DRAFT

MAG 2017 EIGHT-HOUR OZONE MODERATE AREA PLAN FOR THE MARICOPA NONATTAINMENT AREA

APPENDICES

VOLUME FOUR

SEPTEMBER 2016

MARICOPA ASSOCIATION of GOVERNMENTS

DRAFT

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OZONE MODELING PROTOCOL
IN SUPPORT OF
THE MAG 2017 MODERATE AREA PLAN FOR
THE MARICOPA EIGHT-HOUR OZONE NONATTAINMENT AREA
(2008 OZONE STANDARD)

Maricopa Association of Governments

November 2015

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ACRONYMS

ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
ADWM	Arizona Department of Weights and Measures
APCA	Anthropogenic precursor culpability assessment
APM	Aviation performance metrics
APU	Auxiliary power unit
AQMP	Air Quality Modeling Platform
AQTAC	Air Quality Technical Advisory Committee
ASOS	Automated Surface Observing System
ATADS	Air Traffic Activity Data System
AVFT	Alternative vehicle and fuel technologies
CAA	Clean Air Act
CAMx	Comprehensive Air Quality Model with eXtensions
CART	Classification and regression tree
CB6	Carbon bond version 6
CEMS	Continuous Emissions Monitoring System
CFR	Code of Federal Regulations
CISL	Computational Information Systems Laboratory
CMAQ	Community Multiscale Air Quality Model
CPA	Chemical process analysis
DDM	Decoupled direct method
DEASCO3	Deterministic and Empirical Assessment of Smoke's Contribution to Ozone
DOT	Department of Transportation
EDMS	Emissions and Dispersion Modeling System
EGU	Electric Generating Unit
EPA	Environmental Protection Agency
ERG	Eastern Research Group
ESRL	Earth System Research Laboratory
ETMSC	Enhanced Traffic Management System Counts
FAA	Federal Aviation Administration
FR	Federal Register
GIS	Geographic Information System
GSE	Ground support equipment
HPMS	Highway Performance Monitoring System
I/M	Inspection and maintenance
ICAO	International Civil Aviation Organization
ICBC	Initial and boundary conditions
ISHD	Integrated Surface Hourly Database
LAI	Leaf area index
LCP	Lambert Conformal Projection
LTO	Landing and takeoff
MAG	Maricopa Association of Governments

MATS	Modeled Attainment Test Software
MCAQD	Maricopa County Air Quality Department
MCIP	Meteorology-Chemistry Interface Processor
MEGAN	Model of Emissions of Gases and Aerosols from Nature
MOVES	Motor Vehicle Emission Simulator
MOZART	Model for Ozone and Related Chemical Tracers
NAAQS	National Ambient Air Quality Standards
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NEI	National Emissions Inventory
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen oxides
NWS	National Weather Service
OSAT	Ozone source apportionment technology
PCAQCD	Pinal County Air Quality Control District
PEI	Periodic Emissions Inventory
PFT	Plant functional types
PTE	Potential to Emit
RRF	Relative response factor
RRTM	Rapid Radiative Transfer Model
RVP	Reid vapor pressure
SA	Spatial Allocator
SCC	Source classification code
SMOKE	Sparse Matrix Operator Kernel Emissions
TAF	Terminal Area Forecast
TDM	Travel demand model
TOMS	Total Ozone Mapping Spectrometer
TSD	Technical support document
TUV	Tropospheric Ultraviolet Visible
UTC	Universal Time Coordinate
VHT	Vehicle hours traveled
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
WPS	WRF Preprocessing System
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model

1.0 OVERVIEW OF MODELING STUDY

1.1 Background

Under the 1990 Clean Air Act (CAA), the Maricopa eight-hour ozone nonattainment area was classified as a Marginal area for the 2008 ozone National Ambient Air Quality Standard (NAAQS) of 0.075 parts per million (ppm). The Maricopa eight-hour ozone nonattainment area includes the 5,018 square mile area located predominantly in Maricopa County with a portion of Pinal County (i.e., the city of Apache Junction). The effective date of the Marginal area designation was July 20, 2012. Since the Marginal area has up to 3 years from the effective date of the designation for the attainment of the 2008 ozone NAAQS, the attainment date was set to July 20, 2015.

The Maricopa Association of Governments (MAG) prepared the MAG 2014 Eight-Hour Ozone Plan. In compliance with the CAA requirements for the Marginal nonattainment area for ozone, the plan included an Emissions Statement, the 2011 Periodic Emissions Inventory, Pre-1990 Reasonably Available Control Technology Corrections, Nonattainment Area Preconstruction Permit Program, New Source Review, Emission Offset Requirements, Pre-1990 Corrections to Previously Required Vehicle Inspection and Maintenance Programs, and Transportation Conformity Requirements Compliance. Since the modeled attainment demonstration is not required for Marginal areas under the CAA, the plan did not include the attainment demonstration for the 2008 ozone standard. The plan was submitted to the U.S. Environmental Protection Agency (EPA) in June 2014. EPA approved most elements of the plan except for the New Source Review on September 25, 2015.

Since the area did not achieve the 2008 ozone standard by the required deadline of July 20, 2015, the Maricopa eight-hour ozone nonattainment area was subsequently proposed by EPA to be reclassified as a Moderate area on August 27, 2015 (FR, 2015). The deadline for Moderate areas to attain the 2008 ozone standard is July 20, 2018. Since EPA requires a modeled attainment demonstration if an area is classified as a Moderate area for the 2008 ozone standard, MAG has prepared this modeling protocol for the attainment demonstration for the 2008 ozone standard. For the attainment demonstration, EPA requires that all control measures necessary to demonstrate attainment be implemented prior to the start of the ozone season preceding the attainment year. Thus, the modeled attainment demonstration in this study verifies that all implemented federal and local control measures provide enough emission reductions needed to attain the 2008 ozone standard by the end of the ozone season in 2017.

The objectives of this study are to determine whether the Maricopa eight-hour ozone nonattainment area will attain the 2008 ozone standard by the end of the 2017 ozone season and to establish the 2017 conformity budget for onroad mobile source emissions using the most recent version of the EPA Motor Vehicle Emission Simulator (MOVES) model, MOVES2014a (released by EPA on November 4, 2015).

