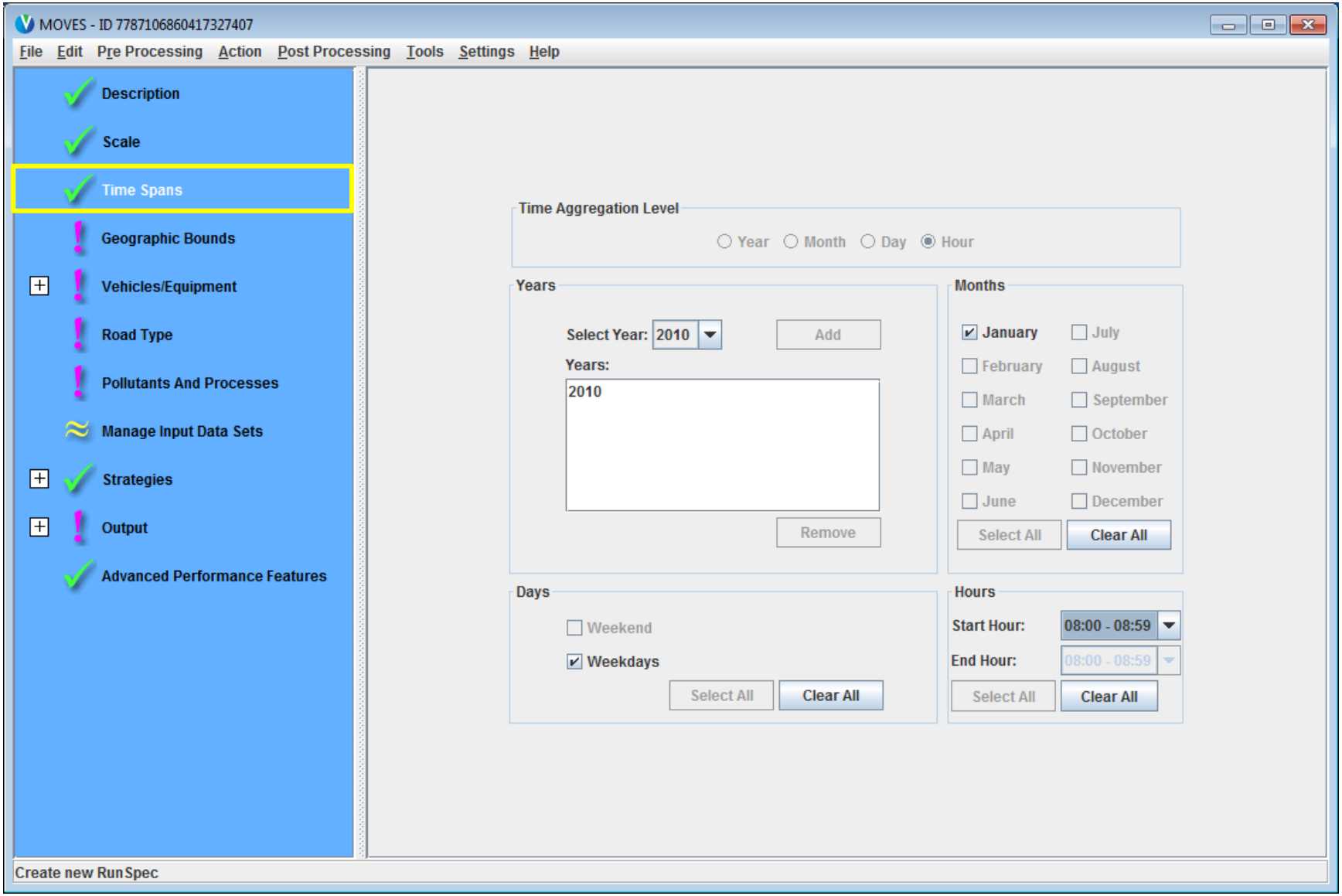
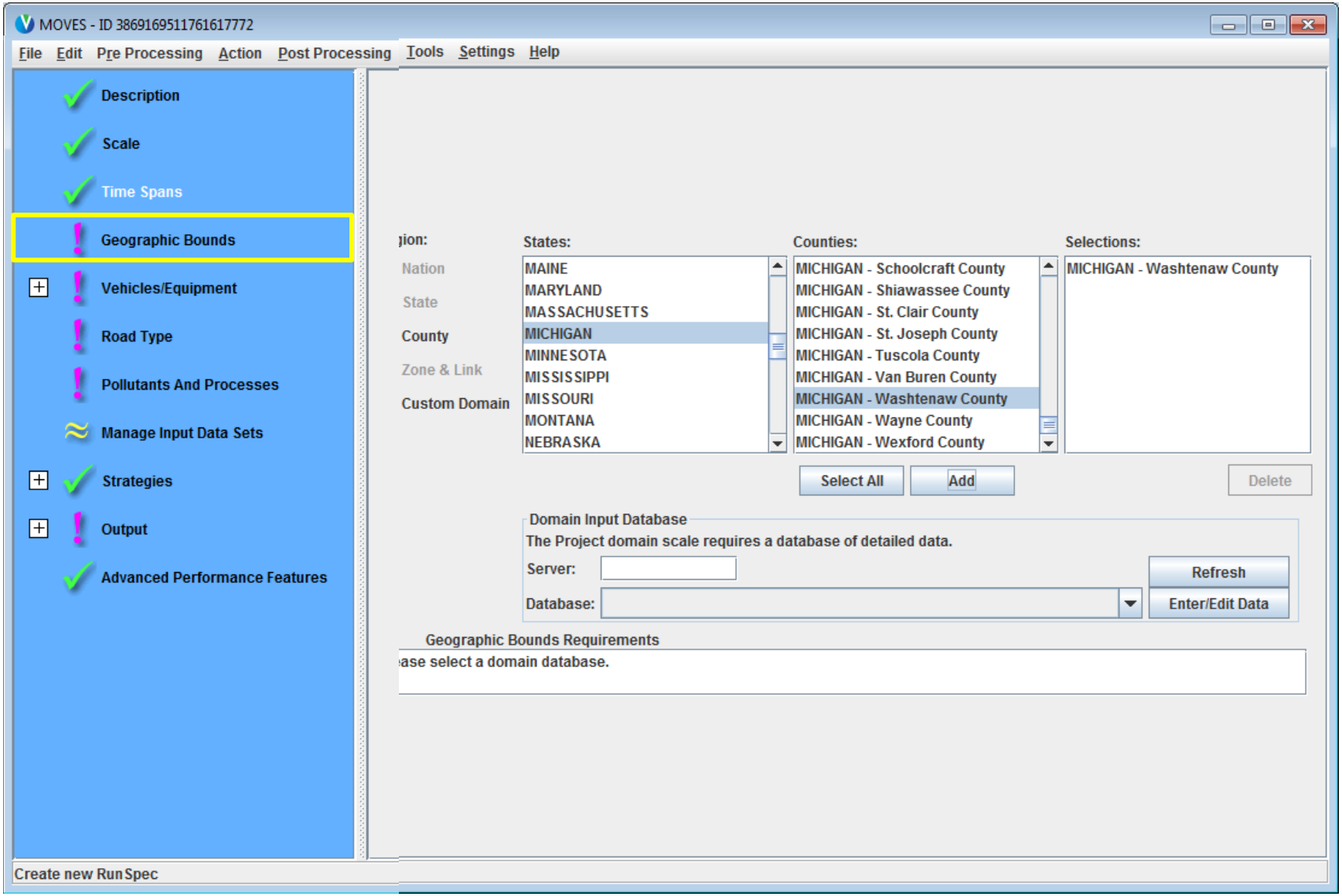
Scale Panel Choice for Project Scale



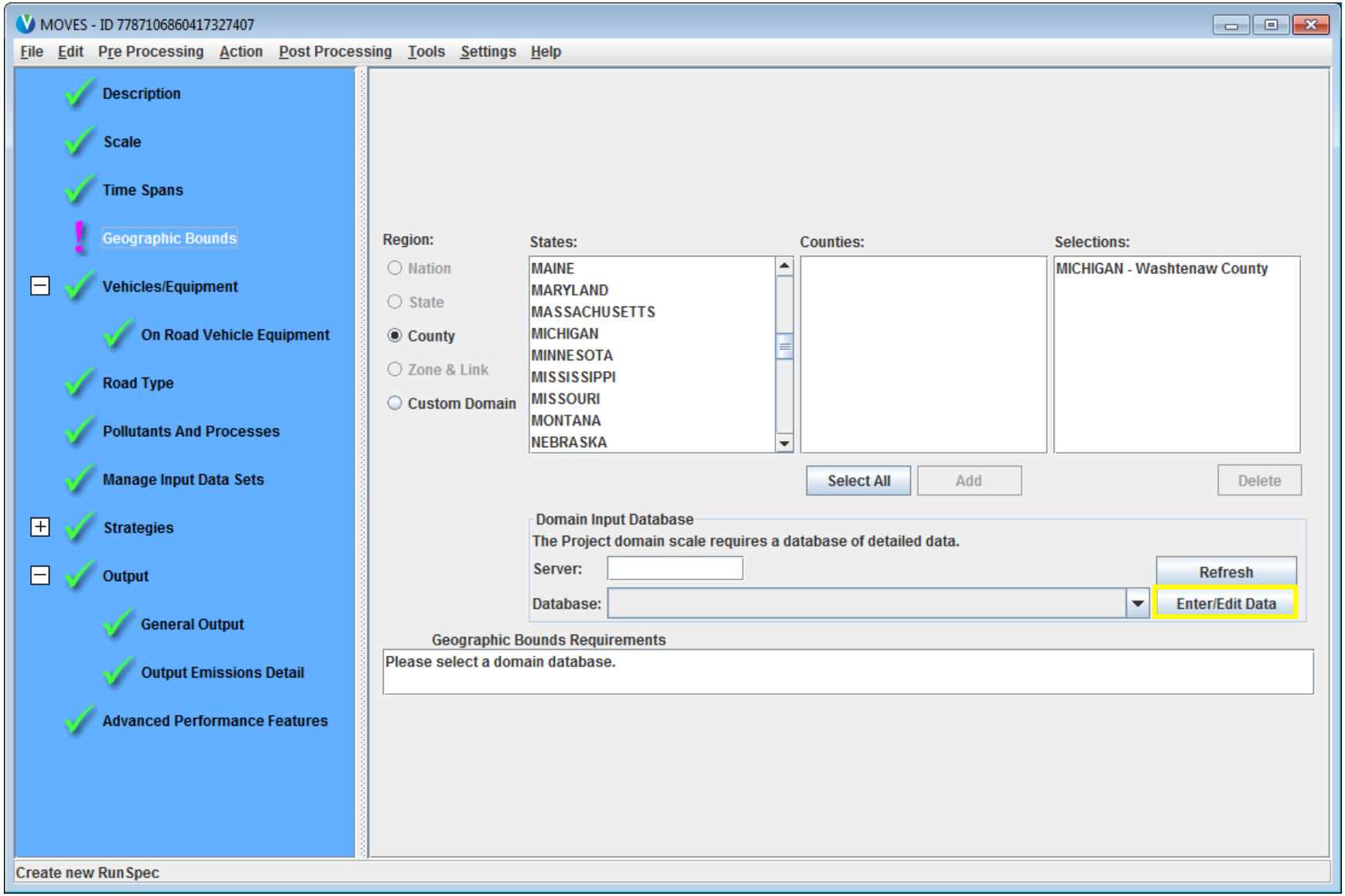
Time Spans for Project Scale



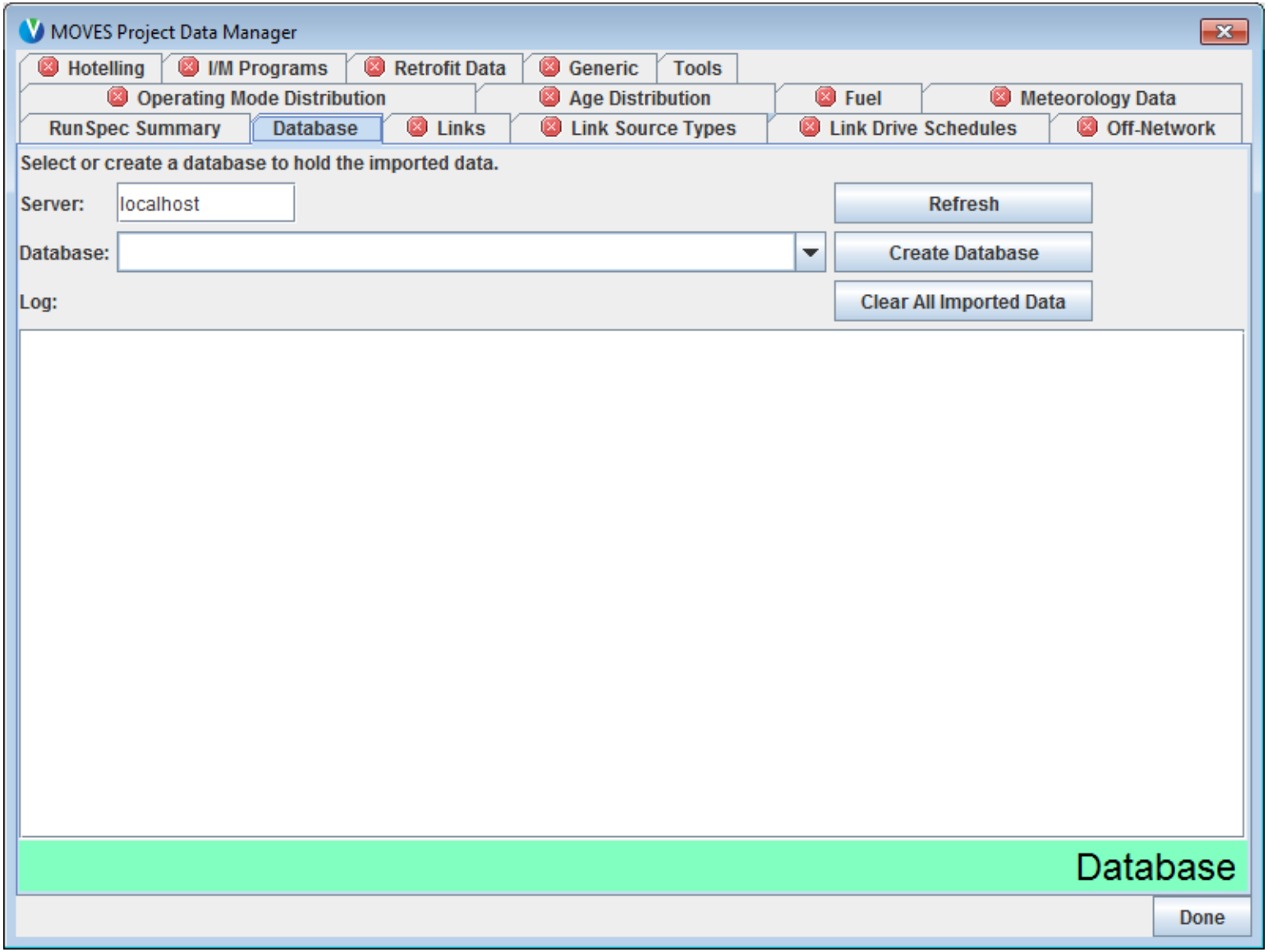
Geographic Bounds in Project Scale



Accessing Project Data Manager (PDM)



A Newly Opened PDM



PDM Inputs

- Links
- Off-Network
- Link Source Types
- Operating Mode Distribution
- Link Drive Schedules

These inputs are unique to the MOVES project scale

- Age Distribution
- Meteorology Data
- Fuel
- I/M
- Hotelling
- Retrofit Data

These inputs are common for both MOVES county scale and project scale analyses

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What is a MOVES link?

- A link is a segment of road or an "off-network" location where a similar type of vehicle activity occurs

- There are two primary types of links:
  1. Running links
     - Used to describe driving activity: e.g., free-flow highways, ramps, arterials, intersections (cruise, deceleration, idle, and acceleration activity)
     - Running exhaust, crankcase, brake/tire wear emissions
     - No limit on the number of running links in a run
  2. Off-Network links
     - Used to describe start and hotelling activity: e.g., parking areas, truck or transit terminals
     - Only needed if a project contains vehicles starting or hotelling
     - Hotelling applies only combination long-haul trucks, sourcetypeid 62
     - Only one off-network link can be defined per run

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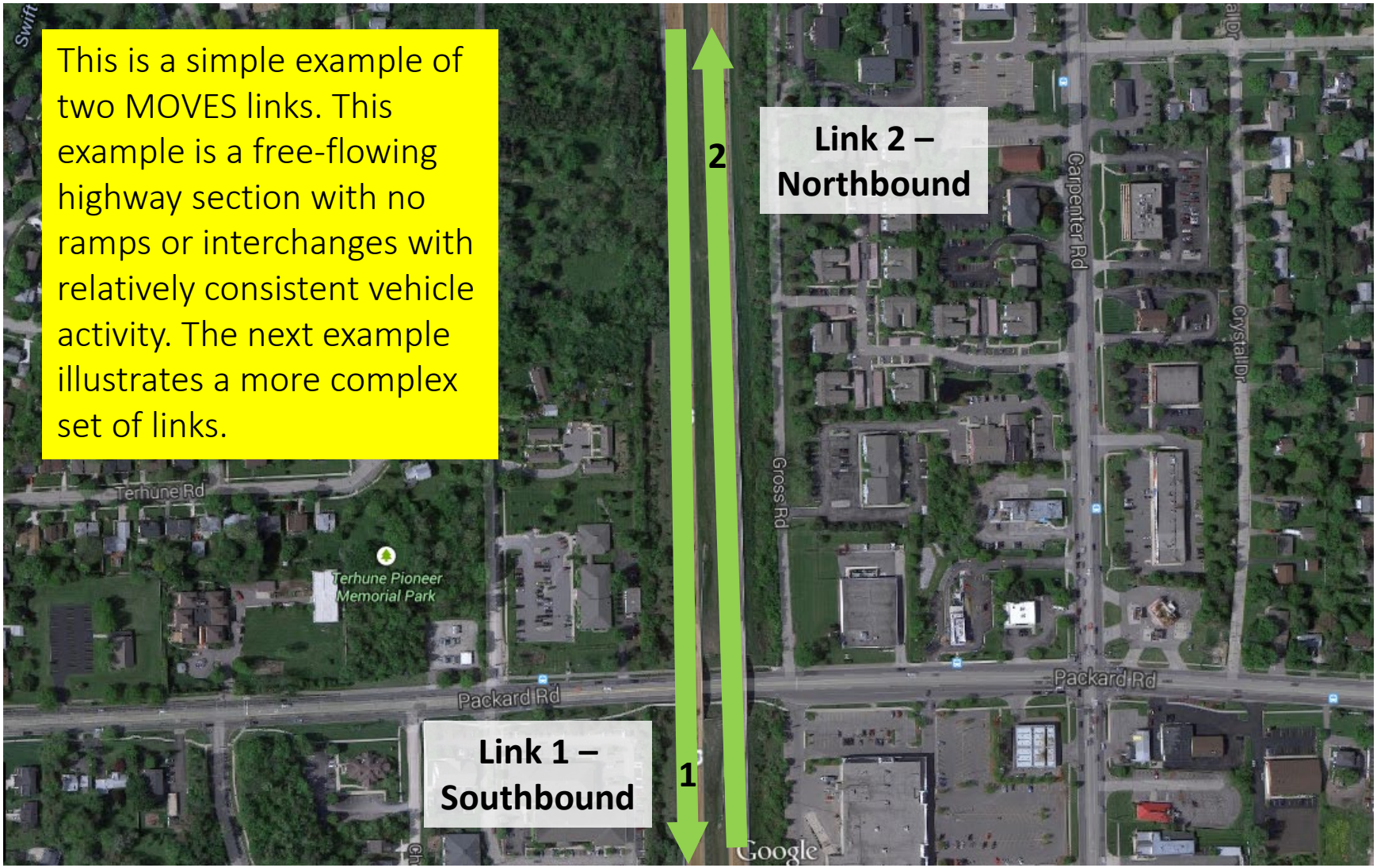
Running Link Examples



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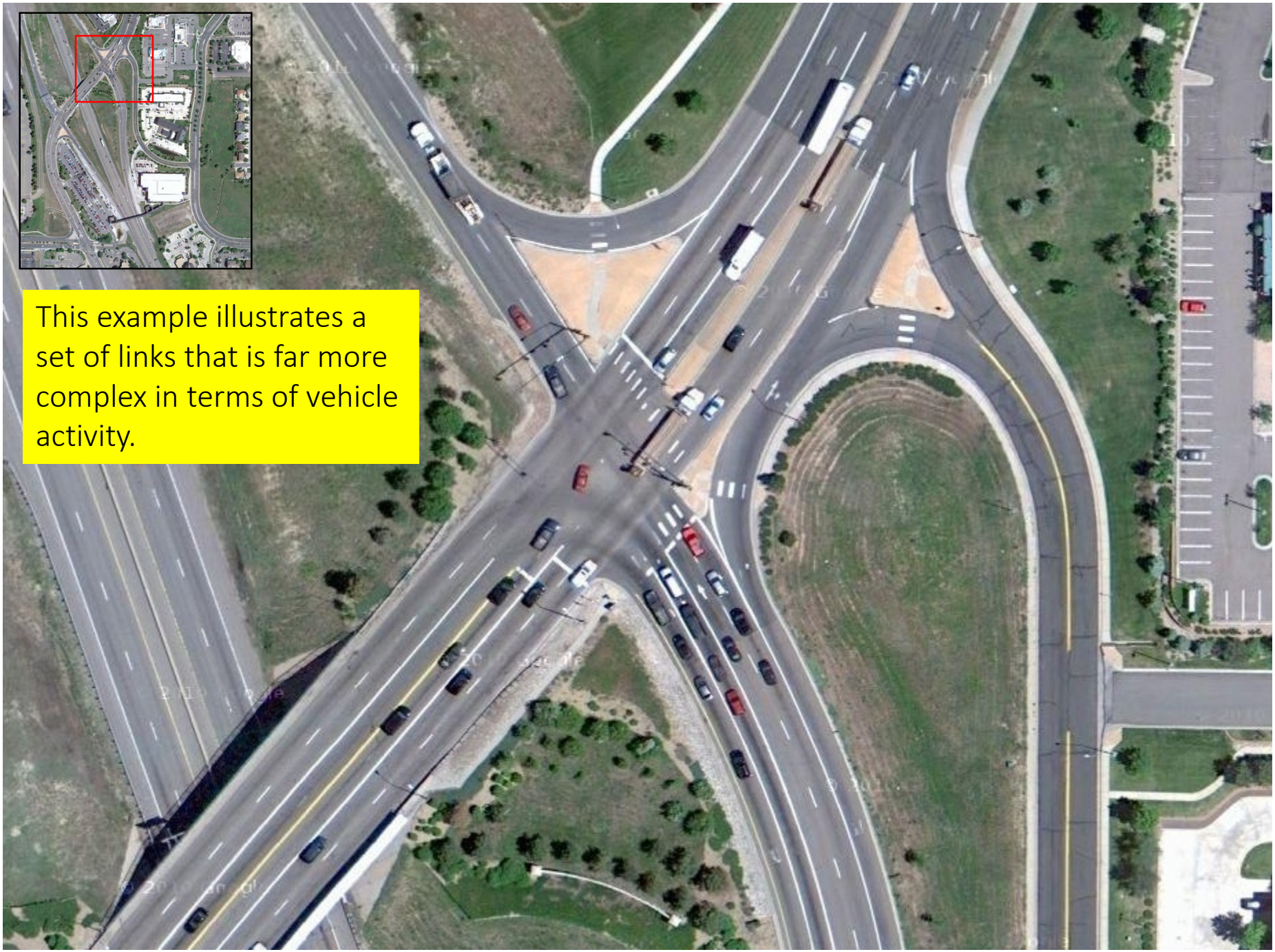
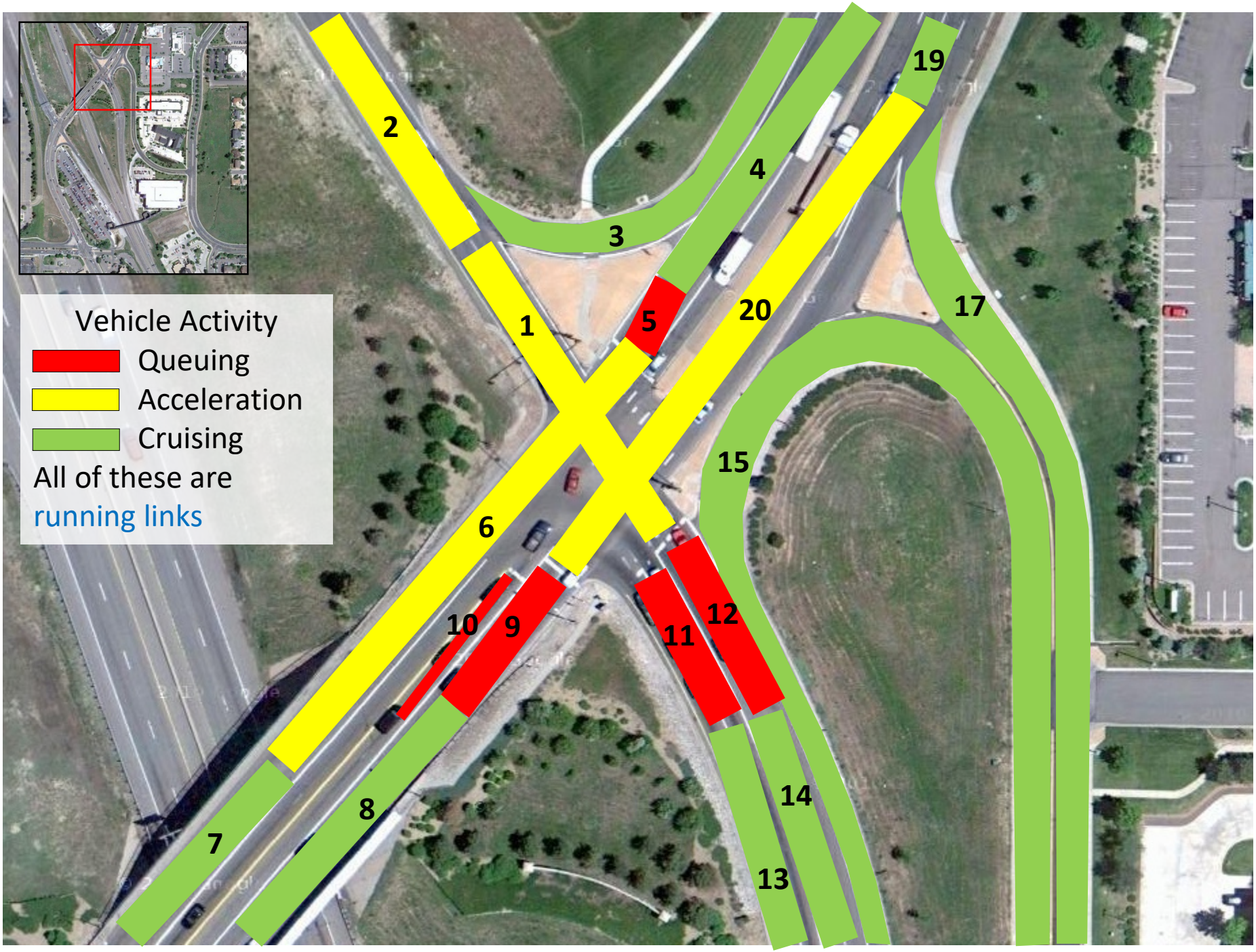