1.2 Purpose of Modeling Protocol

The modeling protocol is based upon the Draft EPA 2014 modeling guidance (EPA, 2014)

and describes modeling methodologies and assumptions which will be used in the modeled attainment demonstration for the 2008 ozone standard. The protocol is viewed as a set of general guidelines that provide focus, consistency, and a basis for consensus for all parties involved in this analysis. This modeling protocol will be reviewed and approved by members of the Air Quality Planning Team prior to commencement of modeling. This team includes staff representatives from MAG, the Arizona Department of Environmental Quality (ADEQ), the Arizona Department of Transportation (ADOT), and the Maricopa County Air Quality Department (MCAQD). Representatives of other agencies, including EPA and the U.S. Department of Transportation (DOT), will be consulted on technical matters, as needed.

2.0 CONCEPTUAL MODEL

The summer ozone season in the Maricopa eight-hour ozone nonattainment area has several meteorological factors that influence elevated ozone concentrations throughout the ozone season: early summer westerly transport of upwind air pollutants; a synoptic weather pattern featuring a high pressure over the northeastern portion of Arizona and a low pressure centered in the southwestern portion of Arizona; daytime local temperatures above 100°F; local emissions coinciding with valley-wide stagnant winds. The spatial distribution of elevated ozone concentrations in the region depends on surface winds that exhibit diurnal valley breezes and directional changes due to surrounding topography.

The conceptual model is developed for the Maricopa eight-hour ozone nonattainment area as follows:

1. Ozone concentrations are elevated during the summer due to intense photochemical reactions associated with increased solar radiation, local stagnation or long range transport of natural and anthropogenic ozone precursor emissions, and synoptic and mesoscale atmospheric dynamics.
2. Anthropogenic emissions are generally repetitive throughout the summer, but biogenic emissions substantially fluctuate depending on the weather conditions. Elevated ozone is created by combinations of these meteorological conditions and ozone precursor emissions generated from anthropogenic and biogenic sources.
3. The interaction of upwind transported and local emissions under various weather conditions characterizes elevated ozone concentrations in the region.

A detailed conceptual model for the Maricopa eight-hour ozone nonattainment area is provided in Appendix A.

3.0 EPISODE SELECTION

The EPA modeling guidance (EPA, 2007 and 2014) suggests the consideration of the following criteria in selecting the modeling episode or modeling time period: 1) The most recently compiled and quality-assured national emissions inventory databases should be

available for the modeling episode, 2) a sufficient number of days should be available so that the modeled attainment test applied at each monitor is based on the ten highest modeled days, 3) the modeling episode must ensure that the modeling system appropriately characterizes low pollution periods, development of elevated periods, and transition back to low pollution periods through synoptic cycles, and 4) the modeling episode should cover a variety of meteorological conditions conducive to elevated ozone concentrations.

Since the EPA National Emissions Inventory (NEI) for the year 2011 is the most recently compiled and quality-assured national emissions inventory, the year 2011 is selected as the base year for the development of the baseline emissions inventory and baseline design values. The baseline design values in 2011 are developed using ozone observations at monitors during the five-year period of 2009 - 2013. Since the full ozone season from May 1 through September 30 provides a sufficient amount of days (i.e., 153 days) for the development of the ten highest modeled days for ozone concentrations, covers a variety of meteorological conditions, and characterizes high-low and transitional conditions of ozone concentrations in the Maricopa eight-hour ozone nonattainment area, the period of May 1 through September 30 in 2011 is selected for the modeling episode in this study. For the modeled attainment demonstration, the initial three days of the modeling episode will be used as the model spin-up period to minimize the impact of fluctuations in the initial condition data. The modeling results from the spin-up period of May 1-3 will not be used for the modeled attainment demonstration.

4.0 MODEL SELECTION

A variety of emissions, meteorology, and air quality models are needed to perform a full attainment demonstration. The models used in this study meet the EPA guidance requirements of having prior peer reviews, appropriate theoretical bases, good performance in previous studies, and available documentation. The most commonly used photochemical air quality models for ozone attainment demonstration are the Comprehensive Air Quality Model with Extensions (CAMx) and Community Multiscale Air Quality Model (CMAQ). The CAMx model provides useful tools of the Ozone Source Apportionment Technology (OSAT) and Decoupled Direct Method (DDM) which have been used in many photochemical modeling applications to evaluate the contributions of pollutants, source categories, and source regions to local ozone concentrations as well as emissions sensitivities. Since the CAMx OSAT and DDM tools have been well tested and successfully applied to many photochemical modeling applications, the CAMx model is selected for the modeled attainment demonstration for the 2008 ozone standard and the supplemental analyses to develop nitrogen oxides (NOx) and/or volatile organic compounds (VOC) emission reduction strategies and to identify which pollutants, source categories, and source region should be controlled. The latest CAMx version 6.2 is used in the study. Figure 4-1 illustrates the MAG air quality modeling system flowchart with CAMx as the core model. Onroad mobile source emissions are generated by the MOVES2014a and MAG MOVESLINK2014 models. MOVESLINK2014 is a MAG developed program that estimates hourly gridded emissions using the Travel Demand