This example illustrates a set of links that is far more complex in terms of vehicle activity.


Vehicle Activity
Queuing
Acceleration
Cruising
All of these are
running links
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
17
19
20

Inputs Unique to Project Scale: Running Links

- For running links, you will need to complete:
  - Links: Used to describe the link (road type, length, etc.)
  - Link Source Types: Used to define vehicle mix on each link
  - Optional inputs:
    - Operating Mode Distribution
    - Link Drive Schedules
- There is no limit on the number of running links that can be defined in one run

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Links Input

- There are 9 columns that need to be completed for each link:
  - LinkID: name of each link in the project, user provides
  - CountyID: Five digit code (comes with template)
  - ZoneID: county ID with zero at the end (comes with template)
  - RoadTypeID: the roadtype for each link, user provides
  - Link Length: in miles, user provides
  - Link Volume: total traffic volume in one hour, user provides
  - Link Average Speed: in mph, user provides
    - Could use optional inputs instead to more precisely define activity
  - Link Description: optional text field, user provides
  - Link Grade: in percent grade (100% = 45 degree slope), user provides

Note: this input also needed for an off-network link

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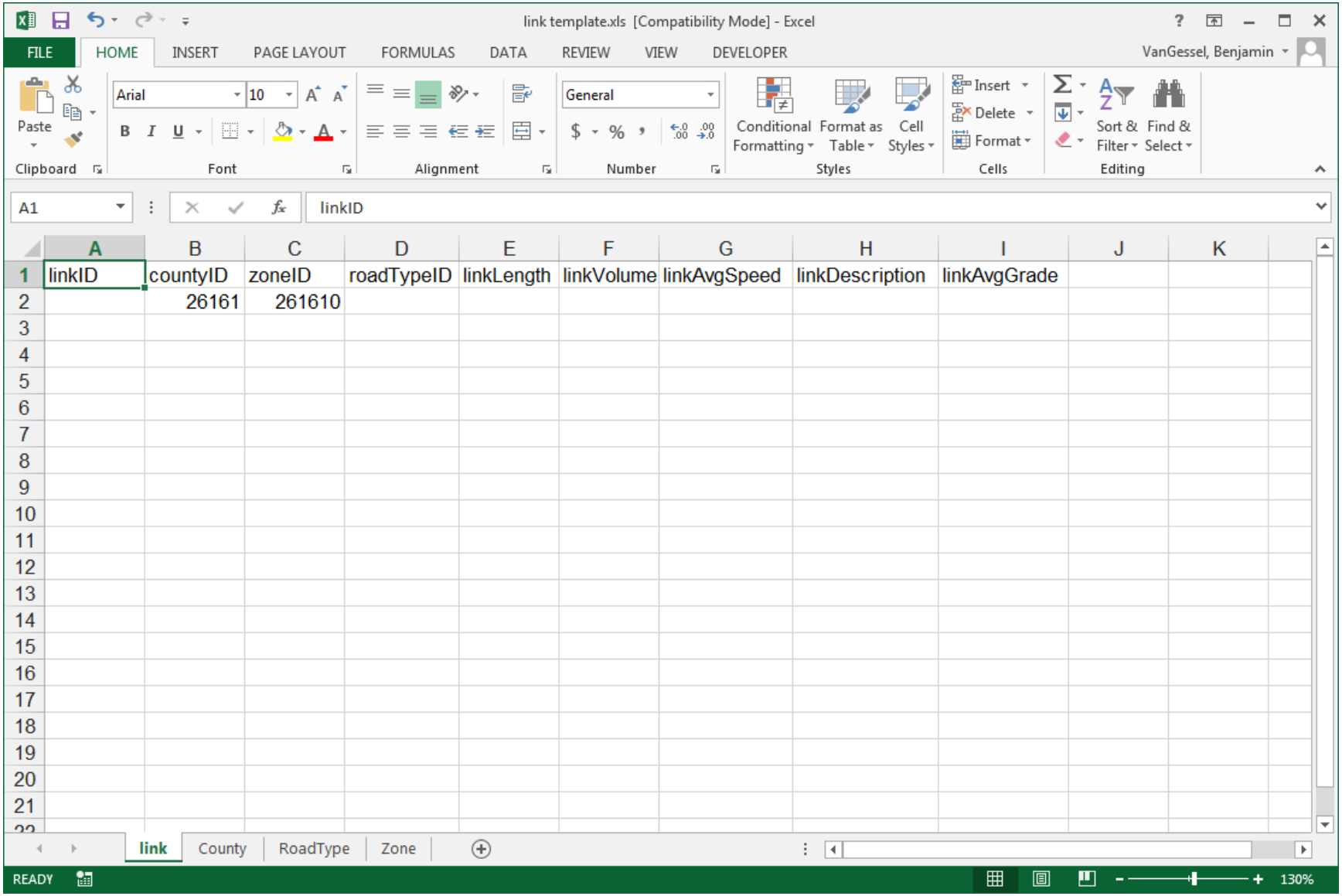
Links Input


link template.xls [Compatibility Mode] - Excel
FILE
HOME
INSERT
PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
DEVELOPER
VanGessel, Benjamin
Paste
Arial
10
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
A1
linkID
linkID
countyID
zoneID
roadTypeID
linkLength
linkVolume
linkAvgSpeed
linkDescription
linkAvgGrade
26161
261610
link
County
RoadType
Zone
READY
130%

Defining Vehicle Activity on Running Links

Users may choose one or more options:

1. Define a link average speed (through the "Links" input)
   - MOVES includes default OpMode distributions based on typical driving cycles

2. Enter a link specific drive cycle, through "Link Drive Schedule" input
   - User defines a second-by-second drive cycle for each link

3. Directly enter a link specific OpMode distribution, through "Operating Mode Distribution" input
   - Precisely describes distribution of activity on a link (fraction of time spent in each OpMode bin)
   - Not a typical output from current traffic models

More about these options later in this module

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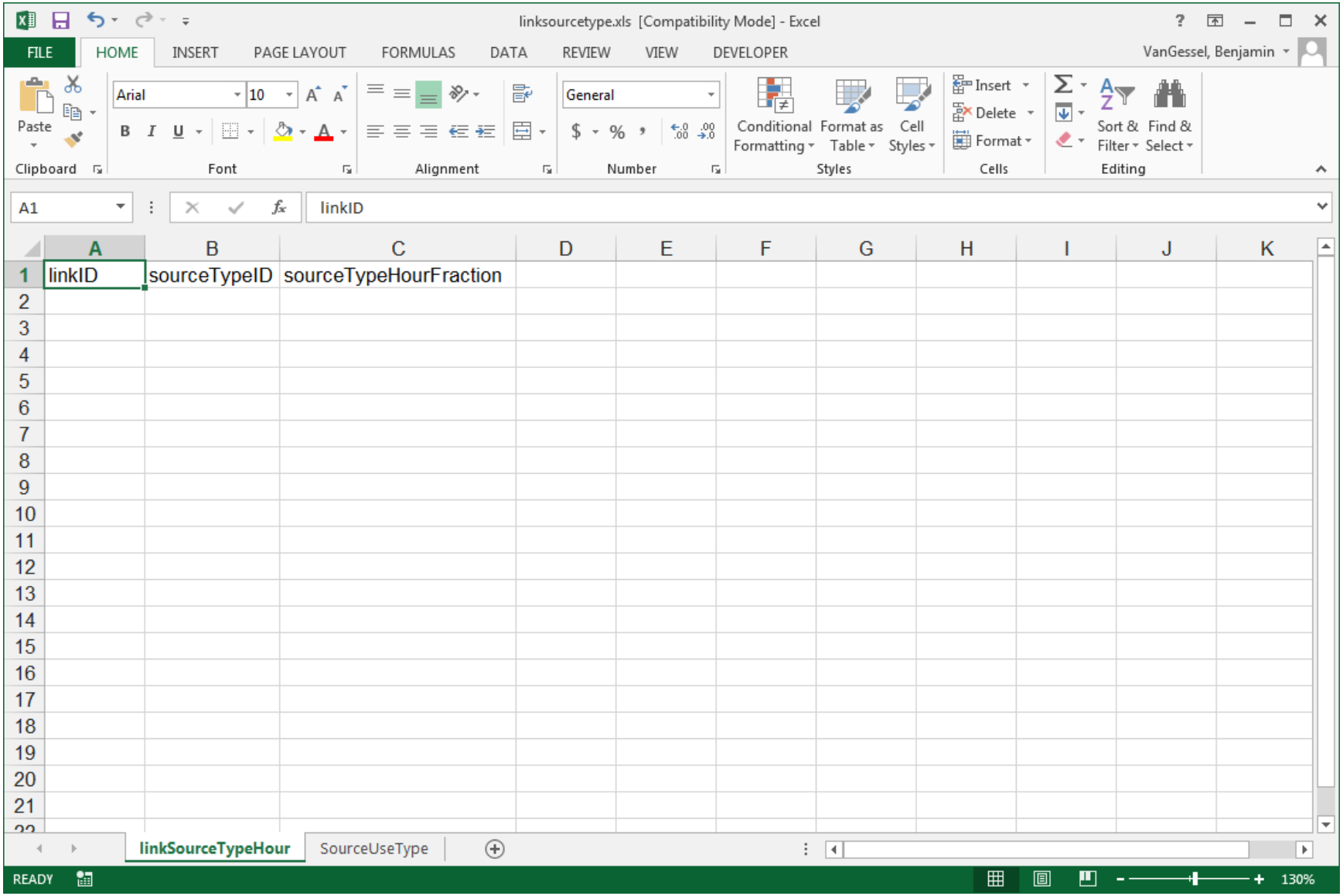
Link Source Type Input (Running Links)

- Three columns need to be completed for each link:
  - LinkID
    - Must include all roadway LinkIDs defined in Links Input
  - SourceType
    - Must include all source types selected in On Road Vehicle/Equipment panel
  - SourceTypeHourFraction
    - Specify vehicle mix (fraction of VHT) on each link
    - Fractions must sum to “1” for each linkID

- Note: This input is not used for an off-network link

Link Source Type Input (Running Links)



Off-Network Link Examples

Bus terminal: start activity only

Truck terminal: start and hotelling activity

- An off-network link represents start and/or hotelling emissions only
- Any driving activity, including idling, that takes place in the same area should be represented with running links
  - E.g., Buses idling at a bus terminal are not hotelling; represent activity with a running link

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Off-Network Link Examples

Park and ride lot

- Start activity only
  - No trucks and therefore no hotelling

Inputs Unique to Project Scale: Off-Network Link

- For an off-network link, you will need to complete:
  - Links: same input as running links
  - Off-Network: Used to describe activity on such a link
  - Operating Mode Distribution: Used to describe fraction of time in each operating mode bin

  Optional:
  - Hotelling Activity Distribution: Used to define type of hotelling activity (only applicable if modeling combination long-haul truck hotelling)

- MOVES can currently model only one off-network link per run

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Links Input for an Off-Network Link

- There are 9 columns that need to be completed:
  - LinkID: name of each link in the project, user provides
  - CountyID: Five digit code (comes with template)
  - ZoneID: county ID with zero at the end (comes with template)
  - RoadTypeID: off-network road type is 1
  - Link Length: for the off-network link, enter “0”
  - Link Volume: total traffic volume in one hour, user provides
  - Link Average Speed: for the off-network link, enter “0”
  - Link Description: optional text field, user provides
  - Link Grade: for the off-network link, enter “0”

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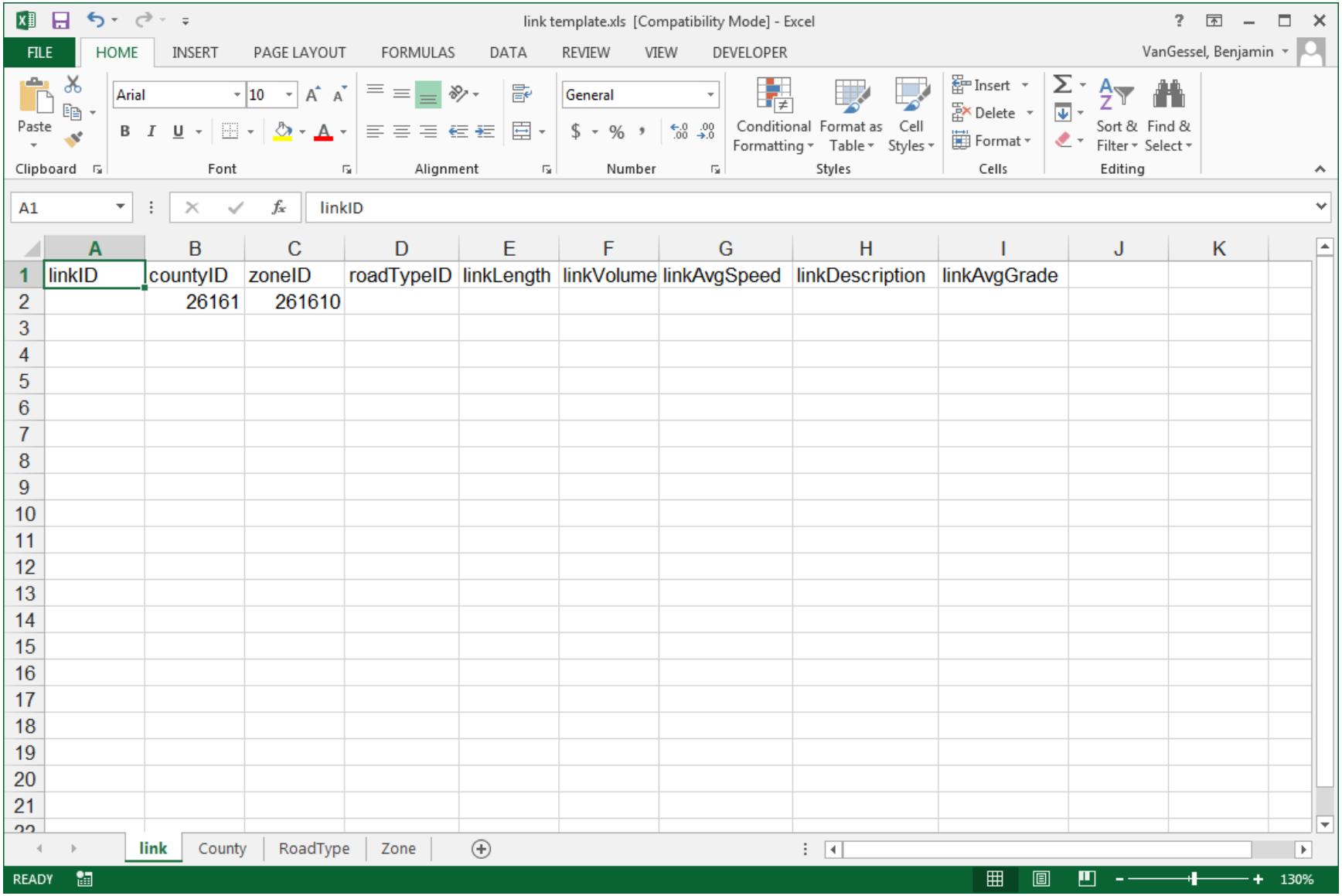
Links Input


link template.xls [Compatibility Mode] - Excel
FILE
HOME
INSERT
PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
DEVELOPER
VanGessel, Benjamin
Paste
Arial
10
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
A1
linkID
linkID
countyID
zoneID
roadTypeID
linkLength
linkVolume
linkAvgSpeed
linkDescription
linkAvgGrade
26161
261610
link
County
RoadType
Zone
READY
130%

Off-Network Input

This input includes six columns:

- ZoneID
- Source Type ID
- Vehicle Population: Average number of off-network vehicles
- Start Fraction: Average fraction of the population which has been started during the hour
  - (may be greater than 1.0 if the average vehicle is started more than once per hour)
- Extended Idle Fraction: Enter range 0 – 1.0
  - Fraction of source hours where hotelling is occurring (e.g. if vehicle population is 20 and 10 vehicles are hotelling for entire hour, enter fraction of 0.5)
  - Used only for long-haul combination trucks (sourcetypeid 62)
- Parked Vehicle Fraction
  - Used only for evaporative emissions and is currently inactive

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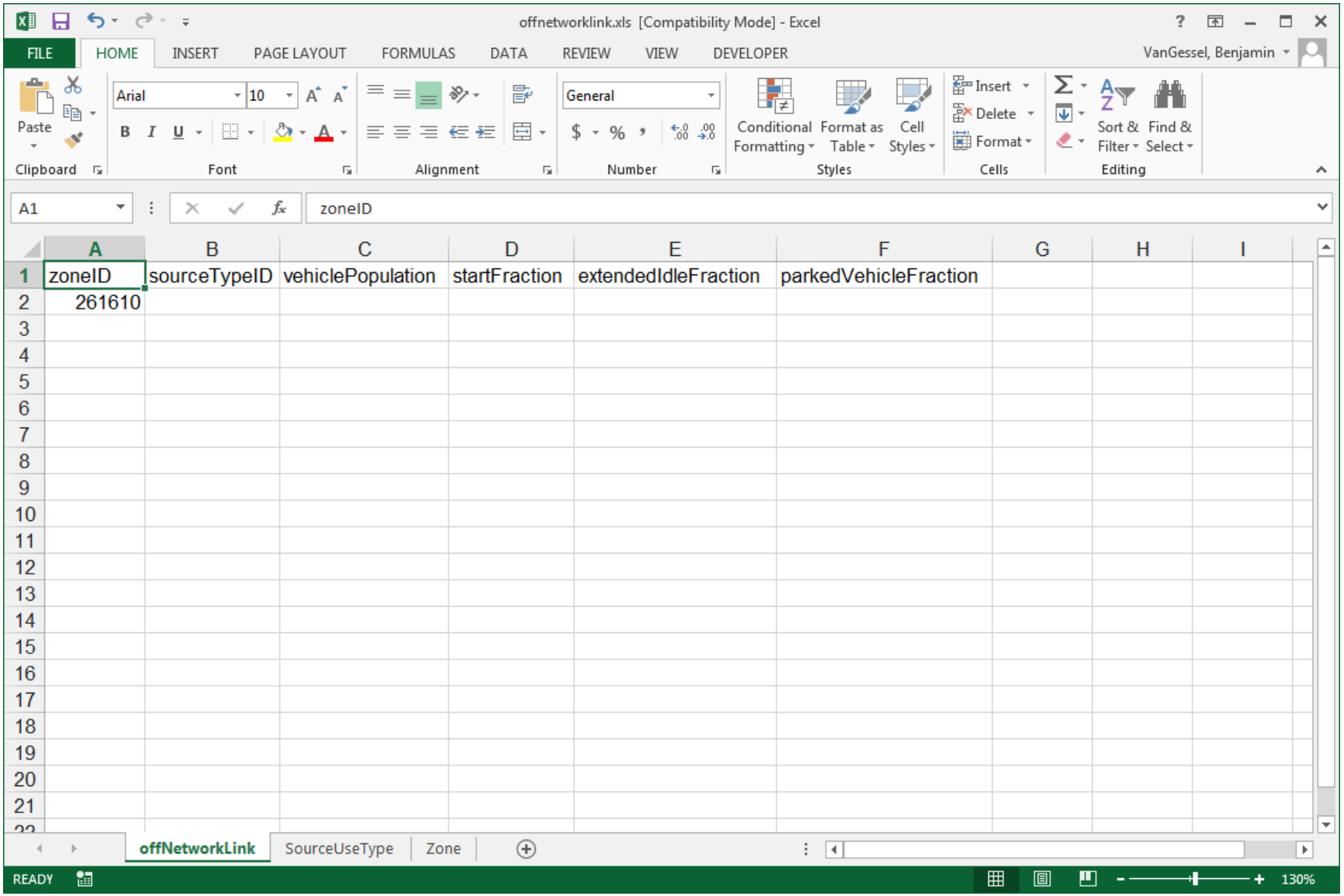
Off-Network Input



Operating Mode Distribution Input

This input needed for off-network link and includes six columns:

- sourceTypeID
- hourDayID
- linkID: in this case, just the off-network link
- pollutantProcessID: combination of pollutant and emissions process producing it
- opModeID: conditions affecting the emissions process, e.g., soak time (how long the vehicle was parked)
- opModeFraction
  - Fraction of the population that is in each operating mode
  - For some processes, there is only one operating mode, and the fraction is always 1
  - For starts, the fractions represent the fraction of the population which has been started during the hour (may be greater than 1.0 if the average vehicle is started more than once per hour)
  - For hoteling, set the opModeFraction to 1 for both opModeID =200 and opModeID =201