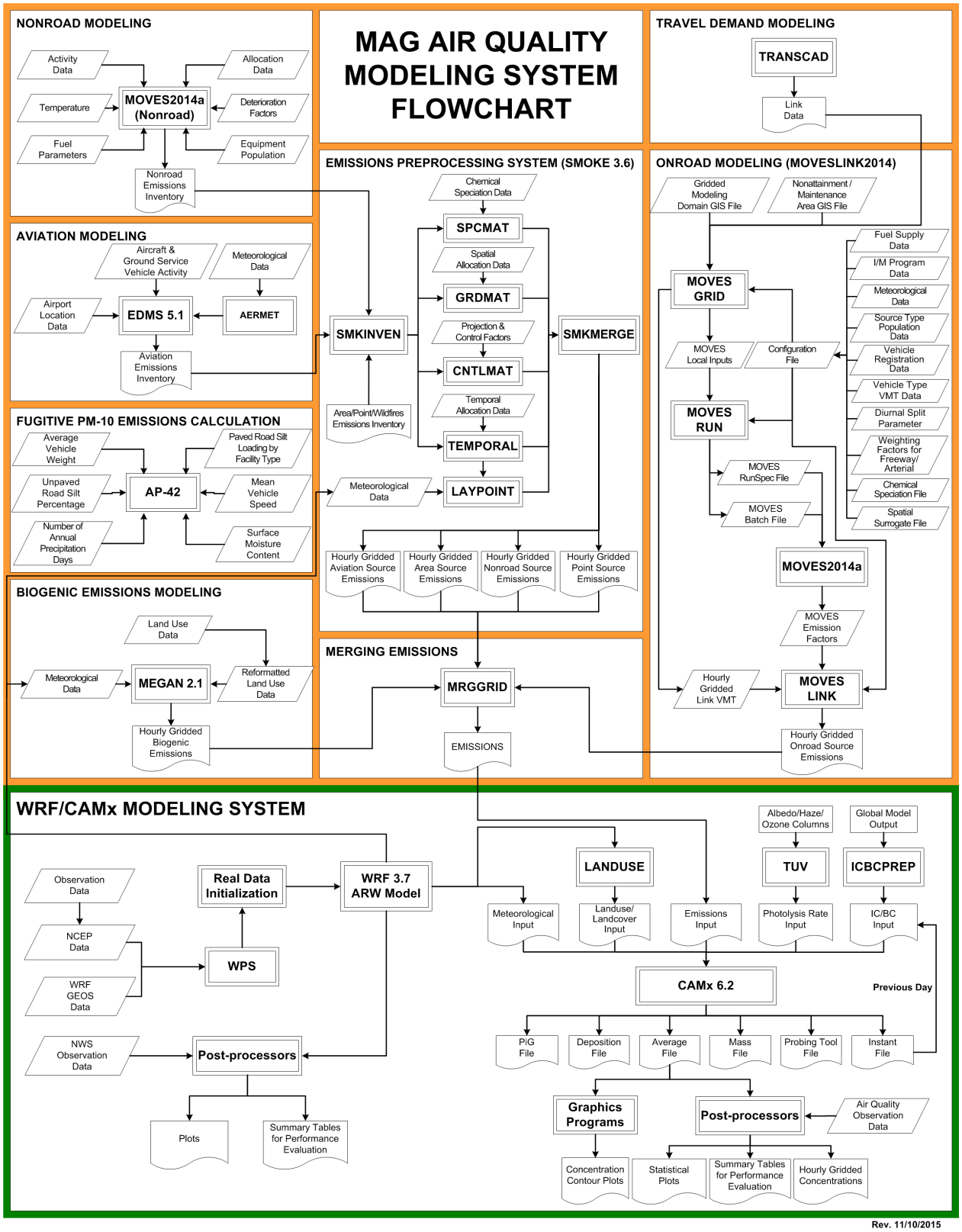

Figure 4-1 MAG air quality modeling system flowchart

Model (e.g., TransCAD) outputs for the photochemical air quality modeling analysis. Nonroad mobile source emissions are developed using the MOVES2014a model and the Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) model. Biogenic source emissions are computed using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.1. The Weather Research and Forecasting Model (WRF) version 3.7 is used to develop meteorological input data for CAMx. The Sparse Matrix Operator Kernel Emissions (SMOKE) version 3.7 is used to develop emissions input data for CAMx. More detailed discussions on the preparation of the emissions inventory and meteorological inputs are provided in Section 6.0.

5.0 MODELING DOMAIN SELECTION

5.1 Horizontal Domain

Selection of the modeling domains takes into account the Maricopa eight-hour ozone nonattainment area boundaries, the distribution of major emissions sources, the location of the meteorological and air quality monitoring sites, and the prevailing winds associated with elevated ozone concentrations, as well as regional air pollutant transport. Figure 5-1 shows the spatial relationship among the master (36 km grid resolution), first-nested (12 km grid resolution), and second-nested (4 km grid resolution) CAMx and WRF modeling domains. Figure 5-2 illustrates the inner modeling domain comprised of 4-by-4 km grid cells that covers the Maricopa eight-hour ozone nonattainment area, Maricopa County, and portions of Pinal, Gila, and Yavapai Counties.

Since ozone concentrations in the Maricopa eight-hour ozone nonattainment area can be substantially influenced by transported ozone and ozone precursor emissions from outside the Maricopa eight-hour ozone nonattainment area (EPA, 2015b), the master 36 km grid modeling domain (36 km domain) covers the 48 contiguous U.S. States along with the southern portion of Canada and the northern portion of Mexico. The extensive coverage of the master modeling domain of CAMx and WRF is designed to capture the characteristics of long-range transport of ozone and ozone precursor emissions to the Maricopa eight-hour ozone nonattainment area. The 36 km domain will be used to generate initial and boundary conditions for the 12 km grid modeling domain (12 km domain). The 12 km domain will be used to provide boundary and initial condition data for the core 4 km grid modeling domain (4 km domain). The CAMx modeled attainment demonstration will be performed with the 4 km domain.

In accordance with EPA guidance, the WRF modeling domains are developed to be larger than the CAMx modeling domains to simulate ozone concentrations around the boundaries of the CAMx modeling domains. The modeling domain configurations are provided in Table 5-1. The CAMx inner 4 km domain encompasses the entire Maricopa eight-hour ozone nonattainment area, consisting of 56 grid cells in the west-east direction and 44 grid cells in the south-north direction. The origin of the modeling domain (the southwest corner of the inner domain) is located at 226.004 km easting and -165.879 km northing in Lambert Conformal Projection (LCP). The domain has an area of approximate 15,222 square miles.

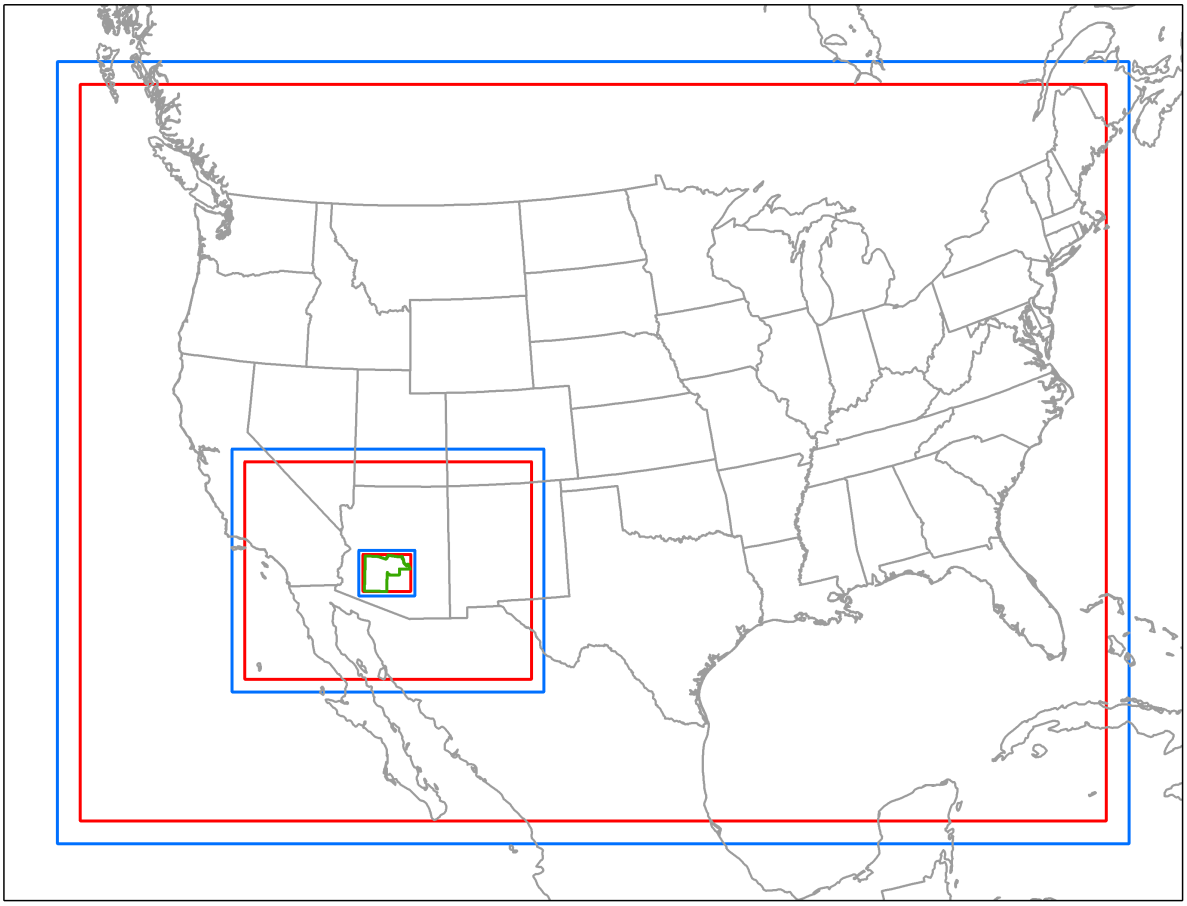

Figure 5-1 CAMx photochemical modeling domains (red: 36/12/4 km) and WRF meteorological modeling domains (blue: 36/12/4 km)

Table 5-1 WRF and CAMx modeling domains

WRF Modeling Domains		
Grid Resolution	**Grid Size**	**LCP Range (km)**
36 km x 36 km	141 by 103	(-1,674.004, -1,361.879) to (3,401.996, 2,346.121)
12 km x 12 km	123 by 96	(-846.004, -641.879) to (629.996, 510.121)
4 km x 4 km	66 by 54	(-246.004, -185.879) to (17.996, 30.121)
CAMx Modeling Domains		
Grid Resolution	**Grid Size**	**LCP Range (km)**
36 km x 36 km	135 by 97	(-1,566.004, -1,253.879) to (3,293.996, 2,238.121)
12 km x 12 km	113 by 86	(-786.004, -581.879) to (569.996, 450.121)
4 km x 4 km	56 by 44	(-226.004, -165.879) to (-2.004, 10.121)