Note: this input is optional for running links

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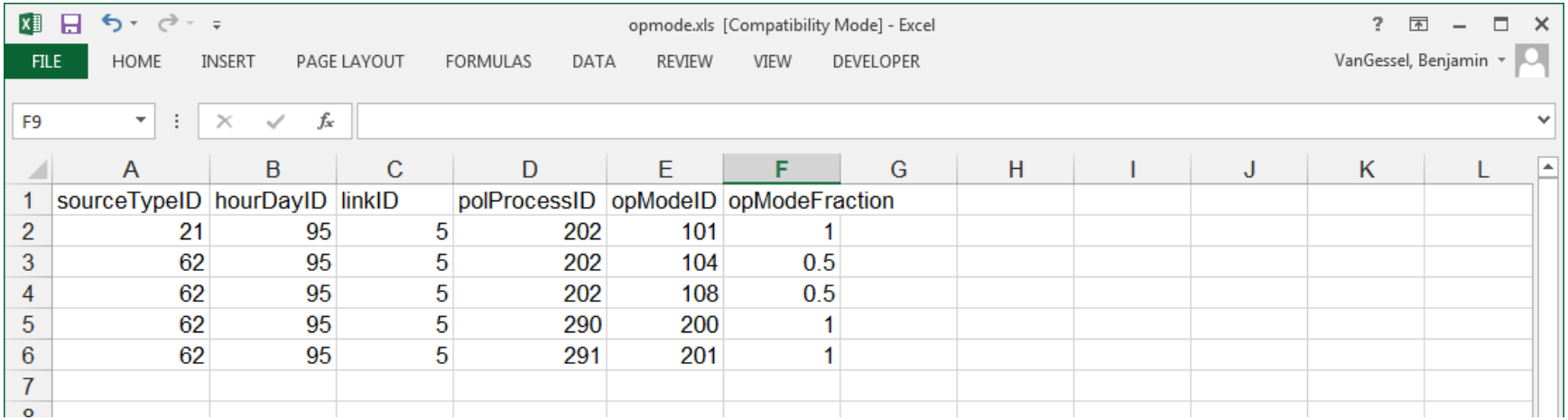
Off-Network Input: Operating Mode



	A	B	C	D	E	F	G	H	I	J	K	L
1	sourceTypeID	hourDayID	linkID	polProcessID	opModeID	opModeFraction						
2	21	95	5	202	101	1						
3	62	95	5	202	104	0.5						
4	62	95	5	202	108	0.5						
5	62	95	5	290	200	1						
6	62	95	5	291	201	1						
7												

polProcess IDs:

21	190	90	Extended Idle Exhaust	1	Total Gaseous Hydrocarbons
22	191	91	Auxiliary Power Exhaust	1	Total Gaseous Hydrocarbons
23	201	1	Running Exhaust	2	Carbon Monoxide (CO)
24	202	2	Start Exhaust	2	Carbon Monoxide (CO)
25	215	15	Crankcase Running Exhaust	2	Carbon Monoxide (CO)
26	216	16	Crankcase Start Exhaust	2	Carbon Monoxide (CO)
27	217	17	Crankcase Extended Idle Exhaust	2	Carbon Monoxide (CO)
28	240	40	Nonroad	2	Carbon Monoxide (CO)
29	290	90	Extended Idle Exhaust	2	Carbon Monoxide (CO)
30	291	91	Auxiliary Power Exhaust	2	Carbon Monoxide (CO)
31	301	1	Running Exhaust	3	Oxides of Nitrogen (NOx)
32	302	2	Start Exhaust	3	Oxides of Nitrogen (NOx)

opMode IDs:

28	101	Soak Time < 6 minutes
29	102	6 minutes <= Soak Time < 30 minutes
30	103	30 minutes <= Soak Time < 60 minutes
31	104	60 minutes <= Soak Time < 90 minutes
32	105	90 minutes <= Soak Time < 120 minutes
33	106	120 minutes <= Soak Time < 360 minutes
34	107	360 minutes <= Soak Time < 720 minutes
35	108	720 minutes <= Soak Time
36	150	Hot Soaking
37	151	Cold Soaking
38	200	Extended Idling
39	201	Hotelling Diesel Aux
40	203	Hotelling Battery AC
41	204	Hotelling APU Off

Hotelling Input (Optional, Off-Network Link)

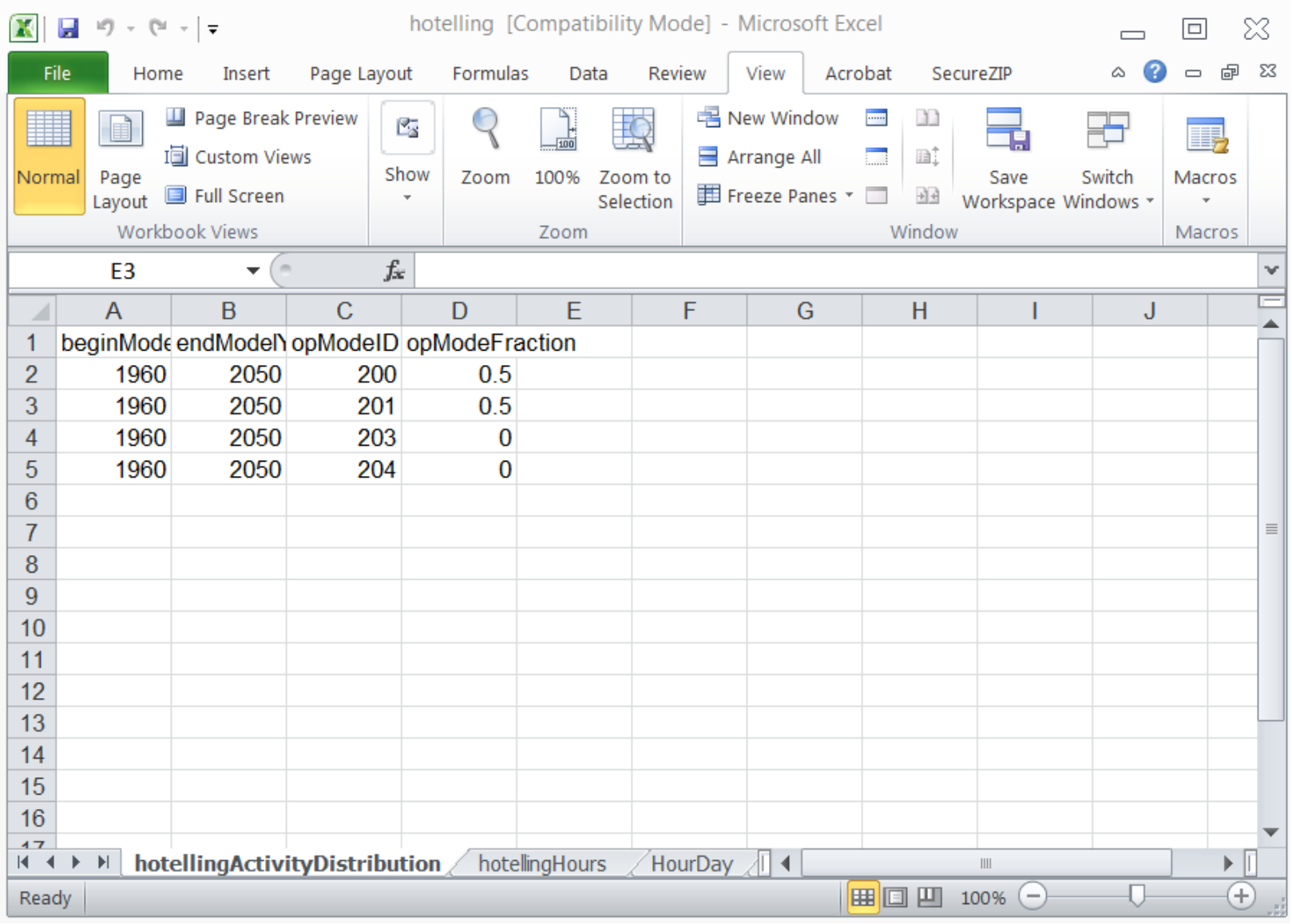
This input includes four columns:

- Beginning model year of trucks hotelling
- Ending model year of trucks hotelling
- opModeID:

28	101	Soak Time < 6 minutes
29	102	6 minutes <= Soak Time < 30 minutes
30	103	30 minutes <= Soak Time < 60 minutes
31	104	60 minutes <= Soak Time < 90 minutes
32	105	90 minutes <= Soak Time < 120 minutes
33	106	120 minutes <= Soak Time < 360 minutes
34	107	360 minutes <= Soak Time < 720 minutes
35	108	720 minutes <= Soak Time
36	150	Hot Soaking
37	151	Cold Soaking
38	200	Extended Idling
39	201	Hotelling Diesel Aux
40	203	Hotelling Battery AC
41	204	Hotelling APU Off

- opModeFraction: fraction of the population that is in each operating mode

Hotelling Input



Hotelling Summary

Hotelling information entered in three tables:

- Off-Network input
  - Fraction of source hours when hoteling is occurring
- Hotelling input
  - Fraction of the vehicle population that is in each operating mode by model year range
  - Operating modes are extended idle (truck engine on), auxiliary power unit (APU on)
- Operating Mode Distribution input
  - Always set op modes 200 and 201 equal to 1

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Project Scale Class Demonstration

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Demonstration Objectives

- Use the MOVES project scale in a practical example: modeling carbon monoxide emissions from a freight terminal and connector links
- Evaluate emissions under two activity input options
  - Run #1: Average Speeds
  - Run #2: Drive Cycles (link-drive schedule)
- Produce link specific grams/hour emission factors for use in air quality modeling
- Demonstrates full-range of MOVES capabilities at the project scale, but is not intended to reflect technical or policy guidance

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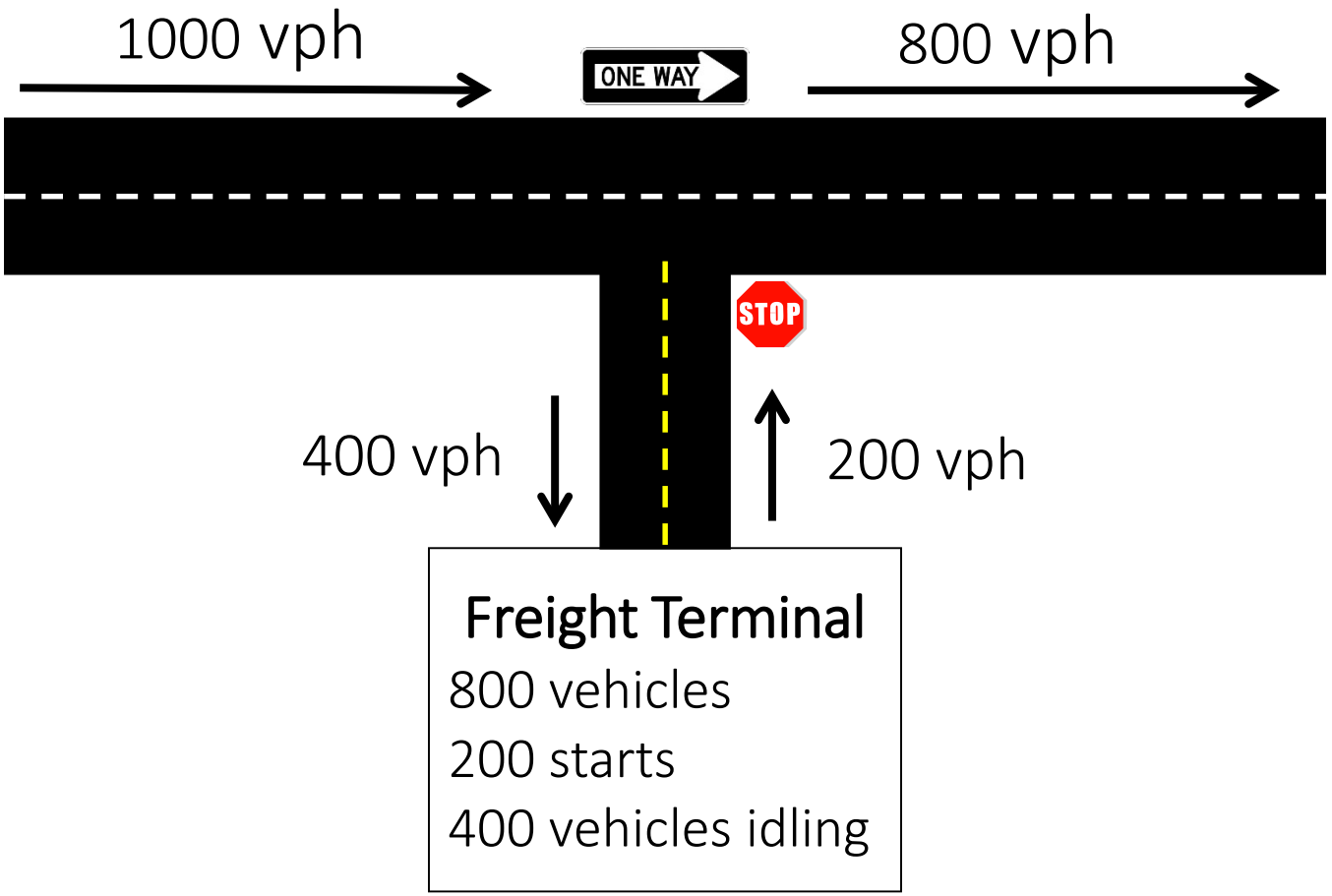
Project Scenario



Scenario Assumptions

- Only CO emissions from running, starts, extended idle and APU considered (no crank-case emissions considered for simplicity)
- The on-road links (running links) consist of heavy-duty combination long-haul diesel trucks and passenger vehicles (source types 62 and 21)
  - not realistic, but assumed for simplicity
- The off-network link consists of only heavy-duty combination long-haul diesel trucks
- Only looking at the peak hour

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Project Details

- Location County: Washtenaw County, MI
- Calendar Year: 2015
- Month: January
- Weekday/Weekend: Weekday
- Time: 8:00 AM to 8:59 AM
- Temperature: 20.3° F
- Humidity: 70.0 %
- Link Roadtype: Urban Unrestricted Access

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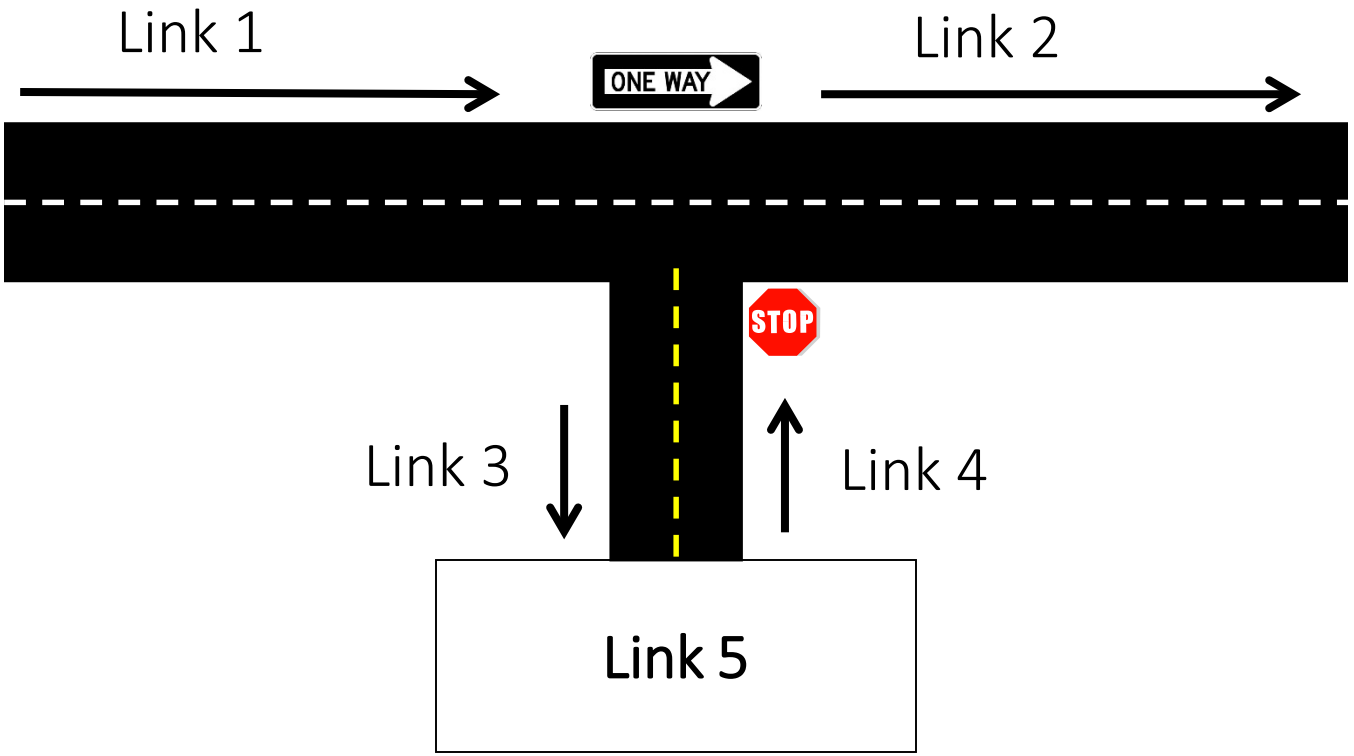
Project Link Details



Link ID	Road Type	Link Length	Link Volume	Truck Fraction	Car Fraction	Average Speed (accounting for intersection delay)
1	Urban Unrestricted	0.5 mi	1000	0.4	0.6	25 mph
2	Urban Unrestricted	0.5 mi	800	0.25	0.75	35mph
3	Urban Unrestricted	0.25 mi	400	1	0	15 mph
4	Urban Unrestricted	0.25 mi	200	1	0	15 mph
5	Off-Network	N/A	800	1	0	N/A

Off-Network Link Details: Freight Terminal

800 Trucks: 200 starts, 400 idle hours

• Average Vehicle Population	800 vehicles
• Start Fraction	0.25
• Hotelling Fraction	0.5
• Hotelling Activity Distribution	0.5 Extended Idle
	0.5 APU Use
• Soak Distribution	0.5 soaking 60 min to 90 min
	0.5 soaking >720 min

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Creating a MOVES Project Scale RunSpec

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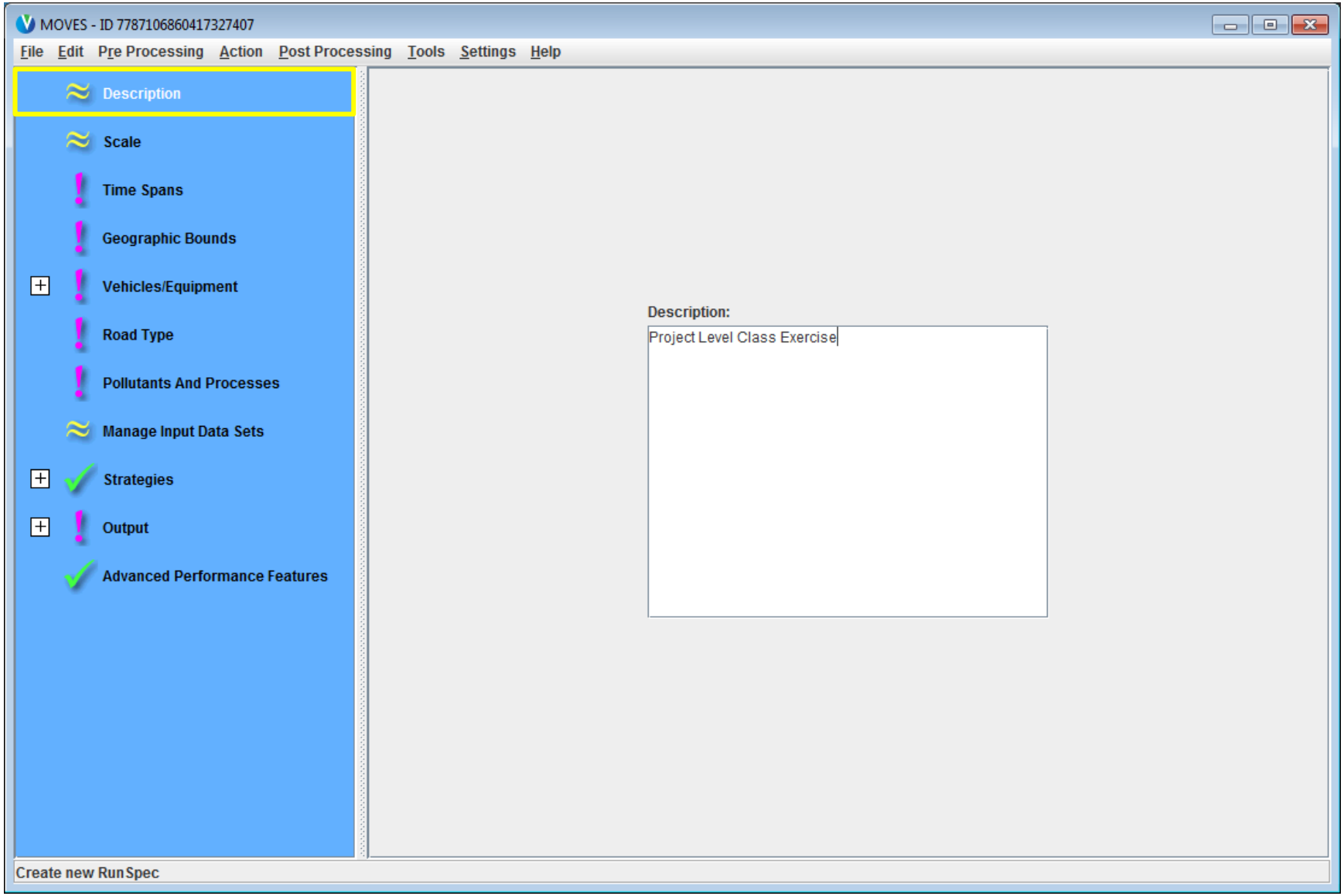
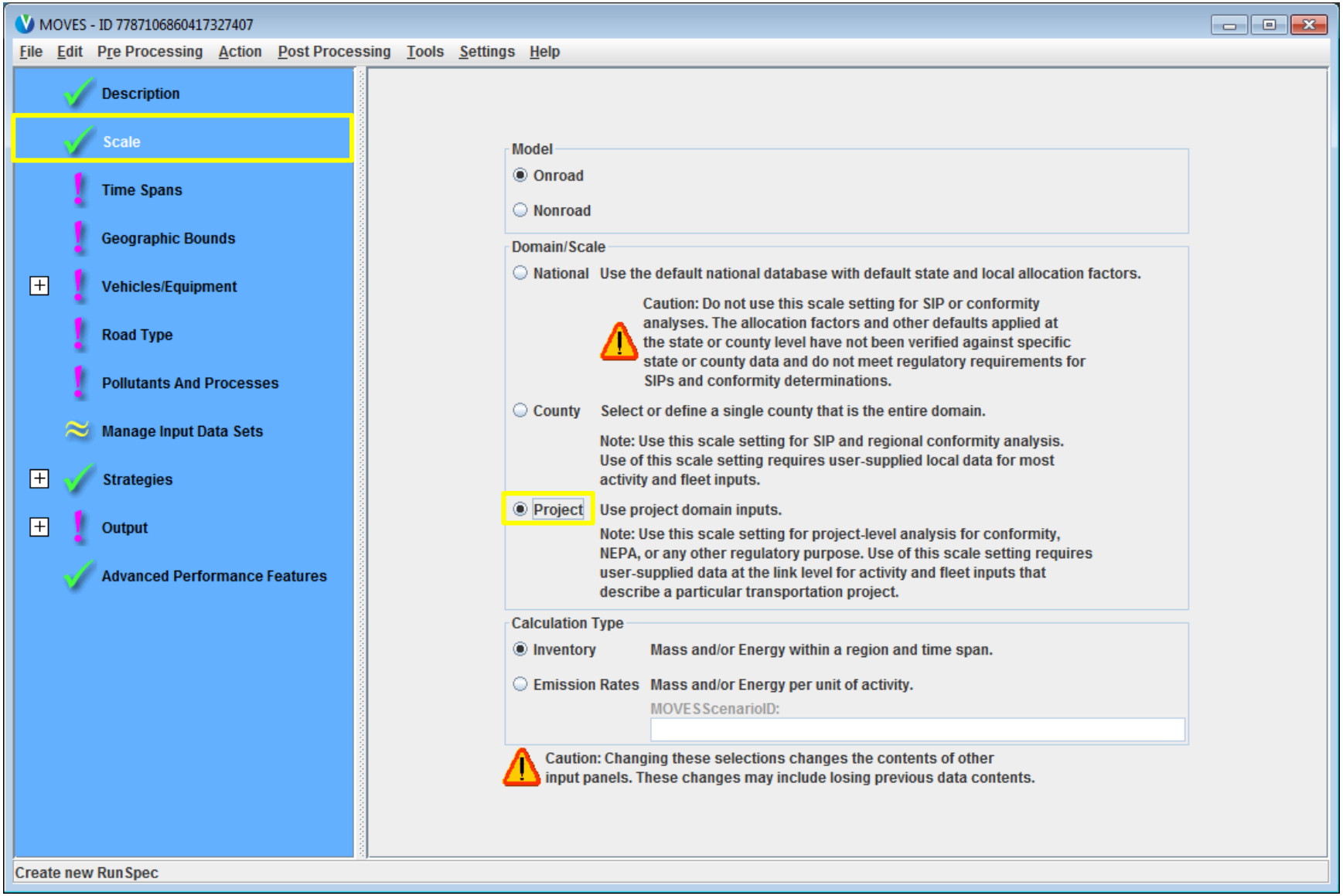
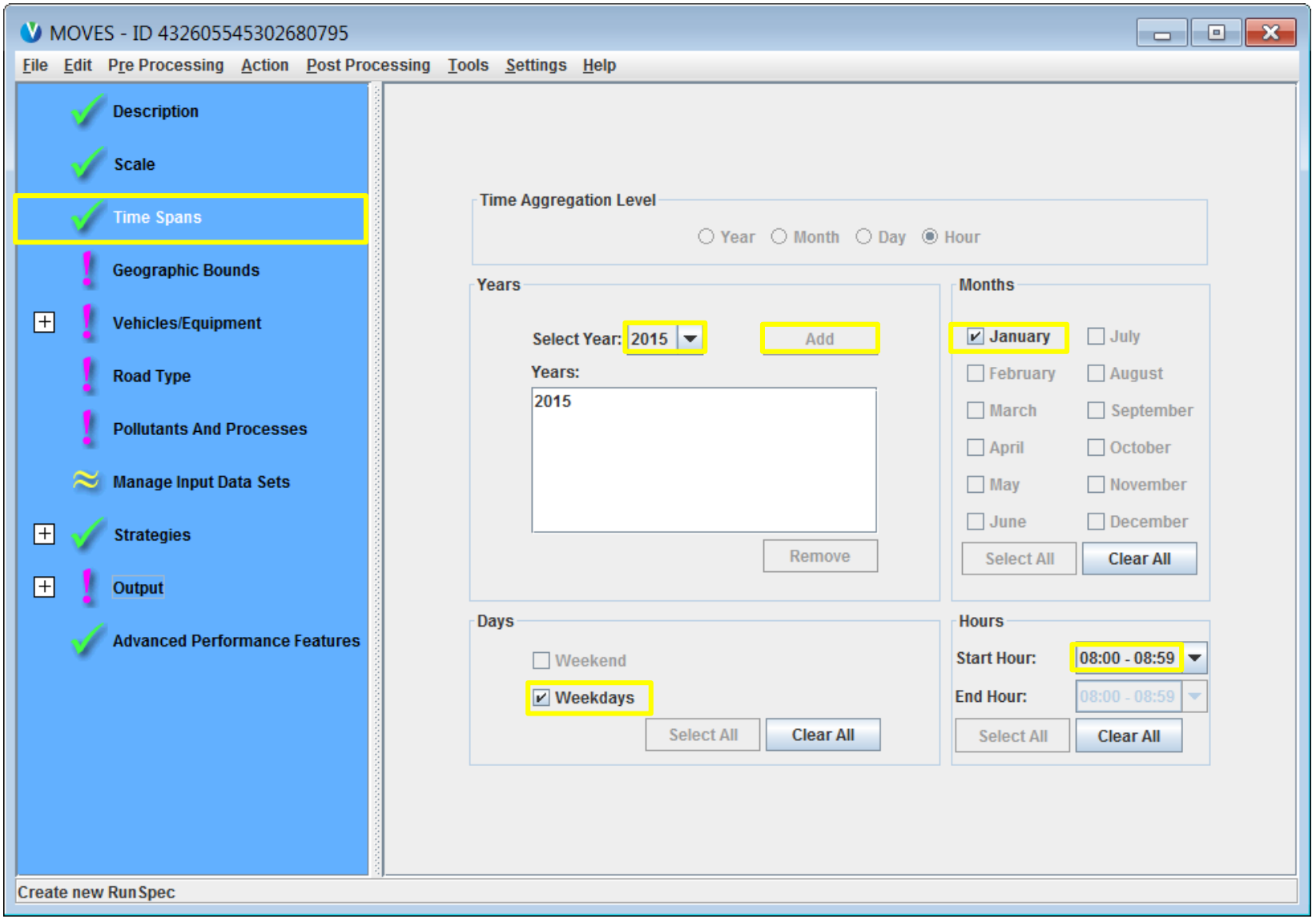
Creating a MOVES Project RunSpec