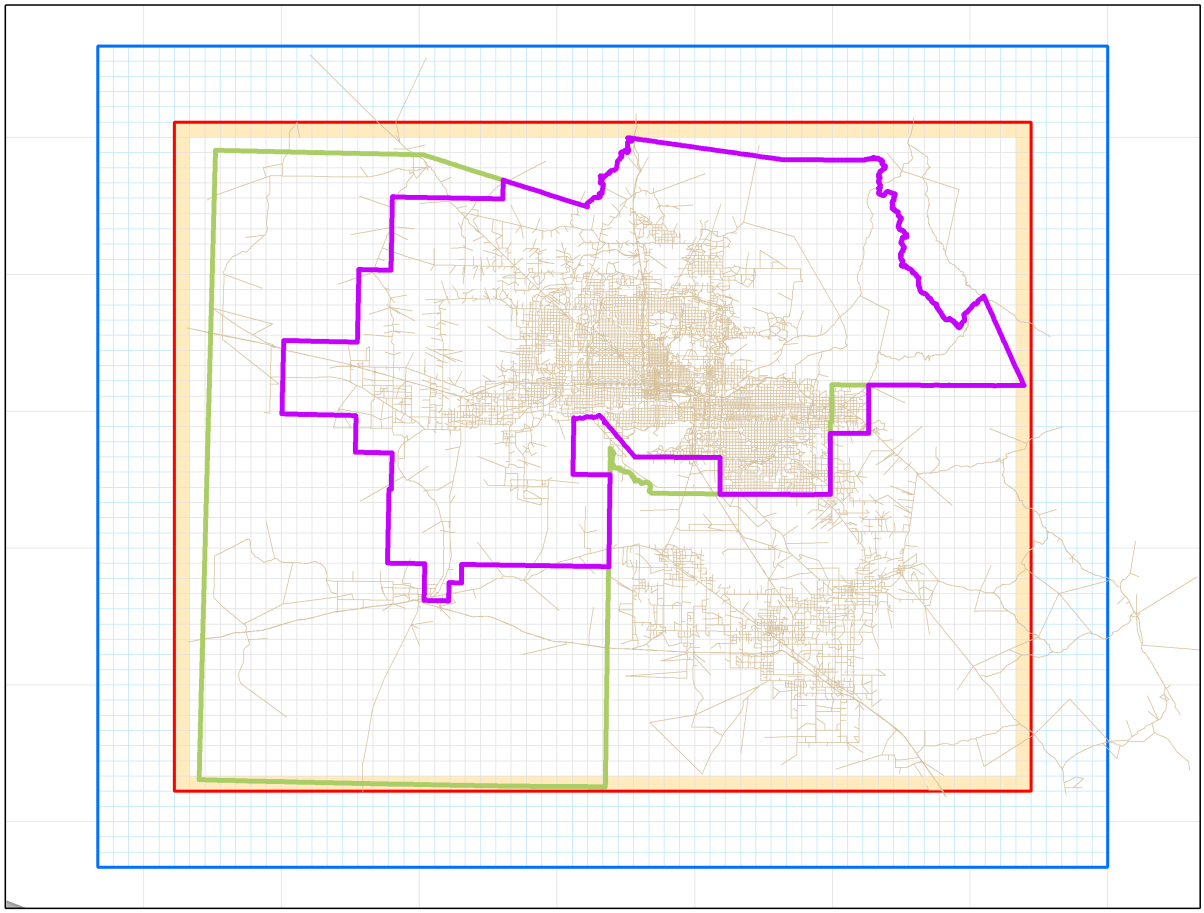

Figure 5-2 The inner-most CAMx modeling domain (red) and WRF modeling domain (blue), along with the Maricopa County boundary (green) and the Maricopa eight-hour ozone nonattainment area (purple)

The domain is large enough to contain potential emission sources within Maricopa and Pinal Counties which are likely to contribute to elevated ozone concentrations in the Maricopa eight-hour ozone nonattainment area.

5.2 Vertical Layer Configuration

The vertical layer resolution and coordinates for WRF and CAMx modeling are based on the sigma coordinate system. The sigma coordinate system uses the terrain-following hydrostatic pressure vertical coordinates ranging from 1 at the surface to 0 at the upper top boundary of the modeling domain. The 23 vertical layers configuration is used for both CAMx and WRF modeling. The upper top boundary is based on the reference pressure of 50.0 hPa. The numbers of approximate pressures and heights of vertical layers for the CAMx and WRF modeling are presented in Table 5-2.

The vertical depth and vertical layer structures of the 12 km and 4 km domains are consistent with those of the 36 km domain.

Table 5-2 Pressures and heights of WRF and CAMx vertical layers

Layer No.	Vertical Layer Pressure (hPa)	Vertical Layer Height (m)
1	933	20
2	929	60
3	925	100
4	921	140
5	914	201
6	906	282
7	898	364
8	889	446
9	877	571
10	860	740
11	843	911
12	826	1,085
13	801	1,352
14	764	1,764
15	713	2,341
16	663	2,945
17	622	3,479
18	580	4,042
19	538	4,638
20	496	5,271
21	392	7,192
22	225	11,339
23	121	14,949

6.0 MODEL INPUTS

6.1 Meteorological Modeling Inputs

6.1.1 WRF Model Configuration

WRF is an off-line dynamic grid model that simulates winds, vertical mixing, temperature, humidity, and solar radiation. The physical schemes used in the WRF model runs are as follows:

- New YSU planetary boundary layer physics,
- Noah LSM surface physics,
- WSM5 cloud mircophysics,
- Thompson cloud microphysics,
- New Multi-scale Kain-Fritsch cumulus parameterization,
- Rapid Radiative Transfer Model (RRTM) for longwave radiation, and
- Goddard scheme for shortwave radiation.

The simulation starting time is 12:00 Universal Time Coordinate (UTC) and the model is reinitialized after each segment run of 1.5 days (36 hours). All 153 consecutive 36-hour simulations are stitched together to form a full ozone season simulation. The first 12 hours of each segment are considered as the spin-up period for the segment run and disregarded after re-initialization, creating a continuous and more accurate representation of the seasonal meteorology. The standard data assimilation approach (grid analysis nudging) is applied to all modeling domains.

6.1.2 WRF Input Data Preparation Procedures

The operational NCEP Eta 212 grid (40 km) archived data (ds609.2) are obtained from the National Center for Atmospheric Research (NCAR) Computational Information Systems Laboratory (CISL) and used as input to the WRF modeling. A customized shell program is used to read and rename input files being processed by the WRF Preprocessing System (WPS). The procedures of the WPS to prepare input to WRF for real-data simulations include 1) defining coarse parent domain and fine nested domains, 2) computing latitude, longitude, map scale factors, and Coriolis parameters at every grid point, 3) interpolating time-invariant terrestrial data to simulation grids, and 4) transferring time-variant data at a standard 3-hour interval.

6.1.3 Meteorological Initial and Boundary Conditions

The meteorological initial conditions for the modeling domains and the lateral boundary conditions for the 36 km domain are generated by the program real.exe based on WPS data. Lateral boundary conditions for the two nested modeling domains are dynamically provided every hour by their parent modeling domains during the WRF simulations. WRF runs for the 36 km domain provide the boundary condition for the 12 km domain and likewise WRF runs for the 12 km domain provide the boundary condition for the 4 km

domain.

6.1.4 WRF Output Data for Meteorological Inputs to Air Quality Models

The Meteorology-Chemistry Interface Processor (MCIP) processes WRF outputs for the CAMx-ready data sets. MCIP is designed to maintain dynamic consistency between the meteorological model and the chemical transport model. MCIP v4.2 reads WRF ouputs for the grid cells of the air quality modeling domain and converts the WRF model outputs to meteorological input format for CAMx, MEGAN, and SMOKE.

6.2 Emission Inputs

Anthropogenic and biogenic source emissions inventories in 2011 and 2017 for the period of May 1 through September 30 are developed for Maricopa and Pinal Counties for the 4 km domain, and the U.S. and portions of Mexico and Canada for the 12 km and 36 km domains for this modeling analysis. The U.S. anthropogenic emissions inventory for the 12 km and 36 km domains are obtained from the EPA 2011 Air Quality Modeling Platform version 6.2 (AQMP v6.2) (EPA, 2015a). The anthropogenic emissions inventory development for the northern portion of Mexico and the southern portion of Canada was contracted with Eastern Research Group (ERG), Inc. ERG provided the 2011 and 2017 anthropogenic emissions in Mexico and Canada on August 31, 2015. The details on the 2011 and 2017 Mexico and Canada emissions inventories are available in Appendix E.

Biogenic emissions in 2011 are developed using MEGAN for the 4 km, 12 km, and 36 km domains. Wildfire emissions in the U.S. are obtained from the EPA 2011 AQMP v6.2 and wildfire emissions in Mexico and Canada are obtained from the Western Regional Air Partnership (WRAP) Deterministic & Empirical Assessment of Smoke's Contribution to Ozone (DEASCO3) project data. Biogenic source emissions including wildfire emissions are assumed to be constant between 2011 and 2017.

The following sub-sections focus on the emissions inventory development for the 4 km domain.

6.2.1 Point Source Emissions

Point sources include major stationary sources that emit a significant amount of air pollutants (i.e., VOC, NOx, CO, SO_2, PM-10, PM-2.5, lead, and NH_3) into the air. Point sources are required to report emissions if they meet the major source definition under 40 CFR Part 70. To develop the emissions inventory for this modeling analysis, point sources are subcategorized into Electric Generating Units (EGU) and non-EGU. EGU refer to power plants. Non-EGU include major stationary sources (except power plants) such as petroleum product storage and transfer facilities, large industrial facilities, and landfills.

EGU and non-EGU point source emissions for Maricopa County in 2011 are based on ozone season day emissions for the period of June through August reported in the Addendum (August 2015) for the 2011 Periodic Emissions Inventory (PEI) for ozone precursors. EGU emissions in 2017 provided by MCAQD are based on the maximum emissions over the 10-year period of 2005 through 2014 for individual EGU (MCAQD, 2015). The new Buckeye Generation Center is planned for operation in 2017 and the

Potential to Emit (PTE) emissions are assumed for the power plant emissions in 2017. Non-EGU emissions in 2011 are projected to 2017 by applying growth factors that are developed using the socioeconomic data, census data, and appropriate growth indicators (e.g., population, employment, agricultural area, gasoline consumption, etc.) between 2011 and 2017, as shown in Table 6-1.

Table 6-1 Growth indices and growth factors for non-EGU point and area sources in Maricopa County

Growth Index	2011	2017	Growth Factor
Agricultural Acres	275,050	268,346	0.98
Airport Operations (operations/year)	1,718,536	1,805,295	1.05
Gasoline Consumption (gallons/day)	4,308,054	3,901,057	0.91
Industrial Employment	336,654	393,824	1.17
Locomotive Diesel Usage (gallons/year)	8,273,092	6,097,290	0.74
Number of Aircrafts in Luke AFB	136	132	0.97
Population	3,843,373	4,239,606	1.10
Roadway Lane Miles	22,551	23,137	1.03

Pinal County EGU and non-EGU emissions in 2011 are provided by the Pinal County Air Quality Control District (PCAQCD) and projected to 2017 emissions by applying growth factors. The growth factors for individual EGU are developed using Pinal County EGU emissions growths extracted from the 2011 and 2017 base case emissions inventories of the EPA 2011 AQMP v6.2. The growth factors for non-EGU are developed using the industrial employment growth between 2011 and 2017. The industrial growth index and growth factor are presented in Table 6-2. PCAQCD provided 2017 emissions for the Coolidge Generation Station by applying a 20% growth to the 2011 emissions because the emissions for the Coolidge Generating Station are left off the 2017 base case emissions inventory of the EPA 2011 AQMP v6.2 (PCAQCD, 2015).

6.2.2 Area Source Emissions

Area sources are defined as all stationary sources which are too small or too numerous to be treated as point sources. Area source emissions for Maricopa County in 2011 are obtained from ozone season day emissions for the period of June through August reported in the Addendum for the 2011 PEI for ozone precursors. The ozone season day emissions are expanded for the development of ozone season day specific emissions for the five

Table 6-2 Growth indices and growth factors for non-EGU point and area sources in Pinal County

Growth Index	2011	2017	Growth Factor
Agricultural Acres	449,368	447,425	1.00
Airport Operations (operations/year)	176,724	262,008	1.48
Gasoline Consumption (gallons/day)	417,529	378,125	0.91
Industrial Employment	8,111	7,752	0.96
Locomotive Diesel Usage (gallons/year)*	8,273,092	6,097,290	0.74
Population	384,221	444,680	1.16
Roadway Lane Miles	6,368	6,508	1.02

* The locomotive diesel usage and projection for Maricopa County are assumed for Pinal County.

months modeling period of this study. Area source ozone season day emissions in 2011 are projected to emissions in 2017 by applying growth factors which were developed based on the growth indices between 2011 and 2017. The growth indices and growth factors developed for Maricopa County are provided in Table 6-1. The growth factors applied to individual area source categories in Maricopa County are presented in Table C-1 in Appendix C.

Area source emissions in Pinal County for the base year 2011 are obtained primarily from the EPA 2011 AQMP v6.2 because the Pinal County 2011 PEI for ozone precursors is not available. Since the EPA 2011 AQMP v6.2 emissions inventory overestimated emissions for land clearing debris, architectural coatings, landfills, and crematories in Pinal County, corrected emissions for these categories are provided by PCAQCD. The growth factors in Table 6-2 are applied to project Pinal County area source emissions in 2011 to those in 2017. The growth indices and factors applied to individual area source categories in Pinal County are presented in Table C-2 in Appendix C.

6.2.3 Onroad Mobile Source Emissions

EPA released MOVES2014a on November 4, 2015. Because EPA recommends use of the model for new State Implementation Plan (SIP) development, onroad emissions for the 4 km domain will be calculated using MOVES2014a and MAG MOVESLINK2014 for this study. MOVESLINK2014 is a tool designed to process road network and off-network emissions factors from MOVES2014a and link data from the TransCAD Travel Demand Model (TDM) to develop the onroad emissions inventory for regional transportation conformity and photochemical air quality modeling analyses. This tool is developed by

MAG using the Python programming language and Geographic Information Systems (GIS) technology. MOVESLINK2014 reads link-level activity data from the MAG TransCAD traffic assignment, prepares MOVES2014a input data, executes MOVES2014a, and post-processes MOVES2014a outputs.

To calculate vehicle emissions for the selected years, MOVES2014a is executed using local input data for each day of the modeling episode. MOVES modeling scenarios are created using the County Domain/Scale option with the Inventory and Emissions Rates Calculation Type for all road types including off-network.