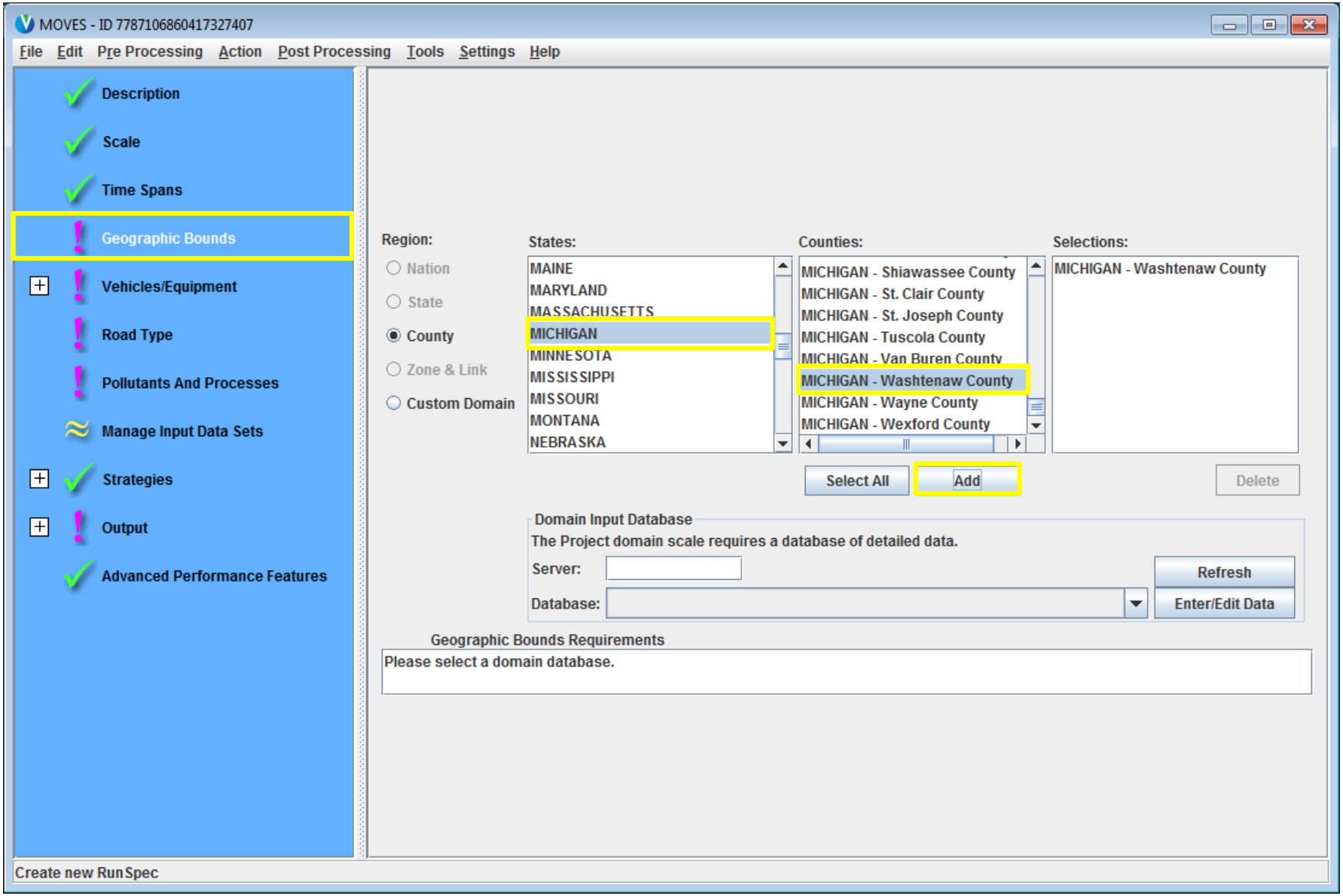
Creating a MOVES Project RunSpec



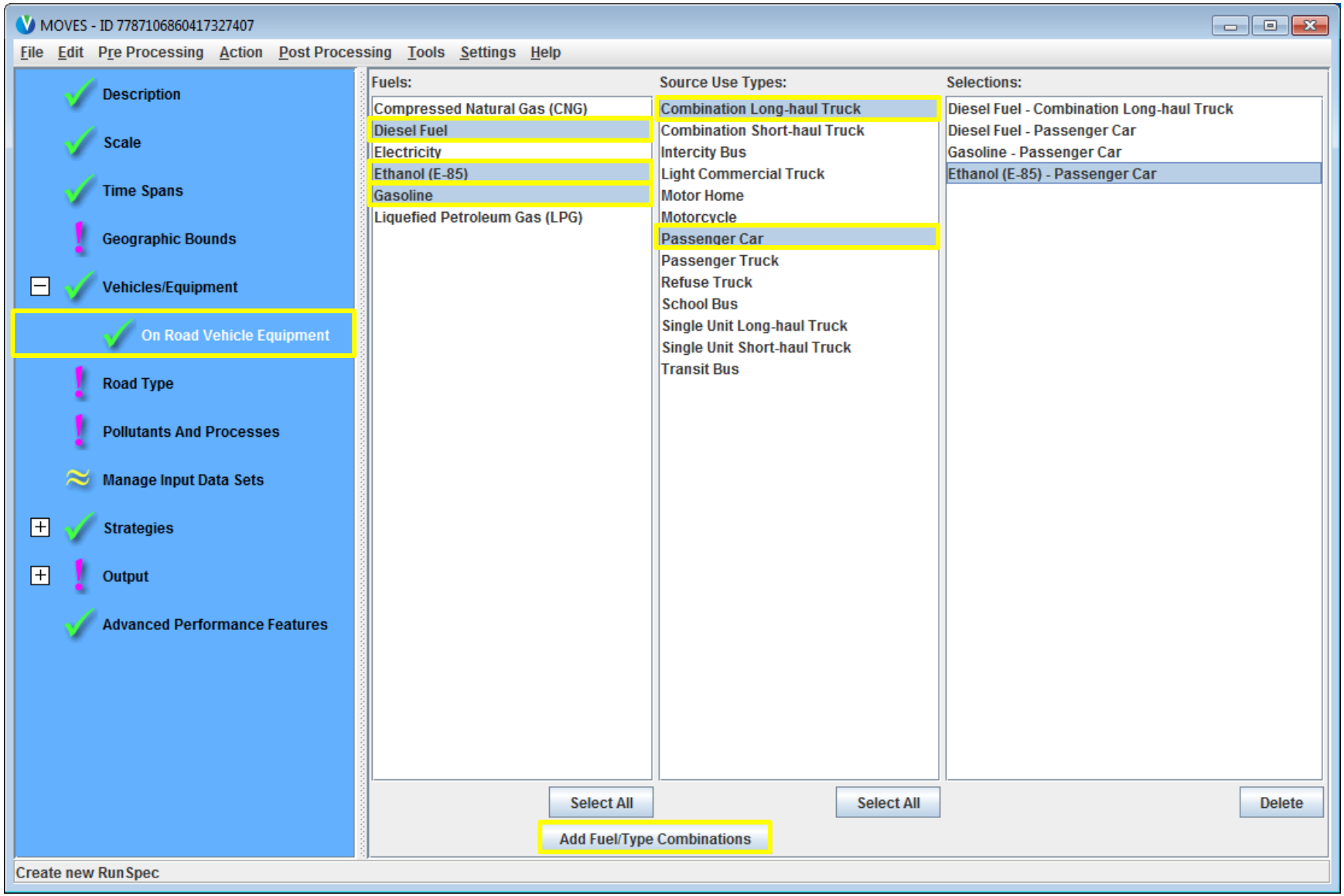
Creating a MOVES Project RunSpec



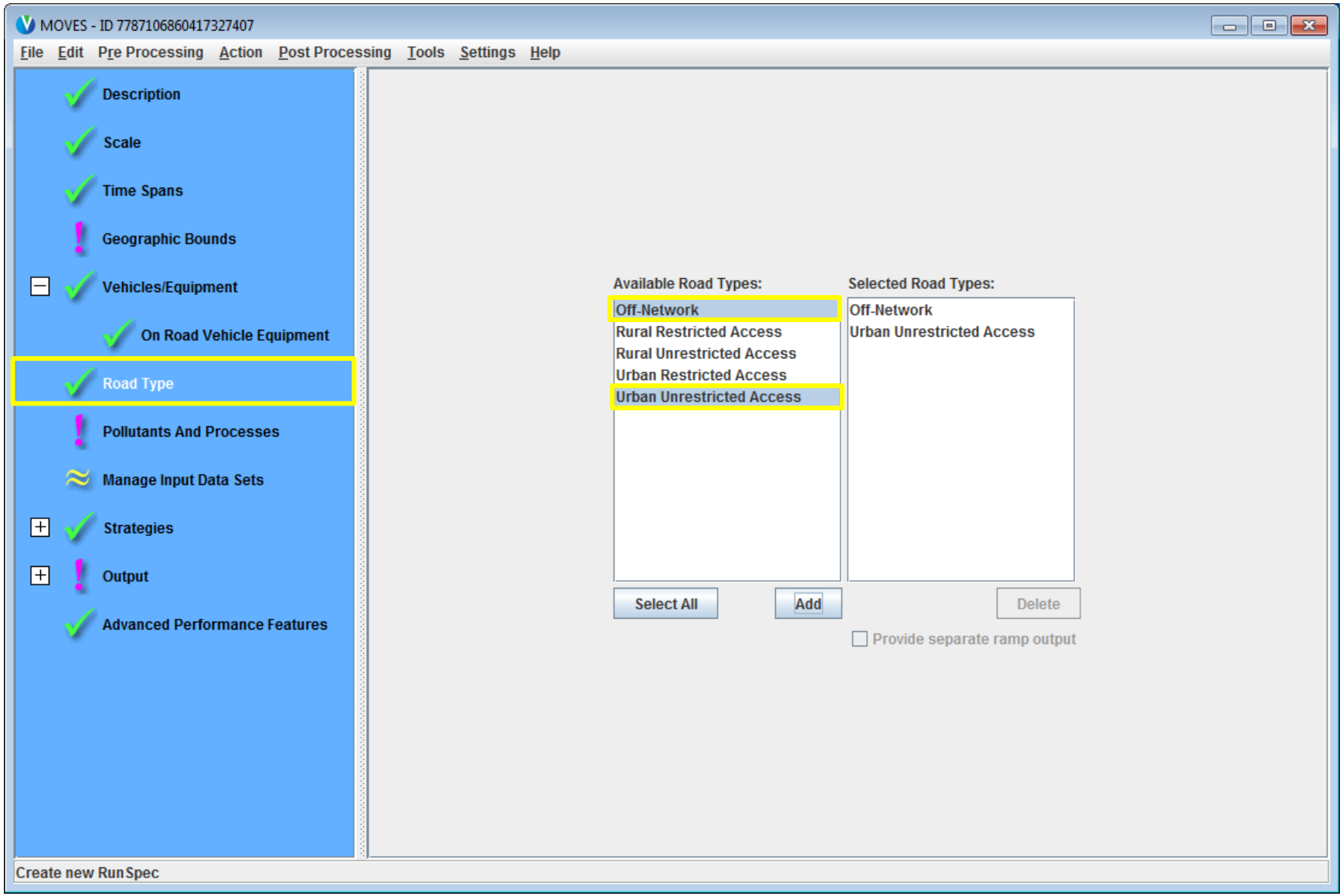
Creating a MOVES Project RunSpec



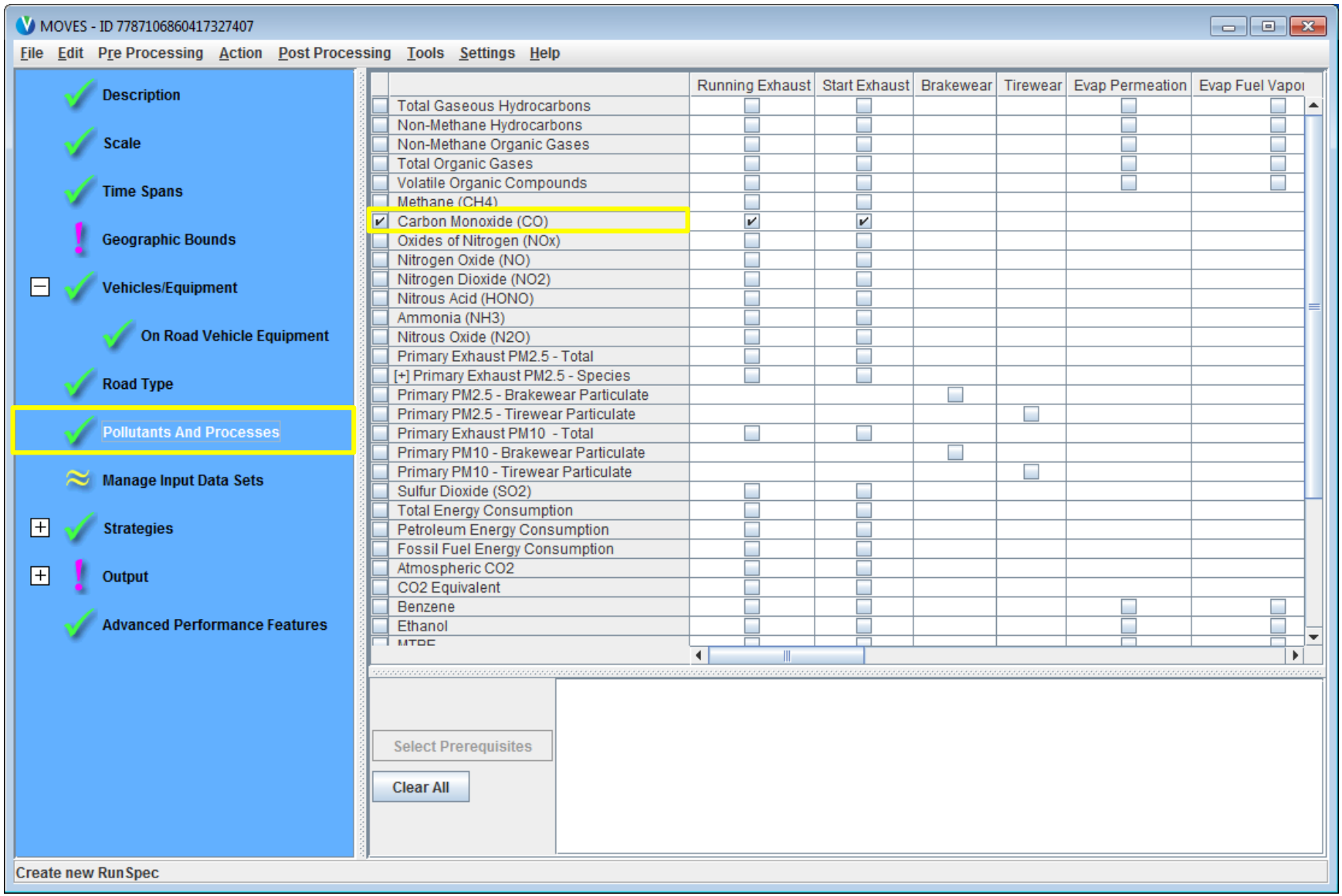
Creating a MOVES Project RunSpec



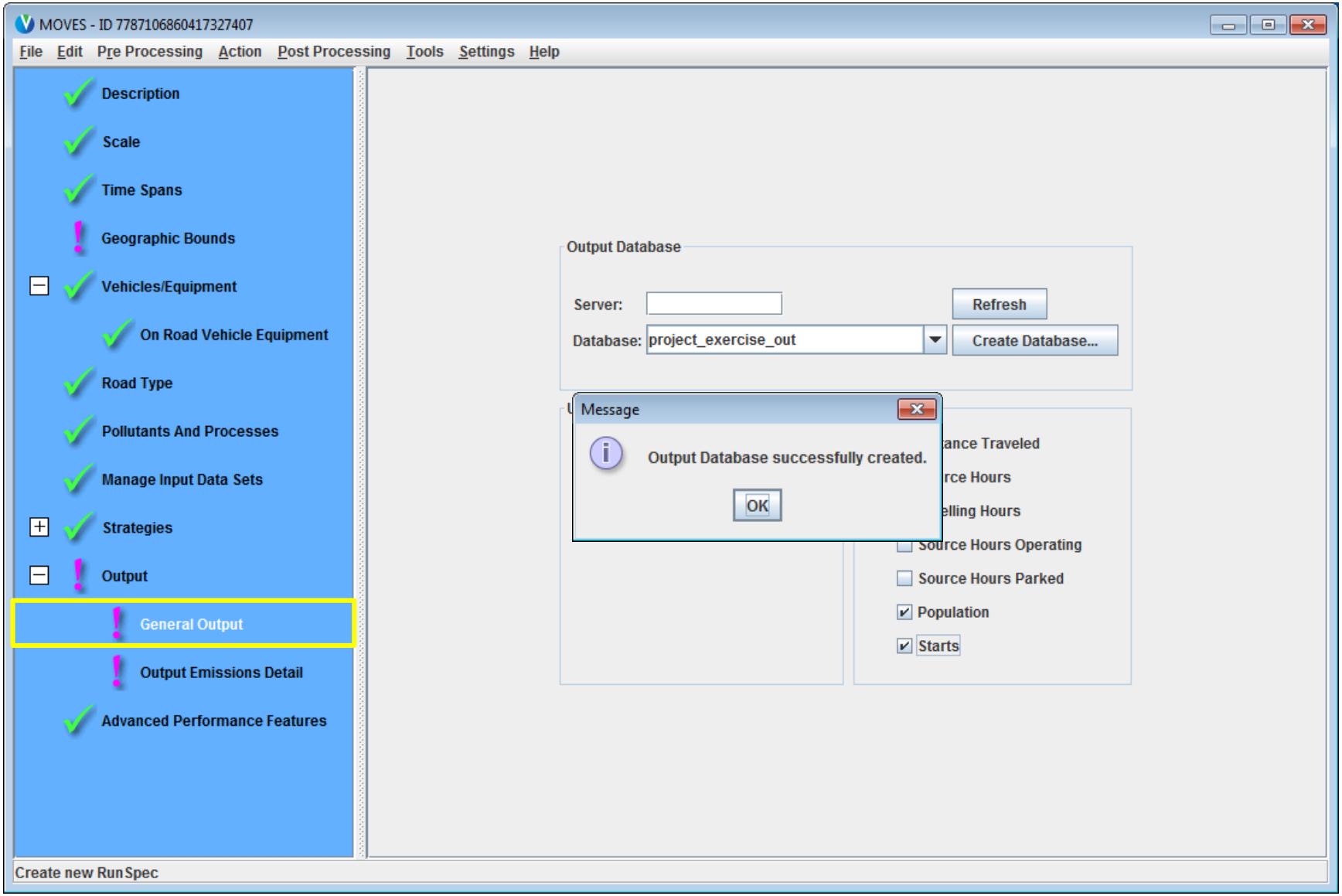
Creating a MOVES Project RunSpec



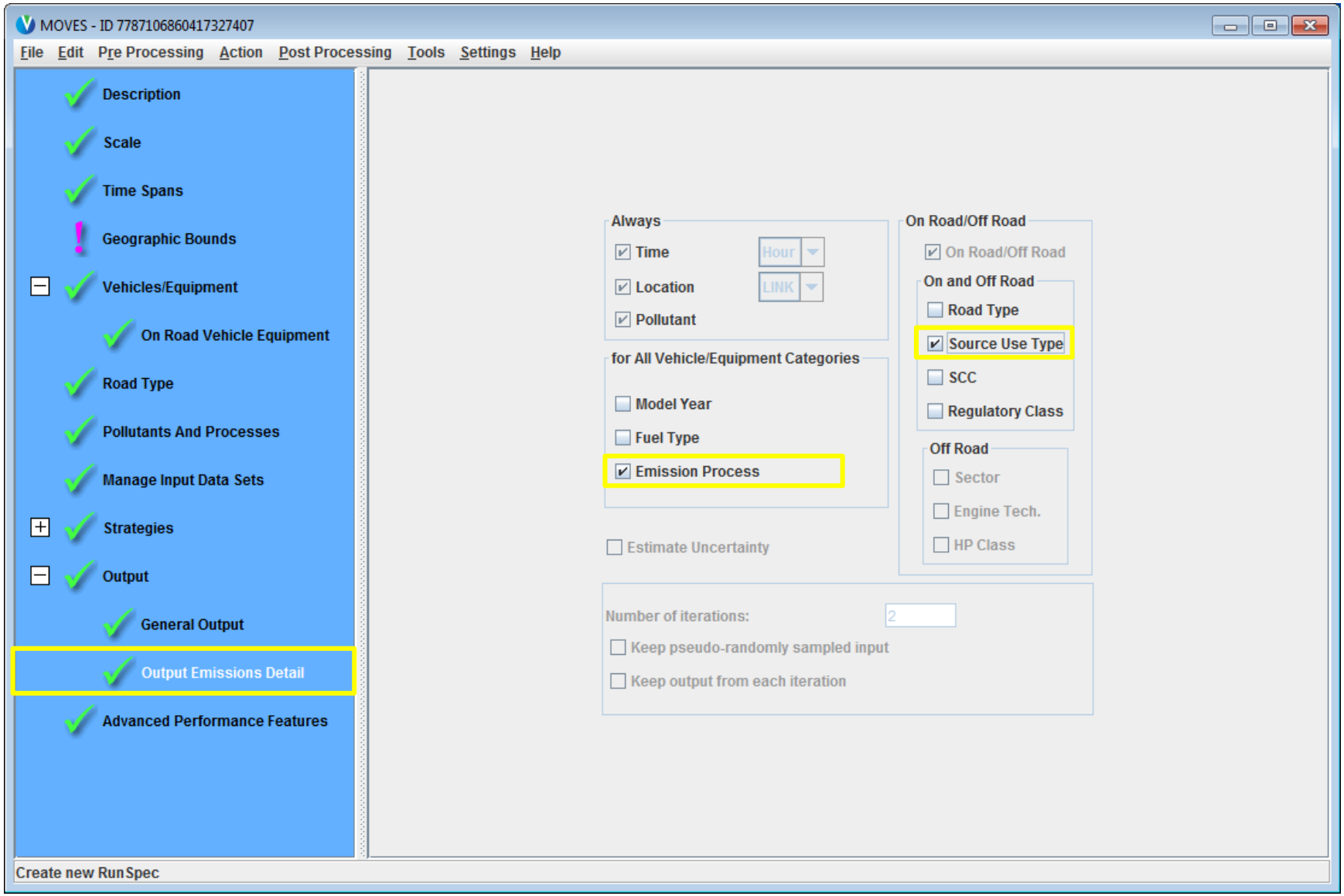
Creating a MOVES Project RunSpec



Creating a MOVES Project RunSpec



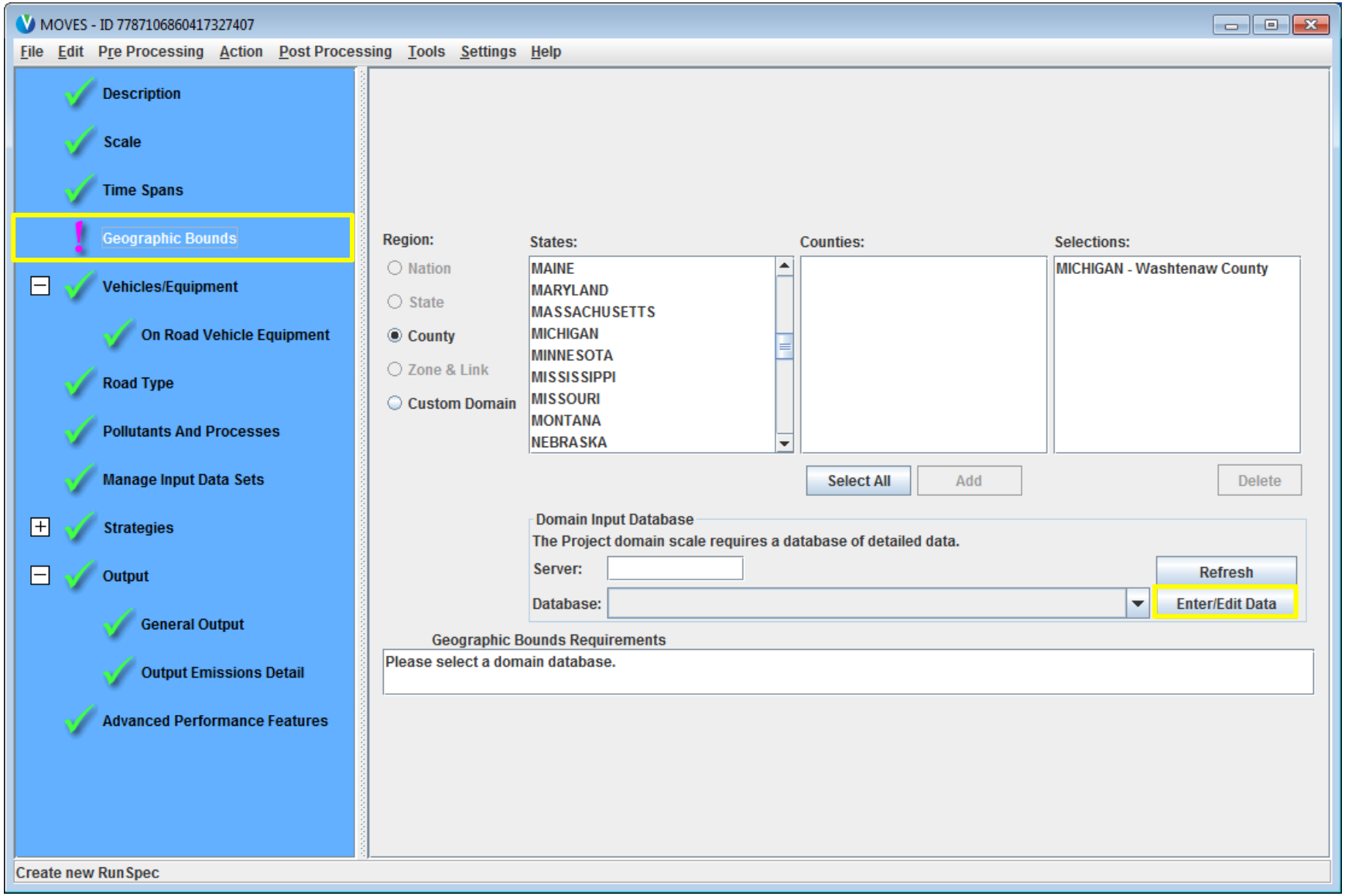
Creating a MOVES Project RunSpec



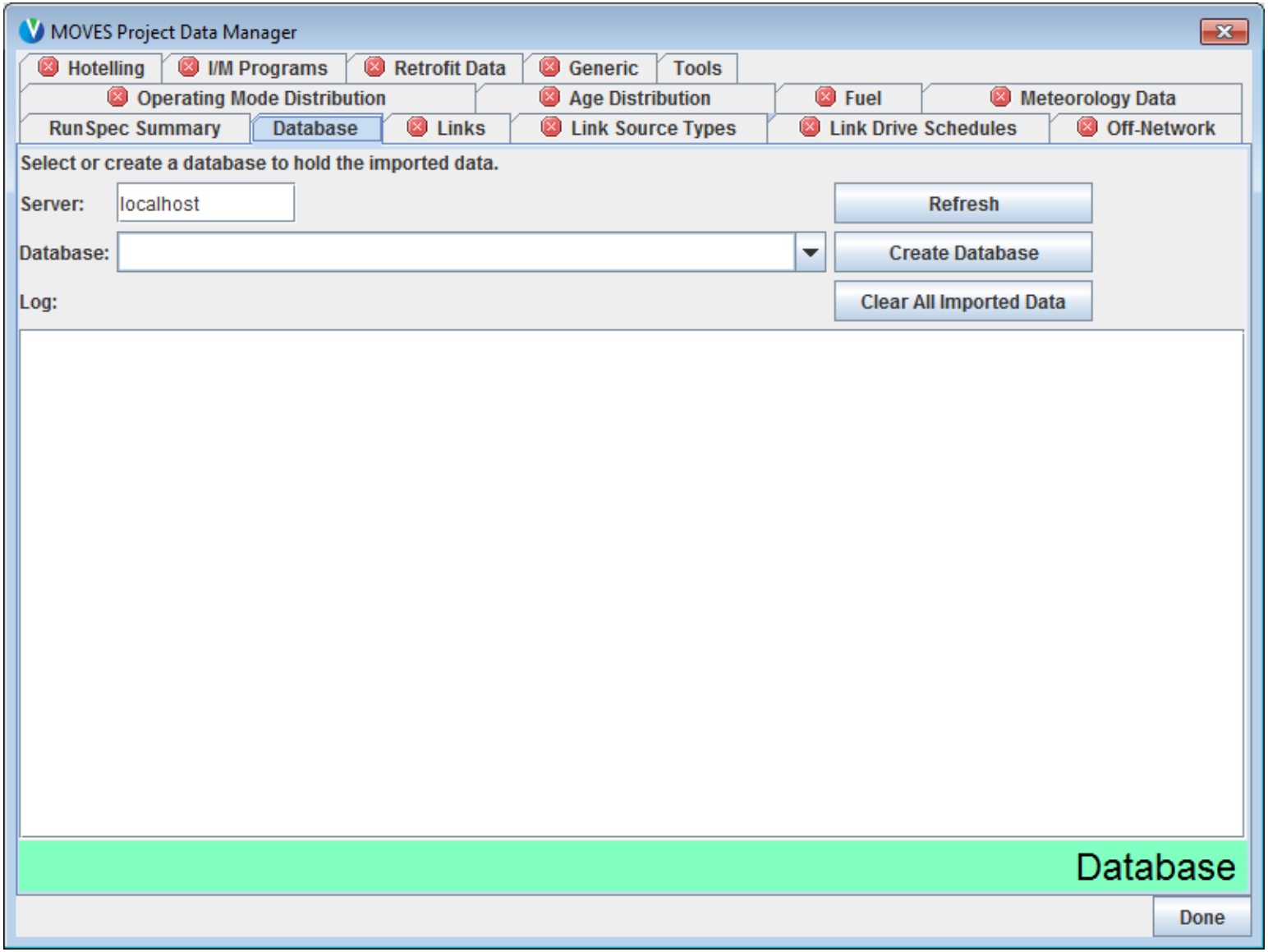
Creating an Input Database

EPA

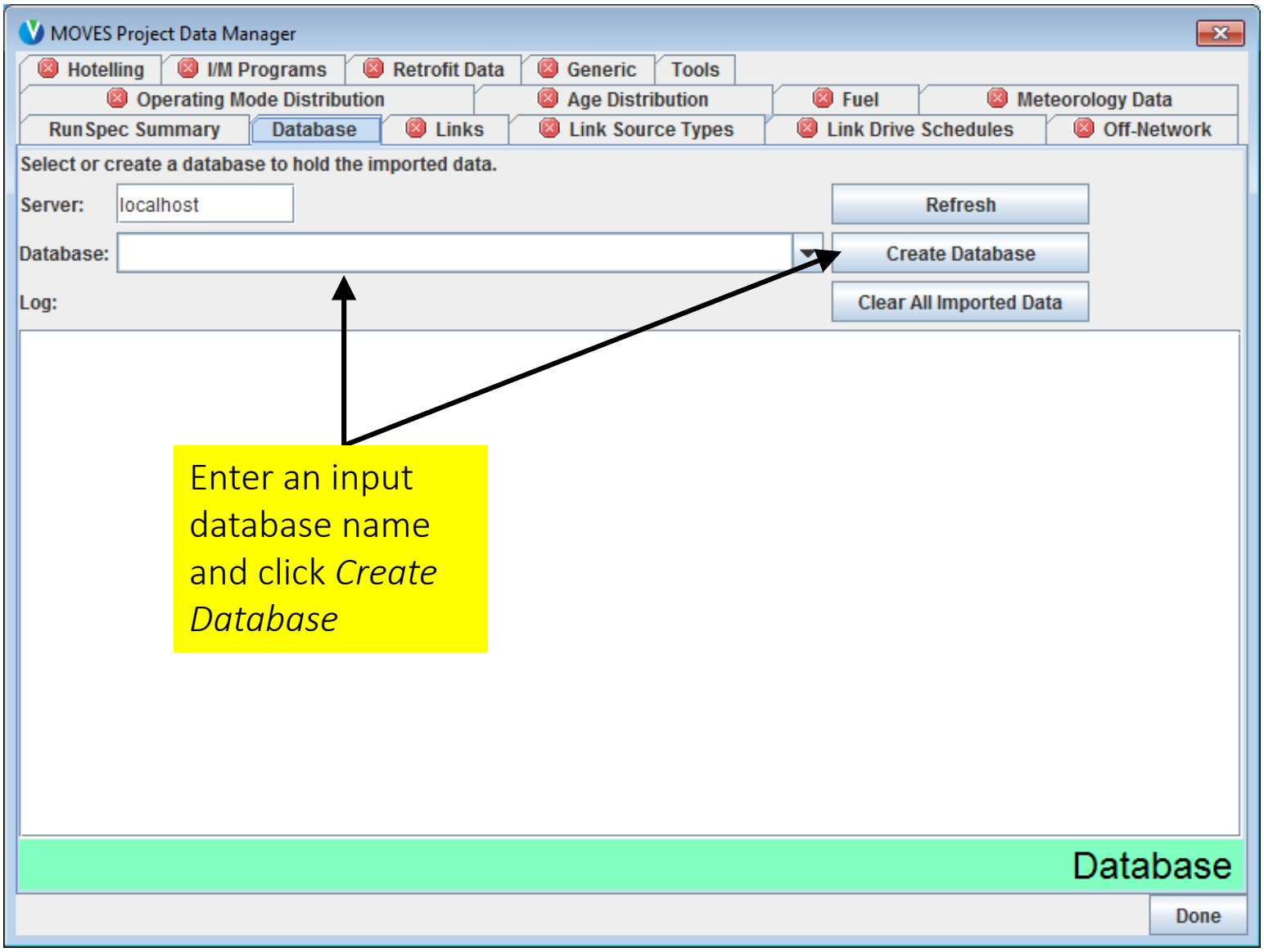
Opening the Project Data Manager



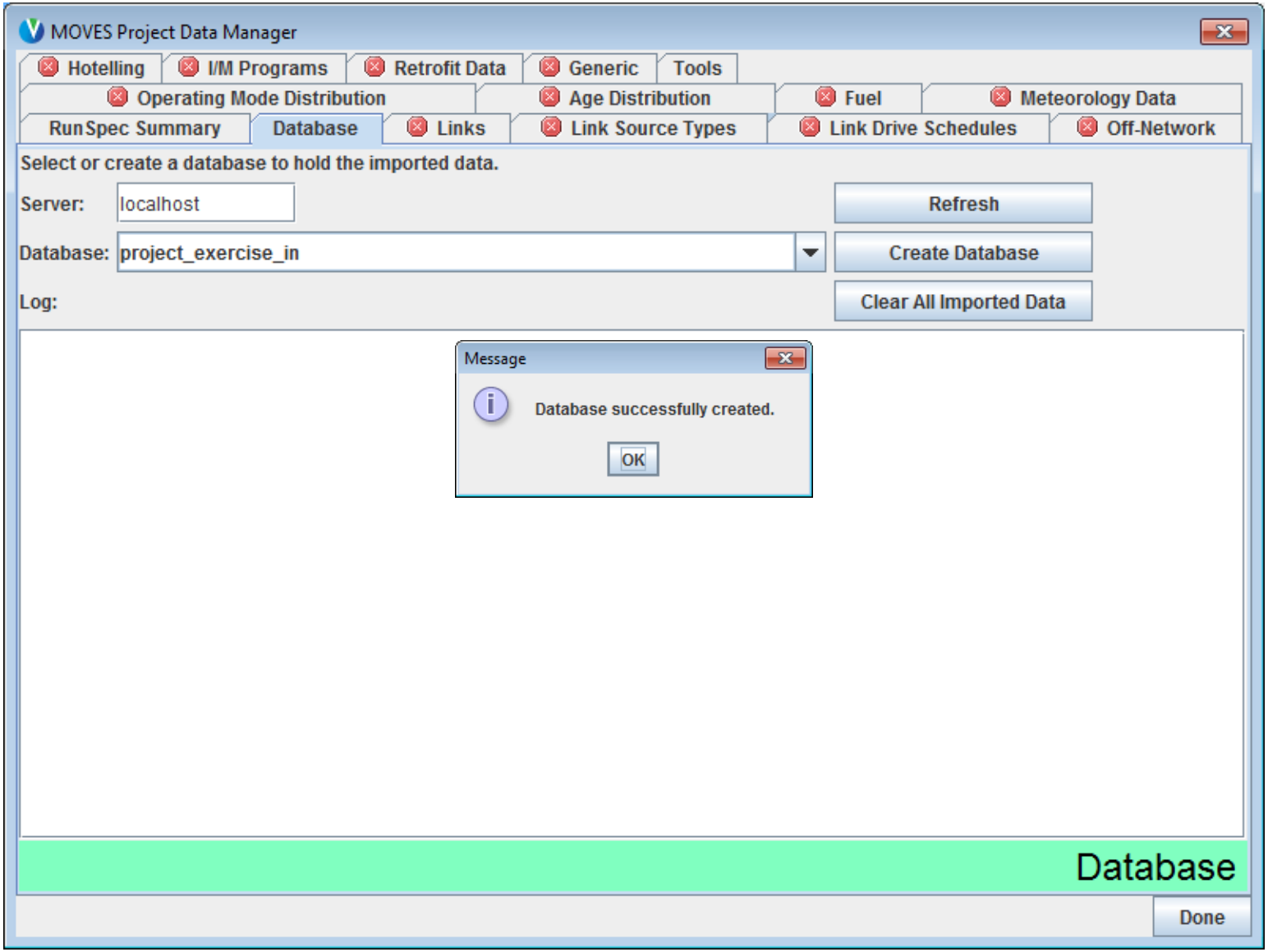
Project Data Manager



Project Data Manager



Project Data Manager

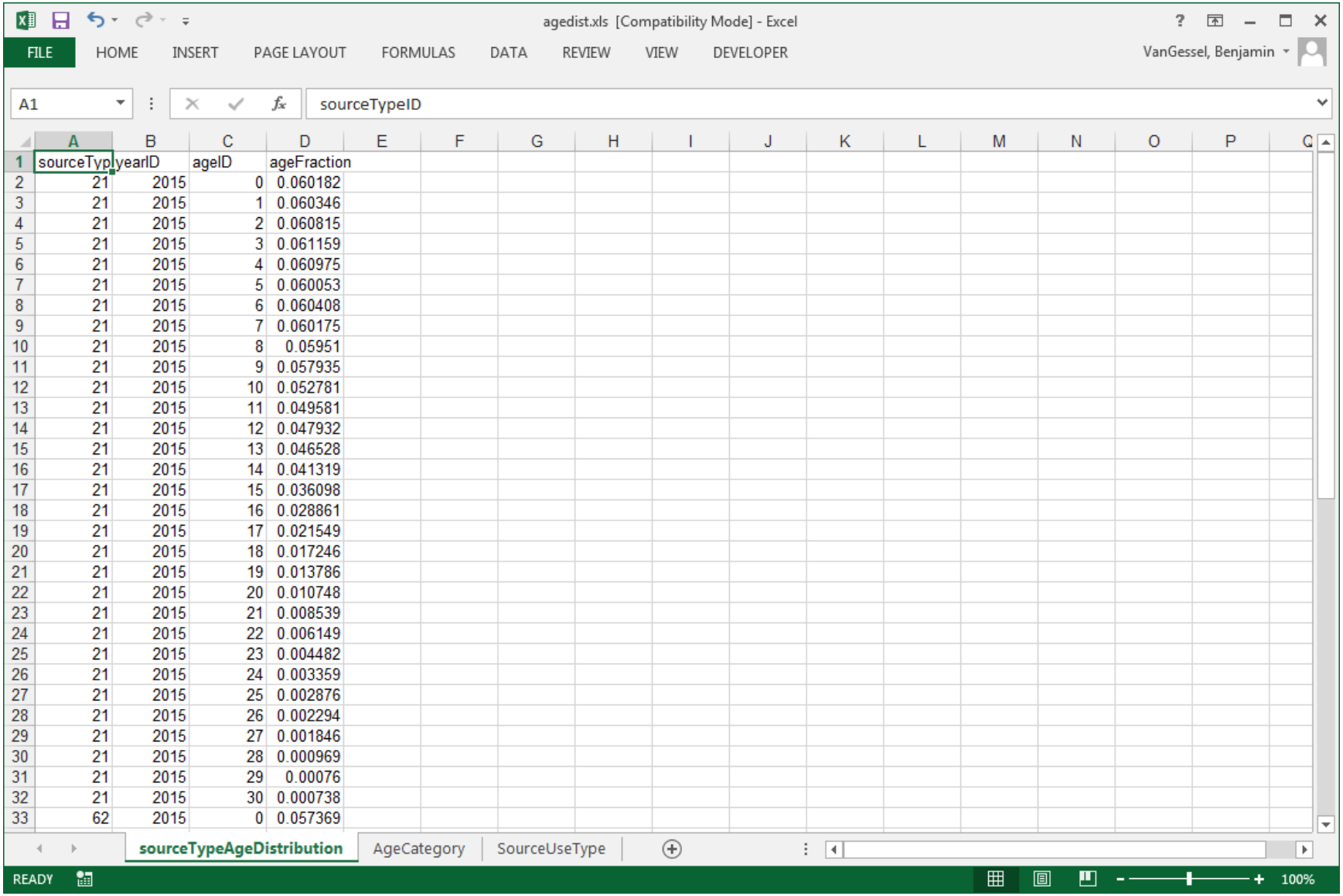


Demonstration Project Inputs

Next slides will show the following inputs completed:

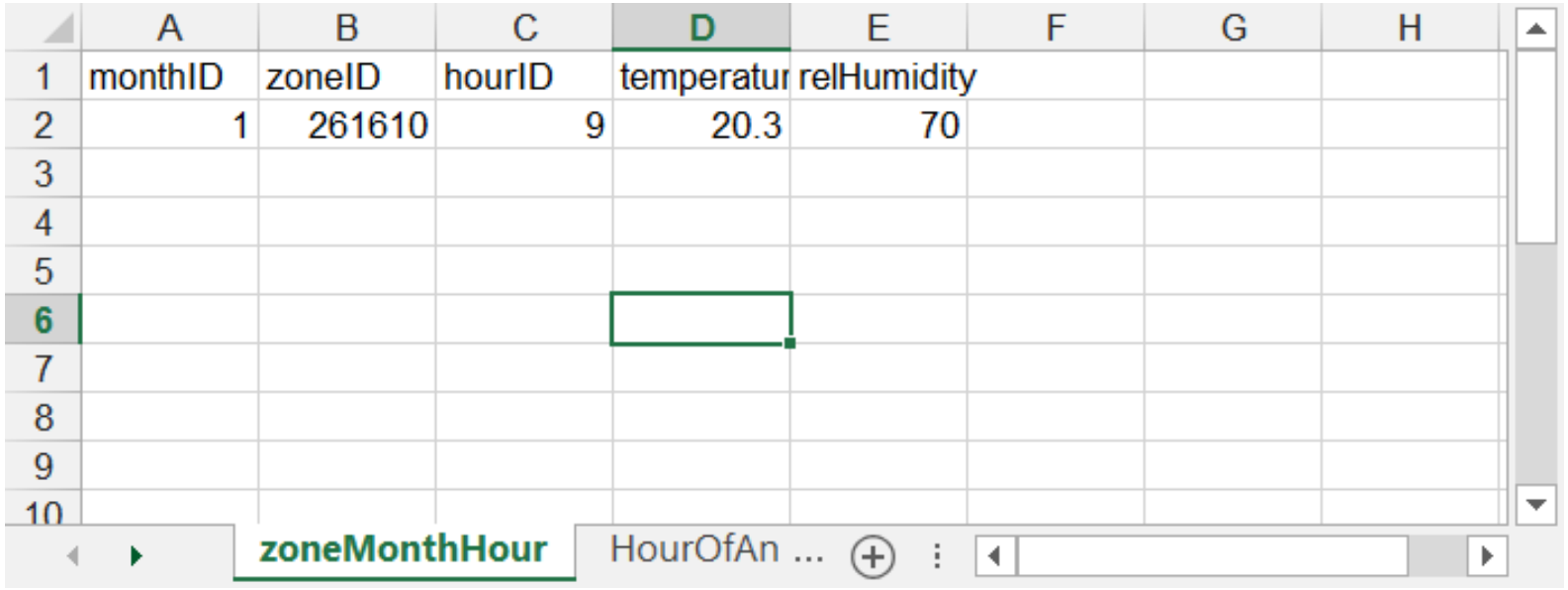
- Age Distribution
- Meteorology Data
- Fuel
- Links
- Off-Network
- Link Source Types
- Operating Mode Distribution
- Hotelling
- Link Drive Schedules (used only in Run #2)

Age Distribution Input



	A	B	C	D
1	sourceTyp	yearID	ageID	ageFraction
2	21	2015	0	0.060182
3	21	2015	1	0.060346
4	21	2015	2	0.060815
5	21	2015	3	0.061159
6	21	2015	4	0.060975
7	21	2015	5	0.060053
8	21	2015	6	0.060408
9	21	2015	7	0.060175
10	21	2015	8	0.05951
11	21	2015	9	0.057935
12	21	2015	10	0.052781
13	21	2015	11	0.049581
14	21	2015	12	0.047932
15	21	2015	13	0.046528
16	21	2015	14	0.041319
17	21	2015	15	0.036098
18	21	2015	16	0.028861
19	21	2015	17	0.021549
20	21	2015	18	0.017246
21	21	2015	19	0.013786
22	21	2015	20	0.010748
23	21	2015	21	0.008539
24	21	2015	22	0.006149
25	21	2015	23	0.004482
26	21	2015	24	0.003359
27	21	2015	25	0.002876
28	21	2015	26	0.002294
29	21	2015	27	0.001846
30	21	2015	28	0.000969
31	21	2015	29	0.00076
32	21	2015	30	0.000738
33	62	2015	0	0.057369

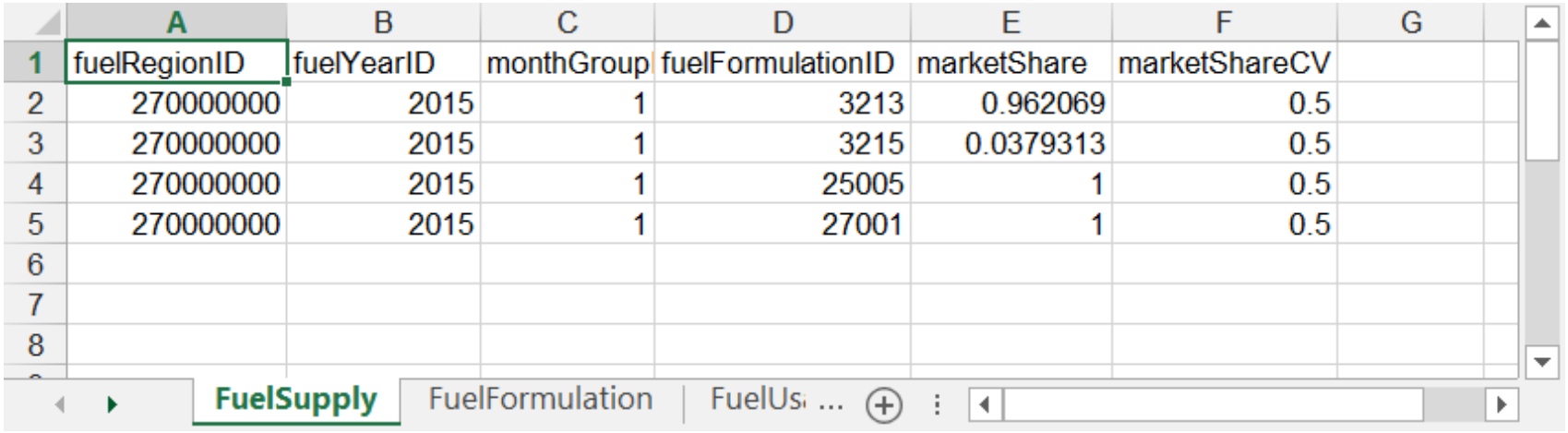
Meteorology Input



	A	B	C	D	E	F	G	H
1	monthID	zoneID	hourID	temperatur	relHumidity			
2	1	261610	9	20.3	70			
3								
4								
5								
6								
7								
8								
9								
10								

zoneMonthHour | HourOfAn ...

Fuel Supply Input



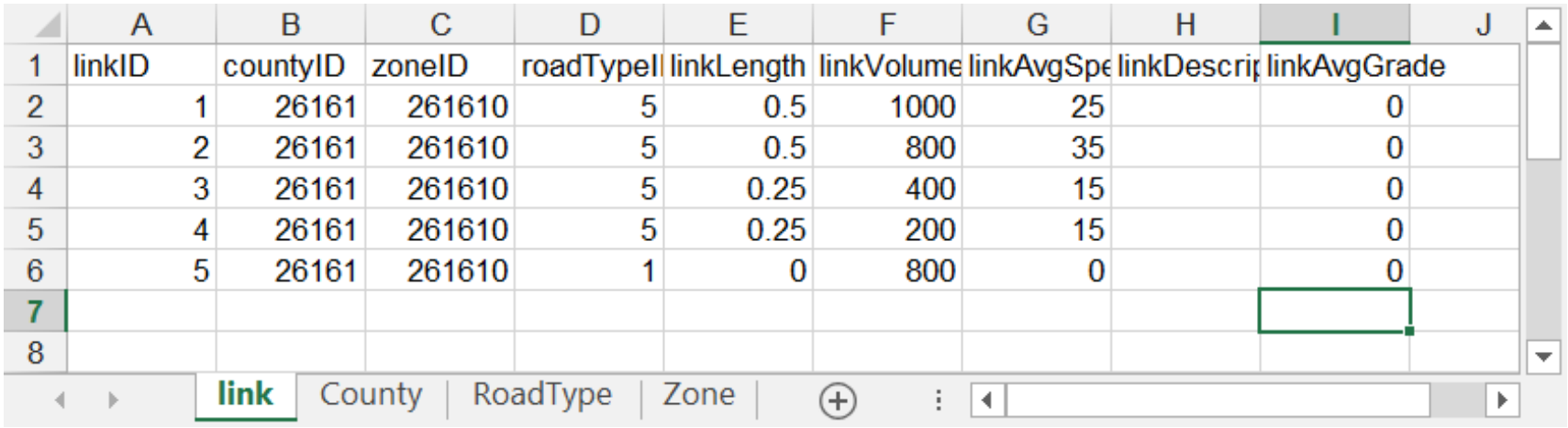
	A	B	C	D	E	F	G
1	fuelRegionID	fuelYearID	monthGroup	fuelFormulationID	marketShare	marketShareCV	
2	270000000	2015	1	3213	0.962069	0.5	
3	270000000	2015	1	3215	0.0379313	0.5	
4	270000000	2015	1	25005	1	0.5	
5	270000000	2015	1	27001	1	0.5	
6							
7							
8							

FuelSupply | FuelFormulation | FuelUs ...

Only Fuel Supply Input shown. All four fuel inputs are imported from the Excel file:

- Fuel Supply
- Fuel Formulation
- Fuel Usage Fraction, and
- AVFT

Links Input



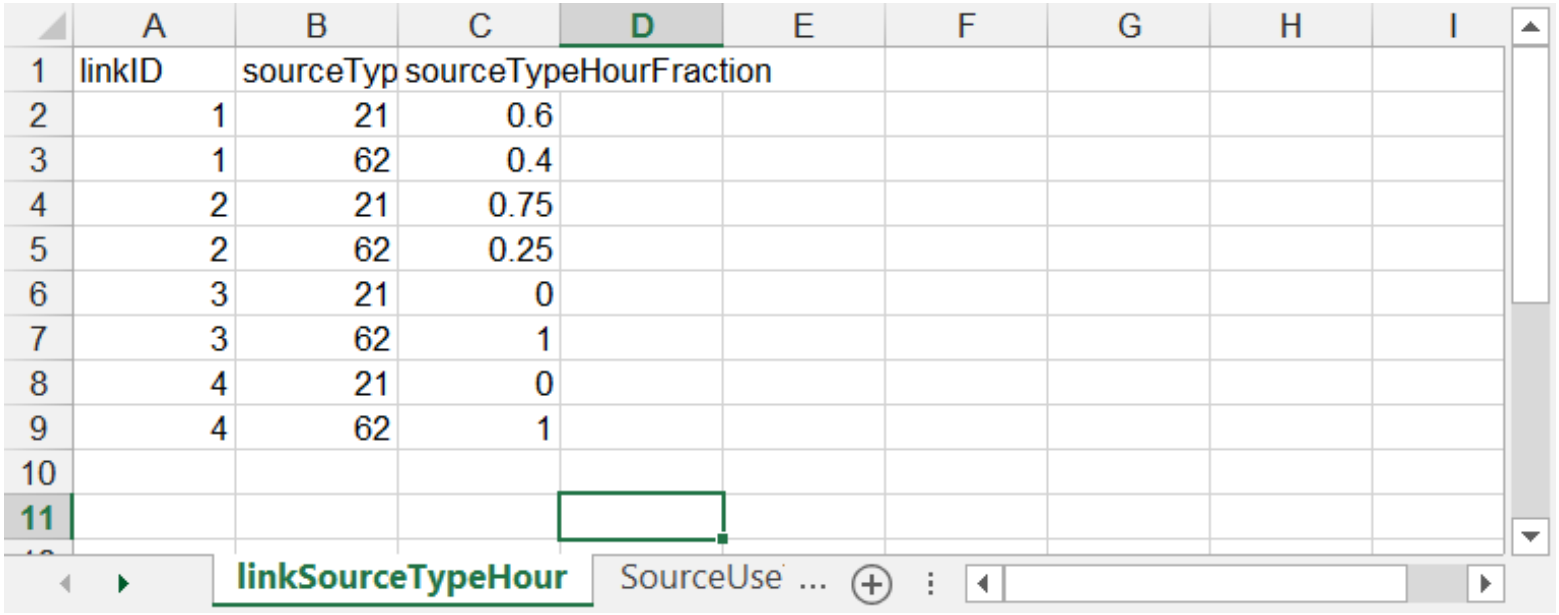
	A	B	C	D	E	F	G	H	I	J
1	linkID	countyID	zoneID	roadTypeI	linkLength	linkVolume	linkAvgSpe	linkDescrip	linkAvgGrade	
2	1	26161	261610	5	0.5	1000	25		0	
3	2	26161	261610	5	0.5	800	35		0	
4	3	26161	261610	5	0.25	400	15		0	
5	4	26161	261610	5	0.25	200	15		0	
6	5	26161	261610	1	0	800	0		0	
7										
8										

link | County | RoadType | Zone

This input is now populated with project specific data (from previous slides)

Links input includes all road types including the off-network link, linkID 5 (roadtypeID 1)

Link Source Type Input

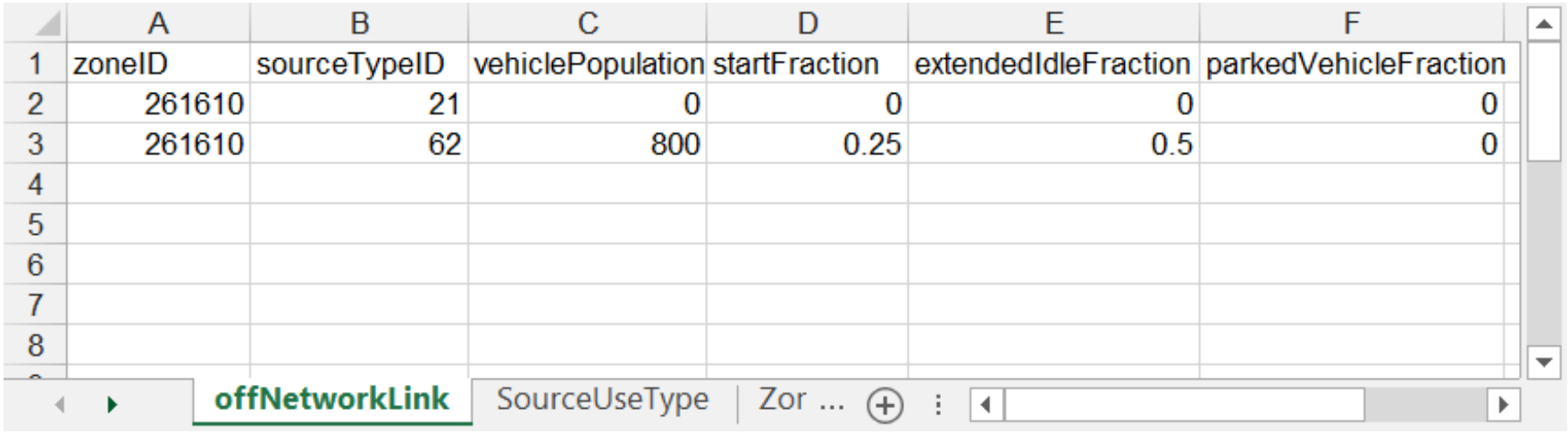


	A	B	C	D	E	F	G	H	I
1	linkID	sourceTyp	sourceTypeHourFraction						
2	1	21	0.6						
3	1	62	0.4						
4	2	21	0.75						
5	2	62	0.25						
6	3	21	0						
7	3	62	1						
8	4	21	0						
9	4	62	1						
10									
11									

This input is used to define the fleet mix on each running link

Note that linkID 5, the off-network link, is not included

Off-Network Input

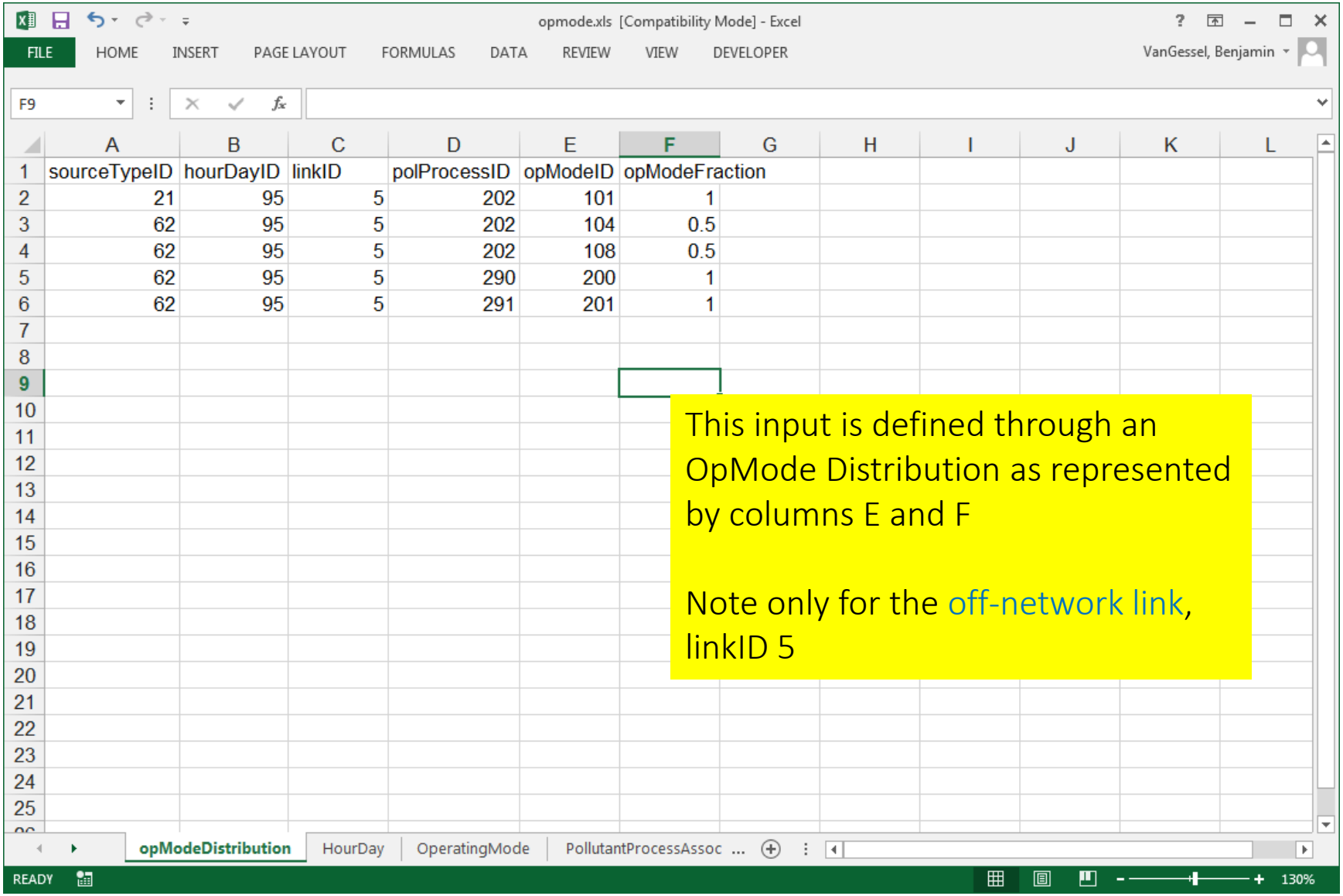


	A	B	C	D	E	F
1	zoneID	sourceTypeID	vehiclePopulation	startFraction	extendedIdleFraction	parkedVehicleFraction
2	261610	21	0	0	0	0
3	261610	62	800	0.25	0.5	0
4						
5						
6						
7						
8						

offNetworkLink | SourceUseType | Zor ...

This input is for the off-network link only; somewhat equivalent to Link Source Type inputs for running links

Operating Mode Input

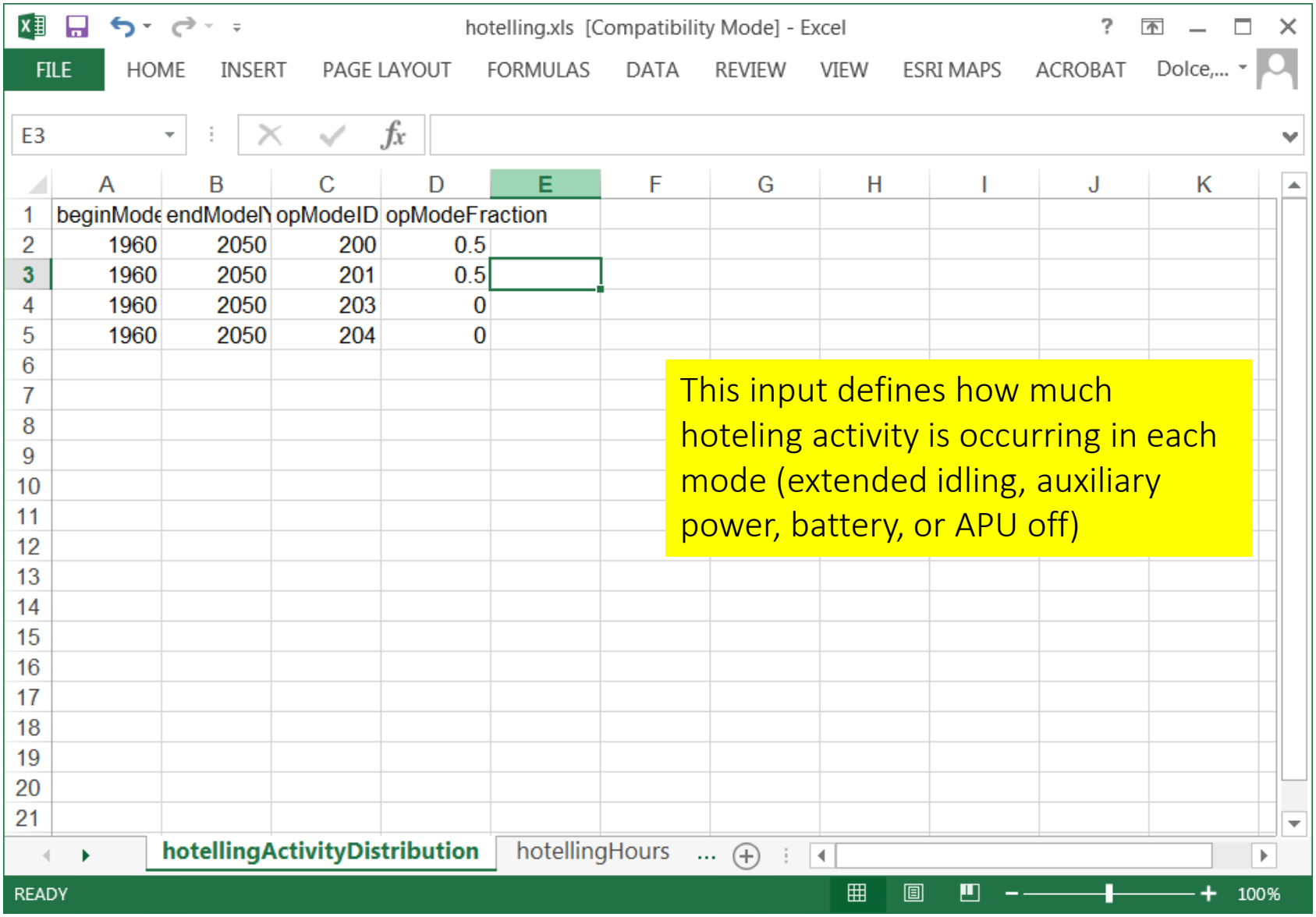


	A	B	C	D	E	F
1	sourceTypeID	hourDayID	linkID	polProcessID	opModeID	opModeFraction
2	21	95	5	202	101	1
3	62	95	5	202	104	0.5
4	62	95	5	202	108	0.5
5	62	95	5	290	200	1
6	62	95	5	291	201	1

This input is defined through an OpMode Distribution as represented by columns E and F

Note only for the off-network link, linkID 5

Hotelling Input



Options for Defining On-Road Activity

EPA

Options for Entering Activity

1. Average Speed – User enters average speed
2. Link Drive Schedule – User enters a drive cycle for each link
3. Operating Mode Distribution – User directly enters OpMode distribution for each link and source type
   - Always required if Off-Network link is defined