MOVES2014a requires local data such as Inspection and Maintenance (I/M) programs, meteorological data, vehicle population, source type age distribution, annual vehicle miles traveled (VMT), monthly/daily/hourly fractions, road type distribution, average speed distribution, ramp fraction, fuel data, and Alternative Vehicle and Fuel Technologies (AVFT). According to EPA guidance (EPA, 2015c), local input data are prepared as follows:

- I/M programs: The I/M programs data were provided by the ADEQ.
- Meteorological data: As a representative of local meteorological conditions, meteorological data measured at the Phoenix Sky Harbor International Airport are obtained from the National Climatic Data Center (NCDC) for the selected episode days in 2011. The same data are applied to the base and future year modeling.
- Vehicle population: Vehicle registration data in Maricopa County for the base year of 2011 are obtained from ADOT and assigned to vehicle populations for the 13 MOVES source types. For the future year modeling, the vehicle registration data for the current year 2015 are adjusted by applying the ratio of the future year source type population to the current year source type population.
- Source type age distribution: The EPA MOVES data converter is used to generate the MOVES age distribution input based on the vehicle registration data from ADOT.
- Annual VMT: The annual VMT data by the Highway Performance Monitoring System (HPMS) vehicle type are derived with the MOVES default VMT fractions for the HPMS vehicle types and the traffic assignment data provided by the MAG Transportation Division.
- Road type distribution: The road type distribution by HPMS vehicle type is derived with the MOVES default VMT fractions for the HPMS vehicle types from the traffic assignment data provided by the MAG Transportation Division.
- VMT fraction: The month/day/hour VMT fractions are developed from traffic count data recorded by continuous traffic counters on freeways (ADOT Freeway Management System) and arterials (Phoenix Automatic Traffic Recorders) in 2007.
- Average speed distribution: Estimates of local average speeds are derived from the traffic assignment data provided by the MAG Transportation Division.

- Ramp fraction: The ramp fraction represents the percent of vehicle hours traveled (VHT) on freeway ramps on both rural and urban restricted roads. The VHT for the ozone modeling domain is obtained from the traffic assignment data provided by the MAG Transportation Division.
- Fuel data: Using the MOVES Fuel Wizard, the MOVES2014a default fuel parameters by month are replaced with the Maricopa and Pinal Counties fuel inspection data provided by the Arizona Department of Weights and Measures (ADWM) for the year 2011. For the future year modeling, the MOVES2014a defaults for the 2017 fuel parameters are used.
- AVFT strategy: The AVFT input for transit buses is updated using the bus fleet information by fuel type provided by Valley Metro.

Based on these inputs, draft onroad emissions have been developed using the MOVES2014 model, as provided in Appendices B and F. The draft onroad emissions will be revised using the MOVES2014a model for the modeled attainment demonstrations and the 15% VOC reduction compliance of the Reasonable Further Progress (RFP).

6.2.4 Nonroad Mobile Source Emissions

Nonroad Equipment Emissions

EPA incorporated its NONROAD2008 model into MOVES2014 in July 2014. Since the nonroad portion of MOVES2014 is identical to the NONROAD2008 model, either the standalone NONROAD2008 or its incorporation into MOVES2014 is allowed for development of nonroad emissions inventories for SIP submissions or other official modeling purposes. On November 4, 2015, EPA released MOVES2014a (EPA, 2015c) and recommended that MOVES2014a be used for nonroad emissions modeling for all new SIP development. EPA justified use of MOVES2014a because it provides slightly different nonroad emissions results due to the new features of nonroad emissions output processes and the updated fuel input files. EPA pointed out that the NONROAD2008 model might no longer work with current operating systems and will no longer be technically supported by EPA. For these reasons, MOVES2014a will be used to estimate ozone precursor emissions for all nonroad mobile sources in Maricopa and Pinal Counties, except for locomotives, aircraft and airport ground support equipment. However, draft nonroad equipment emissions in 2011 and 2017 are calculated using the NONROAD2008 model default populations and activities for Maricopa and Pinal Counties, as are presented in Appendices B and F. The draft nonroad emissions will be revised using MOVES2014a for this study.

Nonroad emissions categories include agricultural equipment, commercial equipment, construction and mining equipment, industrial equipment, lawn and garden equipment (commercial and residential), pleasure craft, railroad equipment and recreational equipment. Logging equipment are assumed to be zero for Maricopa County and Pinal County. MOVES2014a runs are based on the population and activity defaults of the model for Maricopa and Pinal Counties. For commercial lawn and garden equipment, MAG uses locally collected data from a survey of activity and population for these equipment in

Maricopa County (ENVIRON, 2003).

Monthly fuel data in 2011 for Maricopa and Pinal Counties are provided by ADWM. The fuel data include oxygen content, ethanol blend volume percentage and market share, and Reid Vapor Pressure (RVP). Daily minimum and maximum, and average temperatures measured at Sky Harbor International Airport in 2011 are used for MOVES2014a nonroad modeling. Additionally, the model is run with different default profiles depending on the day of the week (EPA, 1999), resulting in unique day-of-week totals depending on the base year 2011 calendar day. Daily emissions for the entire ozone season is constructed, substituting emissions for holidays (Memorial Day, Independence Day, and Labor Day) with the weekend emissions. Locomotive emissions in 2011 are obtained from the Maricopa County 2011 PEI for ozone precursors and the EPA 2011 AQMP v6.2 for Pinal County. Locomotive emissions in 2017 account for the projected locomotive diesel fuel consumptions in 2017.

Airport Emissions

Most airport emissions in Maricopa and Pinal Counties are developed with EDMS version 5.1.4. This model is designed to calculate VOC, NOx, CO, particulate matter, and other gaseous pollutant emissions for aircraft, auxiliary power units (APU), and ground support equipment (GSE). EDMS features up-to-date aircraft engine emission factors from the International Civil Aviation Organization (ICAO) Engine Exhaust Emissions Data Bank.

As shown in Table 6-3, there are 22 airports located in Maricopa and Pinal Counties within the 4 km domain.