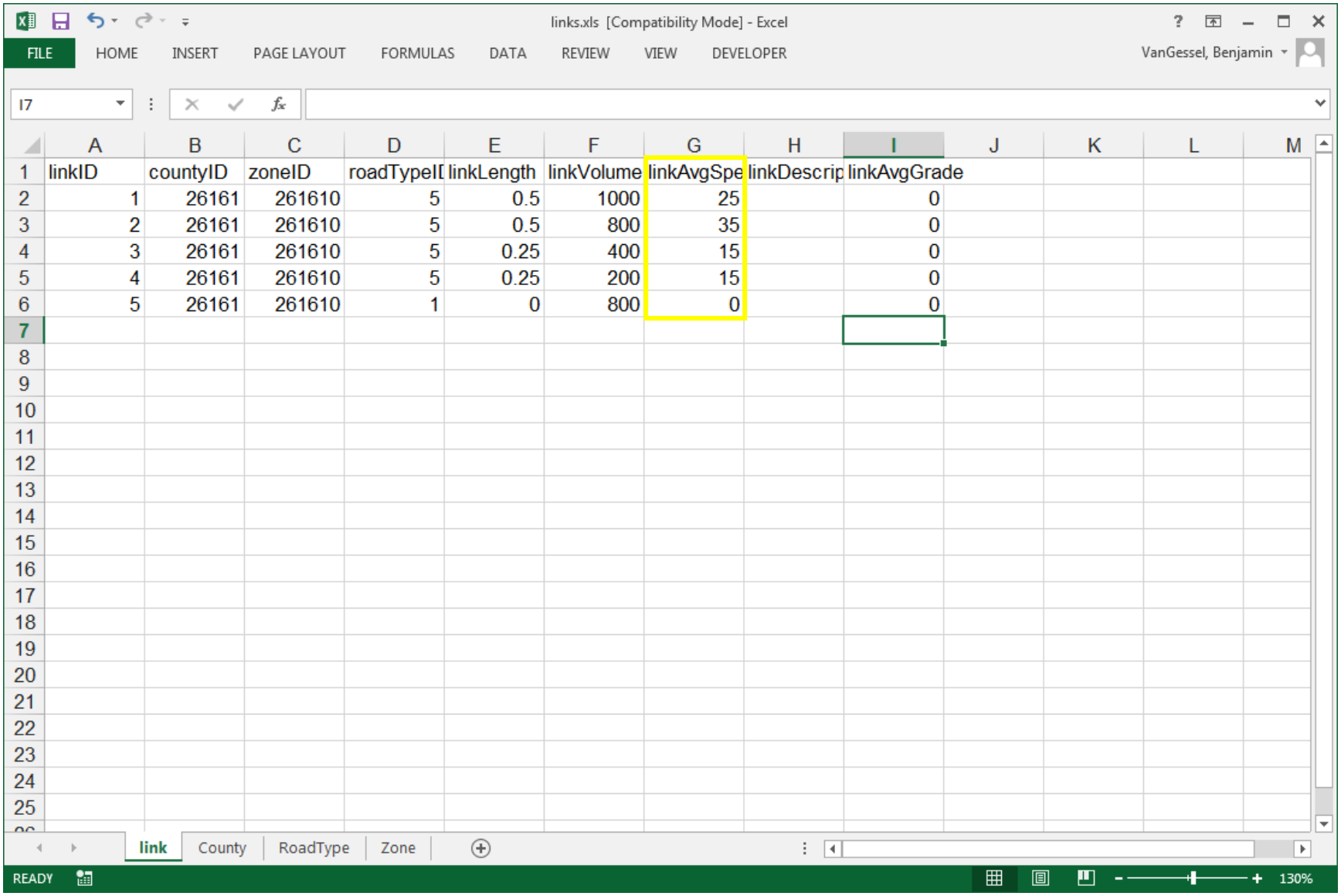
MOVES
Motor Vehicle Emission Simulator

EPA

Option 1: Run with Activity by Average Speed

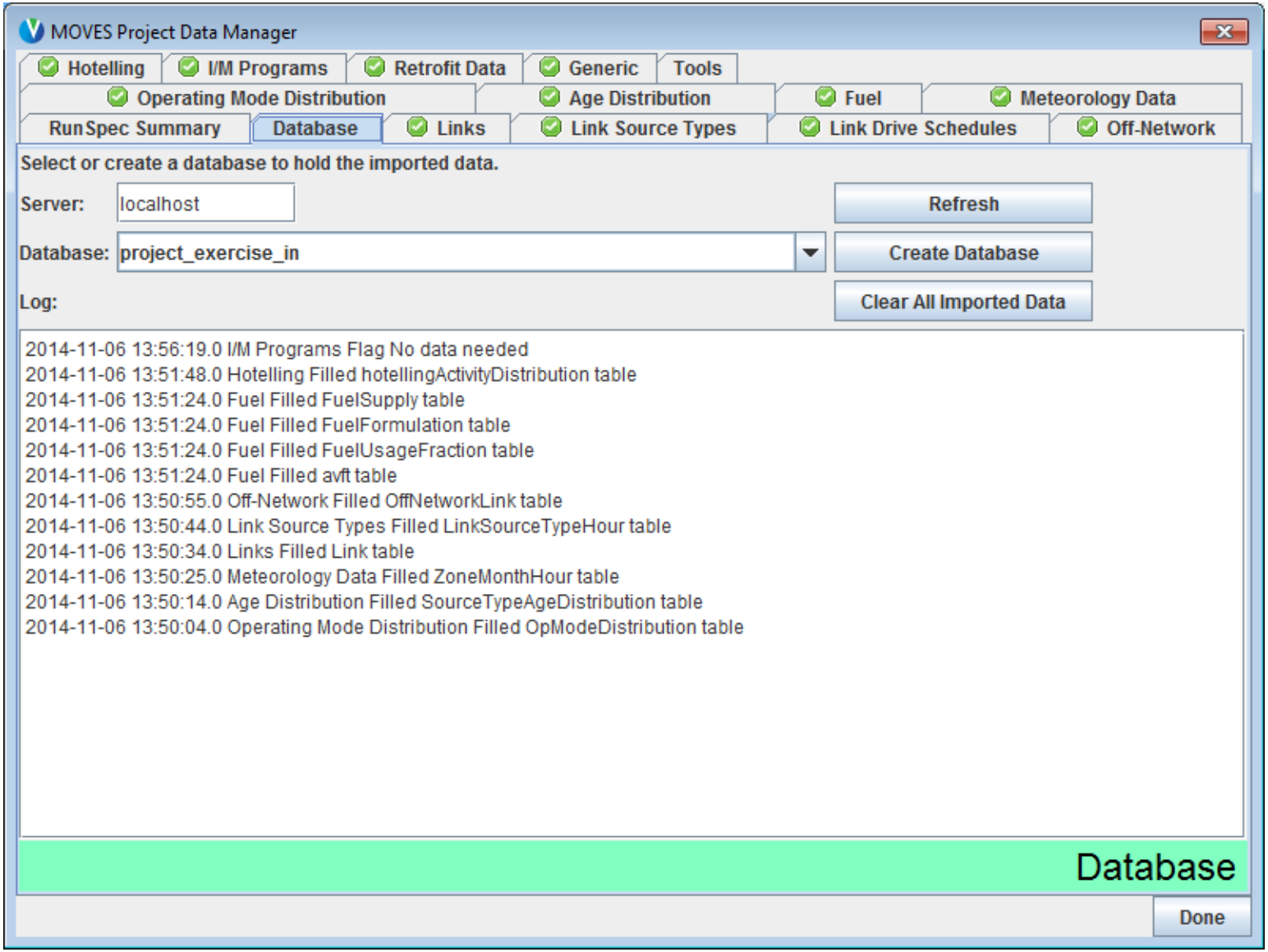
EPA

Already Defined Through Links Input

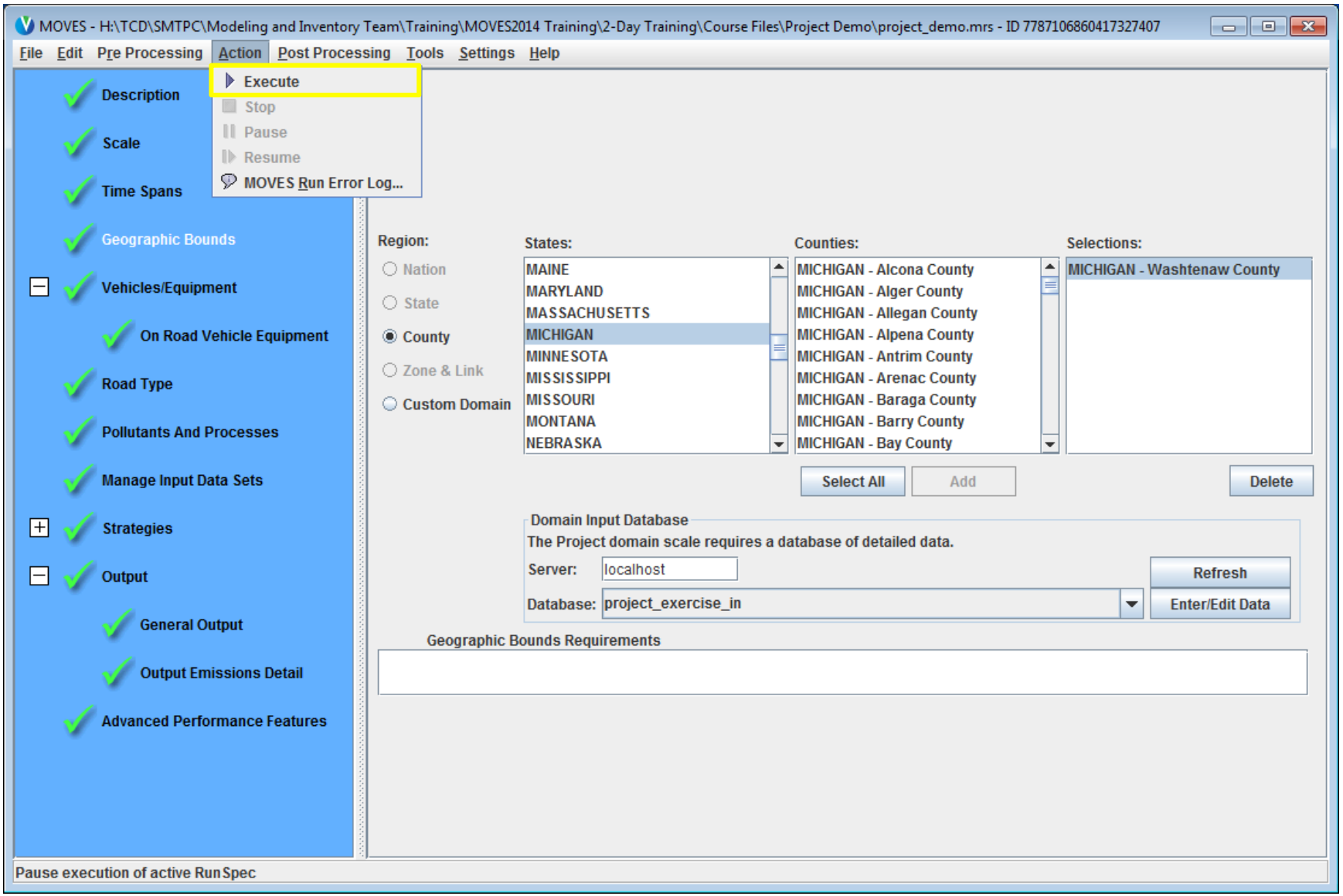


	A	B	C	D	E	F	G	H	I
1	linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpe	linkDescrip	linkAvgGrade
2	1	26161	261610	5	0.5	1000	25		0
3	2	26161	261610	5	0.5	800	35		0
4	3	26161	261610	5	0.25	400	15		0
5	4	26161	261610	5	0.25	200	15		0
6	5	26161	261610	1	0	800	0		0
7									

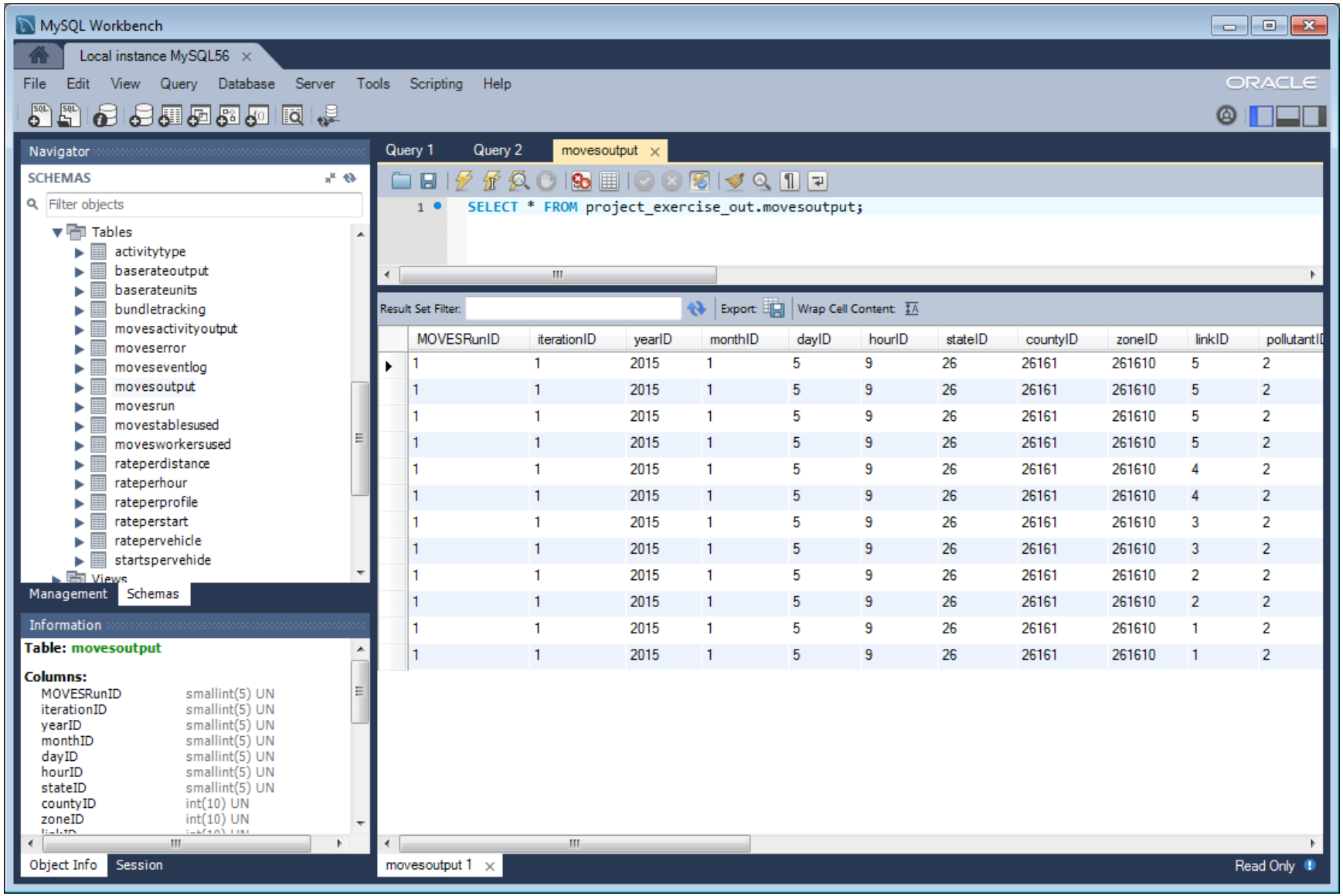
Completed Input Database



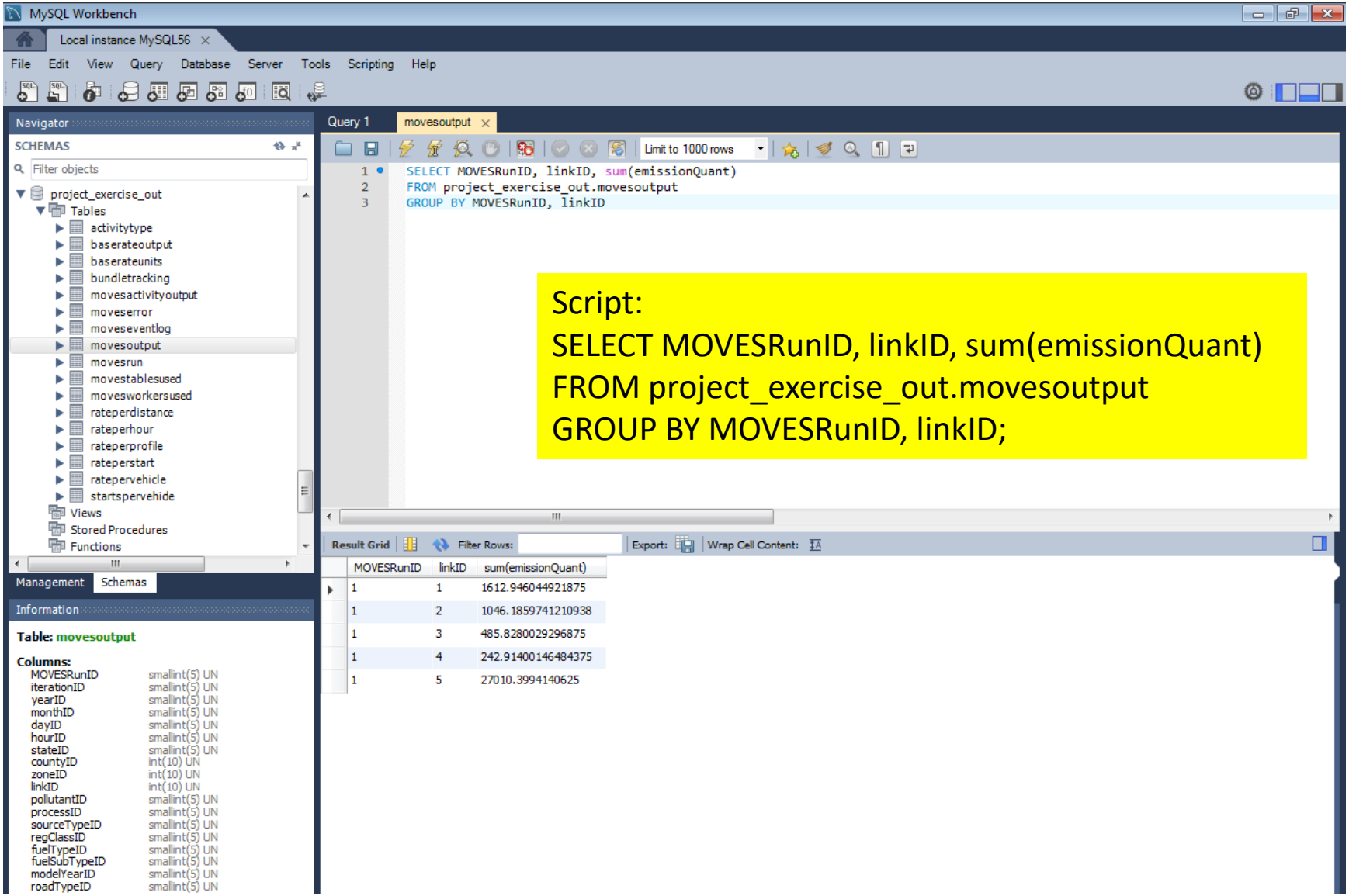
Execute the RunSpec



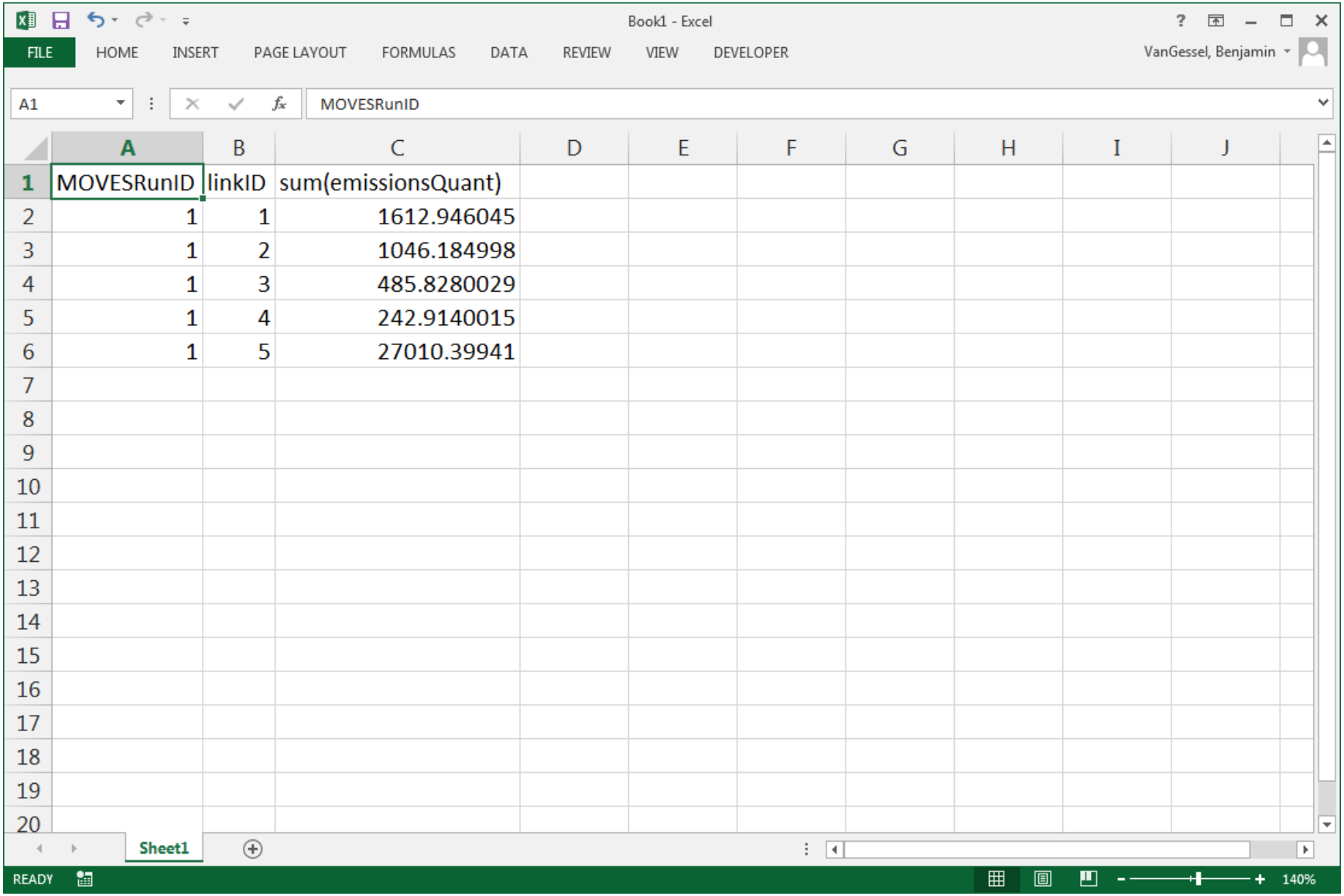
Project Level Outputs in MySQL



Calculating Link Emissions



CO grams/hour Emissions

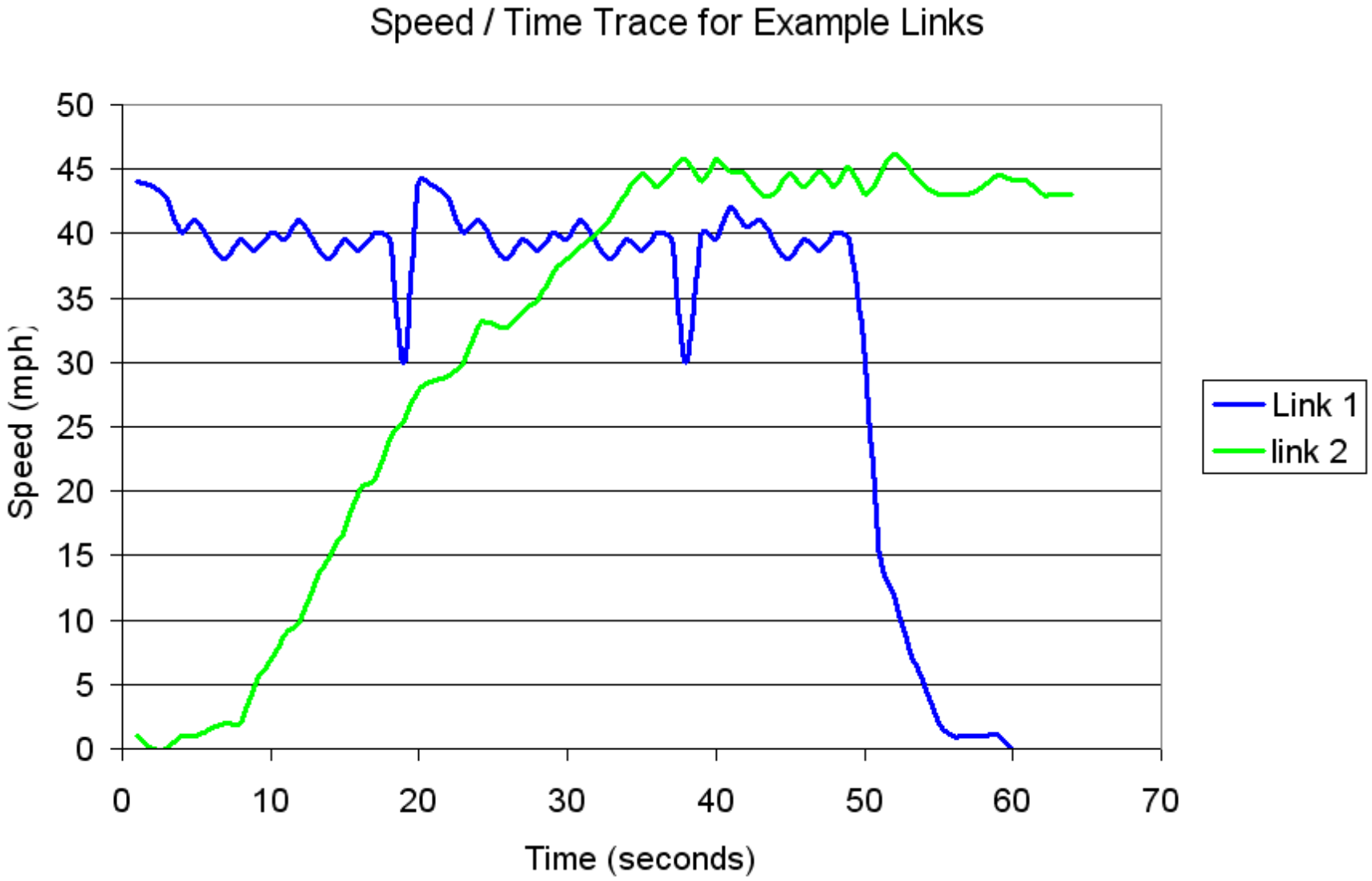


MOVESRunID	linkID	sum(emissionsQuant)
1	1	1612.946045
1	2	1046.184998
1	3	485.8280029
1	4	242.9140015
1	5	27010.39941

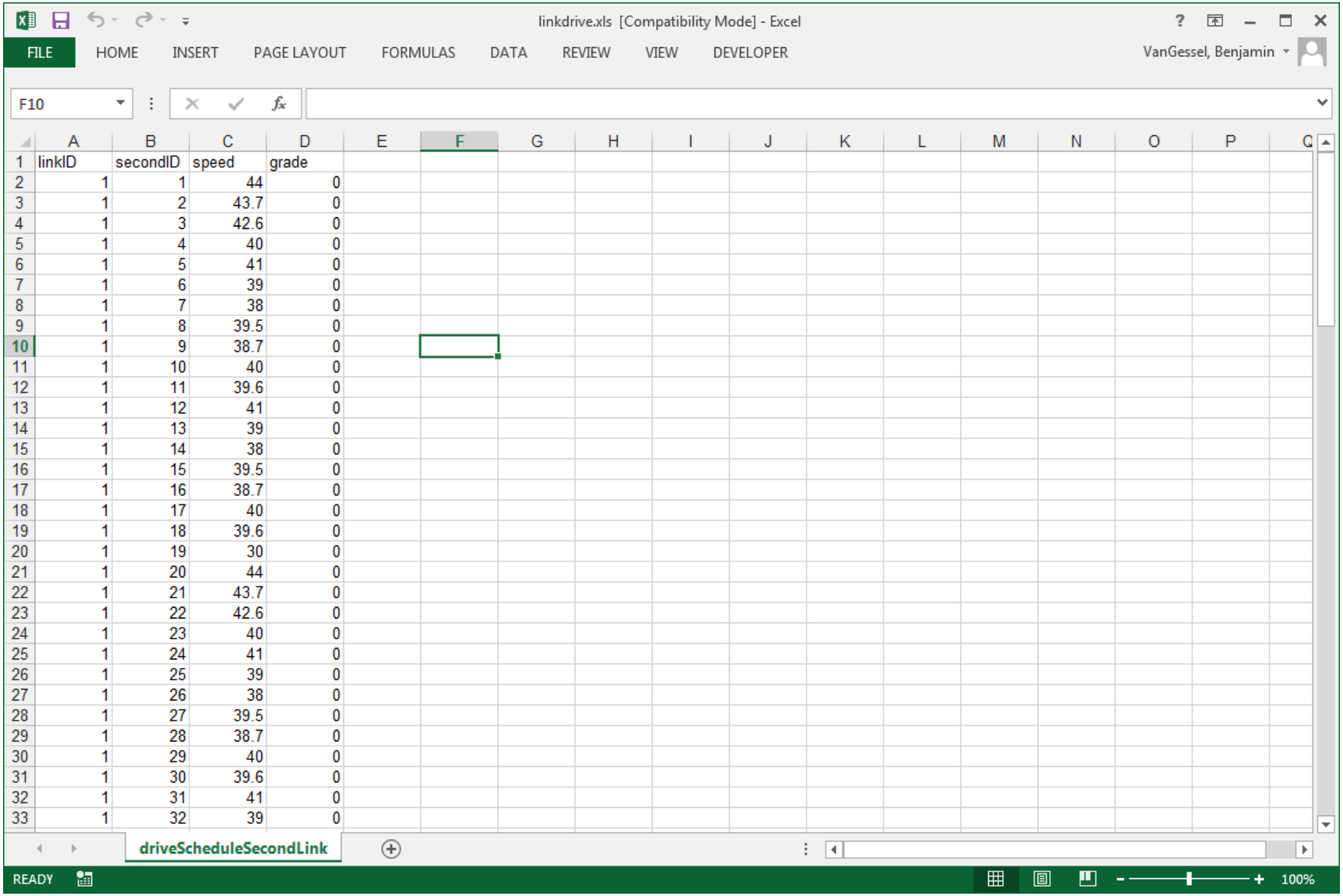
Option 2: Run with Activity by Link Drive Schedule

EPA

Vehicle Trajectory Data from Micro- Simulation Model (links 1 and 2 only)



Second-by-Second Link Drive Schedule


linkdrive.xls [Compatibility Mode] - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DEVELOPER

VanGessel, Benjamin

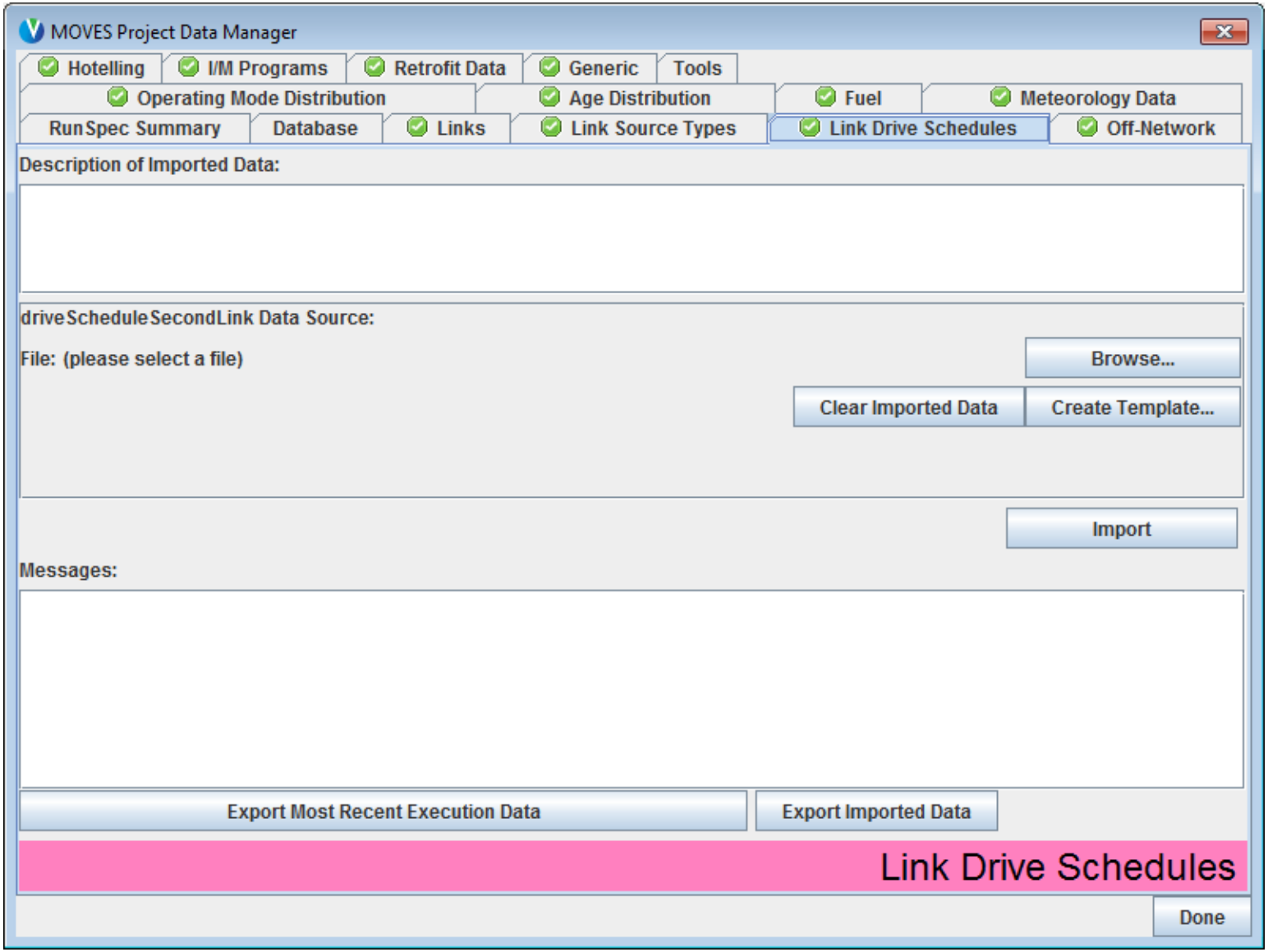
F10

	A	B	C	D
1	linkID	secondID	speed	grade
2	1	1	44	0
3	1	2	43.7	0
4	1	3	42.6	0
5	1	4	40	0
6	1	5	41	0
7	1	6	39	0
8	1	7	38	0
9	1	8	39.5	0
10	1	9	38.7	0
11	1	10	40	0
12	1	11	39.6	0
13	1	12	41	0
14	1	13	39	0
15	1	14	38	0
16	1	15	39.5	0
17	1	16	38.7	0
18	1	17	40	0
19	1	18	39.6	0
20	1	19	30	0
21	1	20	44	0
22	1	21	43.7	0
23	1	22	42.6	0
24	1	23	40	0
25	1	24	41	0
26	1	25	39	0
27	1	26	38	0
28	1	27	39.5	0
29	1	28	38.7	0
30	1	29	40	0
31	1	30	39.6	0
32	1	31	41	0
33	1	32	39	0

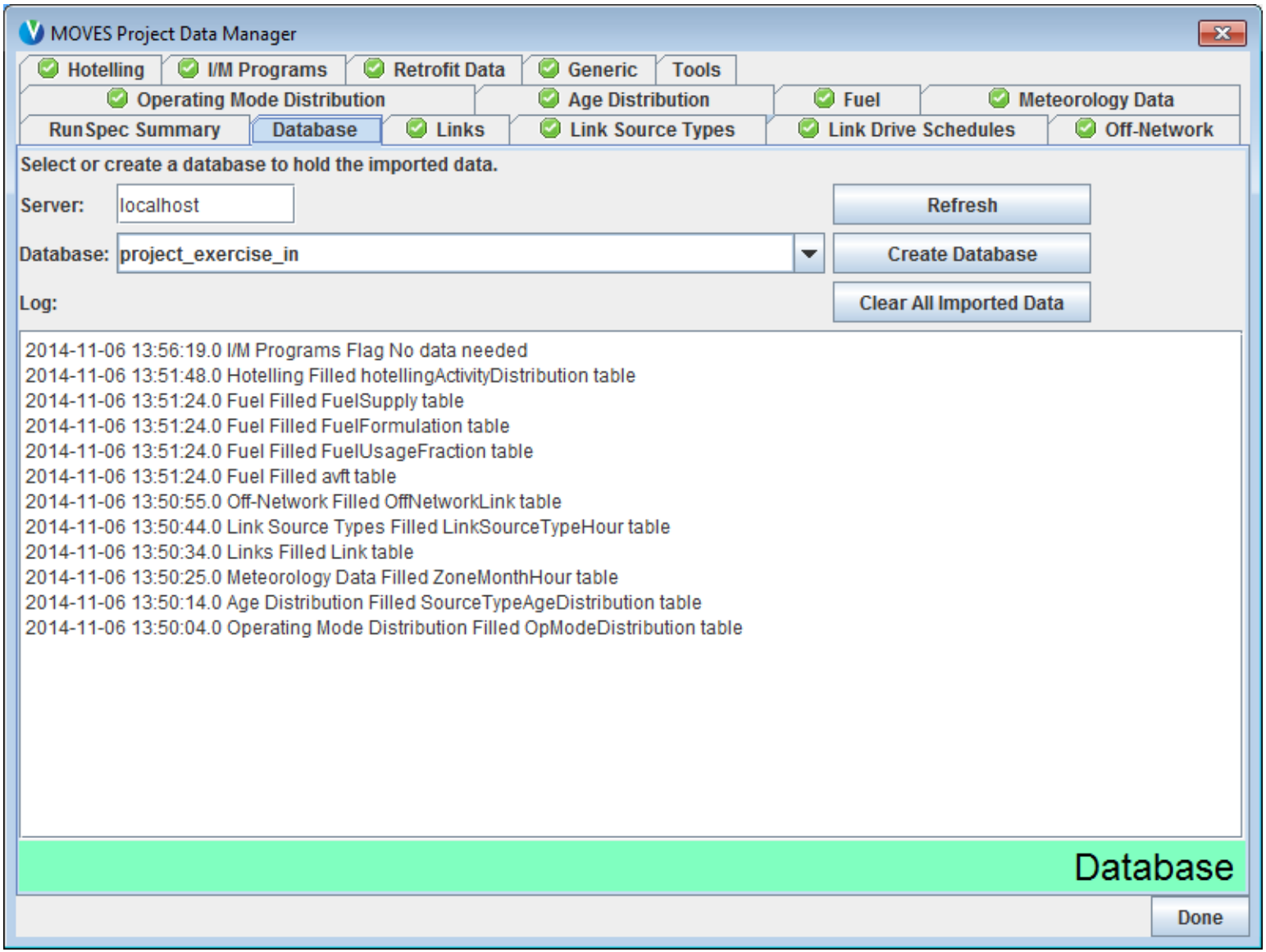
driveScheduleSecondLink

READY 100%

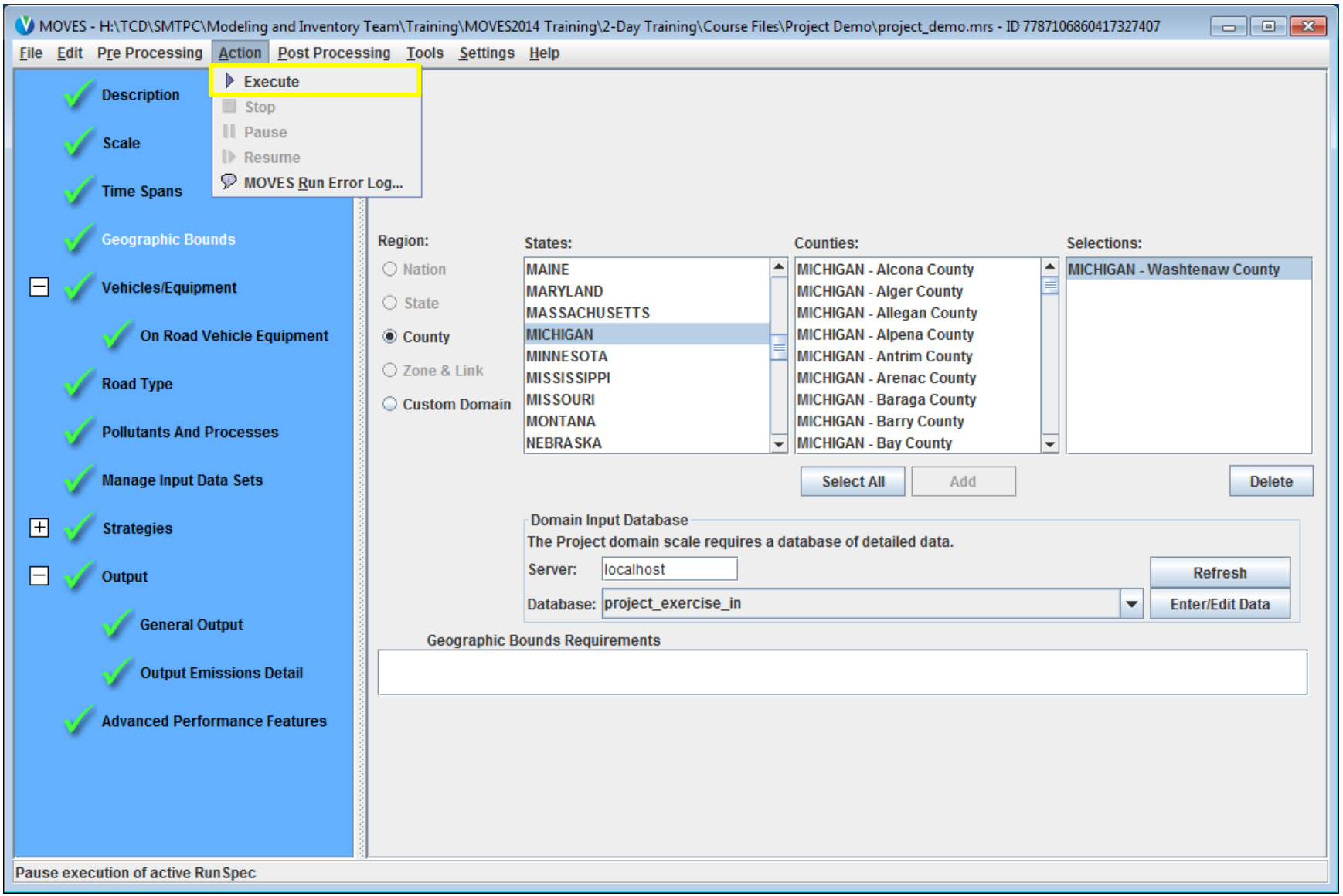
Import Link Drive Schedule



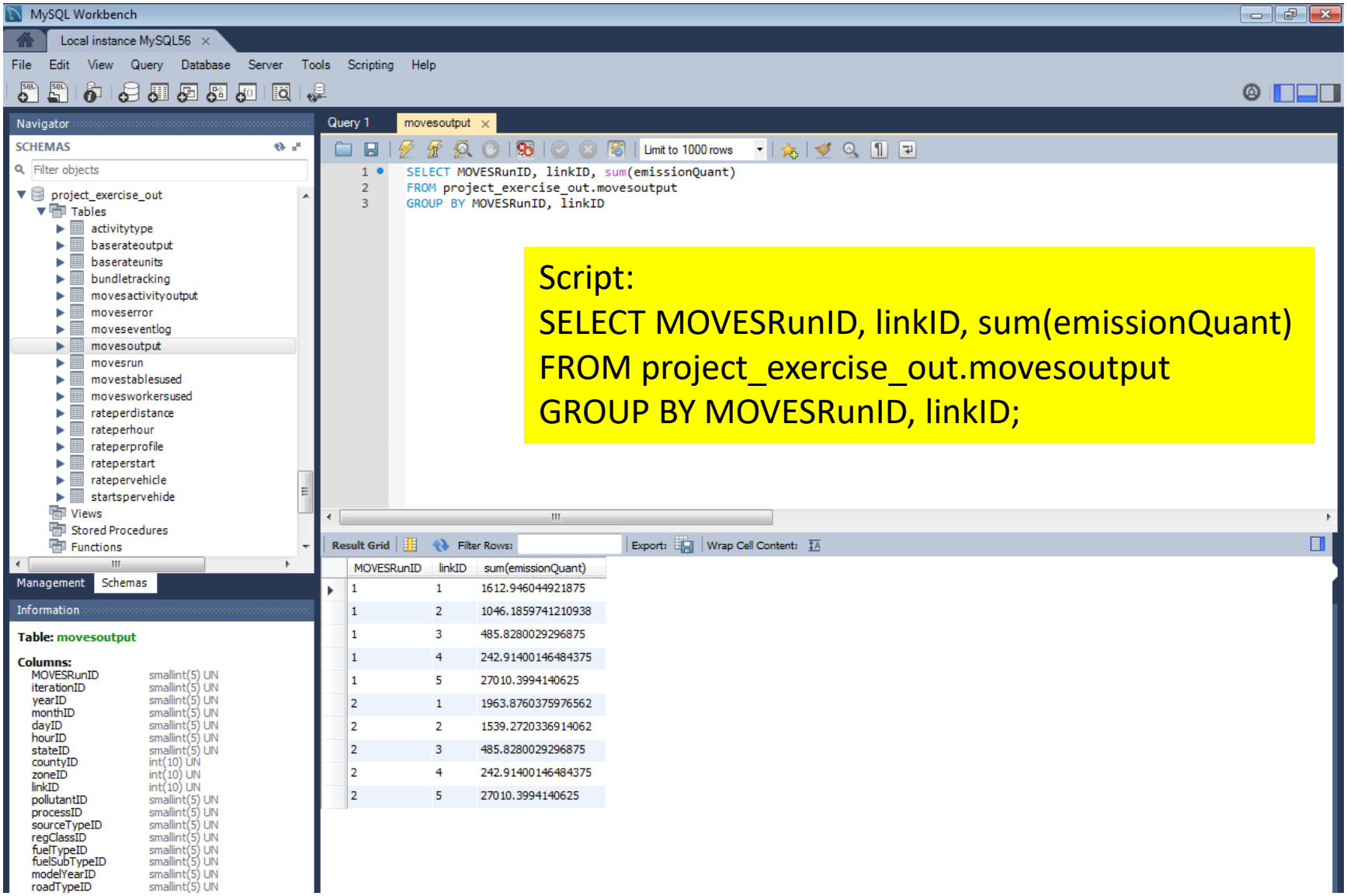
Completed Input Database



Execute the RunSpec



Calculating Link Emissions



Results

Recall from slide 77 that a link drive schedule was provided for Links 1 and 2 only

- Results for Links 1 and 2 differ between the two runs
- Results for Links 3, 4, and 5 are identical in the two runs

MOVESRunID	linkID	sum(emissionQuant)
1	1	1612.946044921875
1	2	1046.1859741210938
1	3	485.8280029296875
1	4	242.91400146484375
1	5	27010.3994140625
2	1	1963.8760375976562
2	2	1539.2720336914062
2	3	485.8280029296875
2	4	242.91400146484375
2	5	27010.3994140625

MOVES
Motor Vehicle Emission Simulator

EPA

Questions?

EPA