To calculate aircraft, APU, and GSE emissions for airports in Maricopa County, EDMS requires the following four inputs:

- Number of landing and takeoff (LTO) cycles: The number of LTO cycles is prepared for four aircraft categories: Air Commercial (AC), Air Taxi (AT), General Aviation (GA), and Military (ML). The day-specific LTO data from the first eight airports in Table 6-3 are retrieved directly from the Airport Operations database in the FAA Air Traffic Activity Data System (ATADS). The monthly LTO data for the other airports, except Luke Air Force Base (AFB), are obtained from MAG 2009 and 2014 airport survey data.
- Aircraft fleet mix: Aircraft fleet mix accounts for the operation distribution of aircraft types. The fleet mix data are developed using FAA Enhanced Traffic Management System Counts (ETMSC) data.
- Operational temporal profiles for aircraft types: The monthly and weekly profiles are developed using the day-specific LTO data for the aircraft categories for individual airports. The hourly profile is created using operation data from the FAA Aviation Performance Metrics (APM) data.
- Mixing height: Based on the Phoenix Sky Harbor Airport surface meteorological data and the Tucson upper air data, the time-varying mixing heights are calculated using EPA AERMET (version 15181) and AERSURFACE (version 13016) models.

Surface and upper air meteorological data are obtained from the NCDC Integrated Surface Hourly Database (ISHD), 1-minute Automated Surface Observing System (ASOS) wind data, and the Earth System Research Laboratory (ESRL) Radiosonde Database.

Table 6-3 Operations for airports in the 4 km domain in 2011 and 2017

No.	Airport Name	Code	County	Latitude	Longitude	2011	2017
1	Chandler Municipal Airport	CHD	Maricopa	33.269	-111.811	161,589	233,855
2	Deer Valley Airport	DVT	Maricopa	33.688	-112.083	317,443	317,247
3	Falcon Field Airport	FFZ	Maricopa	33.461	-111.728	220,080	275,171
4	Glendale Municipal Airport	GEU	Maricopa	33.527	-112.295	87,124	59,130
5	Phoenix Goodyear Airport	GYR	Maricopa	33.423	-112.376	138,606	76,282
6	Phoenix-Mesa Gateway Airport	IWA	Maricopa	33.308	-111.655	171,200	221,259
7	Phoenix Sky Harbor Airport	PHX	Maricopa	33.434	-112.008	461,989	458,242
8	Scottsdale Airport	SDL	Maricopa	33.623	-111.911	141,640	148,813
9	Buckeye Municipal Airport	BXK	Maricopa	33.420	-112.686	53,070	53,070
10	Gila Bend Municipal Airport	GBD	Maricopa	32.958	-112.678	3,536	3,536
11	Pleasant Valley Airport	P48	Maricopa	33.801	-112.251	6,010	6,010
12	Sky Ranch at Carefree Airport	18AZ	Maricopa	33.818	-111.898	3,030	3,030
13	Stellar Airpark	P19	Maricopa	33.299	-111.916	39,056	39,056
14	Luke Air Force Base*	LUF	Maricopa	33.535	-112.383	n/a	n/a
15	Wickenburg Municipal Airport	E63	Maricopa	33.969	-112.799	12,000	12,000
16	Ak-Chin Regional Airport**	A39	Pinal	32.991	-111.919	1,095	36,500
17	Arizona Soaring	E68	Pinal	33.084	-112.161	20,075	20,075
18	Casa Grande Municipal Airport	CGZ	Pinal	32.955	-111.767	119,680	119,680
19	Coolidge Municipal Airport	P08	Pinal	32.936	-111.427	4,250	4,250
20	Eloy Municipal Airport	E60	Pinal	32.807	-111.587	19,800	23,450
21	Kearny Airport	E67	Pinal	33.047	-110.909	1,196	1,196
22	Pinal Airpark	MZJ	Pinal	32.510	-111.325	10,628	56,857

* Emissions are scaled by numbers of aircrafts in 2011 and 2017.

** Operational data at Ak-Chin Regional Airport were collected through a phone conversation with airport manager Tim Costello on 10/27/2015.

The Luke Air Force Base (AFB) emissions in 2011 are developed by scaling the 2008 emissions (Weston, 2010) with the numbers of F-16 aircraft data in 2008 and 2011. The Luke AFB provided the numbers of F-16 aircraft in 2011, and F-16 and F-35 aircraft in 2017. The Luke AFB F-16 emissions in 2011 are projected to 2017 using the ratio of the

number of F-16 aircraft in 2017 to one in 2011. The Luke AFB aircraft and GSE emissions for the future 144 F-35 aircraft of the L6 scenario are obtained from the 2012 environmental impact statement report (USAF, 2012). The Luke AFB emissions in 2017 are calculated by multiplying the ratio of the 60 F-35 aircraft in 2017 to the 144 F-35 aircraft to the L6 scenario emissions and adding F-16 aircraft emissions in 2017.

For the 2017 airport emission calculations for Maricopa County, the latest LTO predictions from the FAA Terminal Area Forecast (TAF) (FAA, 2015) are used for the first eight airports in Table 6-3, while the LTO cycles for other airports are assumed to be the same as those in 2011 since those airports are small and have no operation projections for the future year.

For the seven airports in Pinal County within the 4 km domain, airport operations in 2011 and 2017 are obtained from three sources: (1) MAG airport survey, (2) FAA TAF database, and (3) AirNav.com website. The emissions at the Pinal Airpark in 2017 are scaled by applying the ratio of operations between 2011 and 2017 to the 2011 emissions from the EPA 2011 AQMP v6.2. The aircraft fleet mix data for airports in Pinal County are based on average fleet mix data of the municipal airports in Maricopa County for general aviation and military cateogries. To calculate hourly mixing heights, surface meteorological data at the National Weather Service (NWS) Casa Grande Airport station are extracted from NCDC ISHD.

6.2.5 Biogenic Source Emissions

Biogenic emissions include VOC, NOx, and CO emitted by vegetation and soil. MEGAN version 2.10 (Guenther, 2012) is used to estimate biogenic emissions.

Meteorological data for MEGAN runs are obtained from WRF model outputs. The WRF simulations are postprocessed by MCIP. The output of MCIP is used as input to MET2MEG, which is a component program of MEGAN to generate meteorological input data for MEGAN. The MET2MEG outputs include photosynthetically active radiation at the surface, temperature at 2 meters above the surface, pressure, humidity, wind speed, soil moisture and temperature, and precipitation.

Eight-day average leaf area index (LAI) and percentages of 16 plant functional types (PFT) are used to characterize vegetation coverage and tree distribution in the modeling domains. The LAI data are based on 30 arc-seconds (approximate 1 km) North America Leaf Index (version 2011); the PFT data are 30 arc-seconds North America Plant Functional Type (version 2011); the emissions factors are 30 arc-seconds global emission factors.

6.3 Emissions Preprocessing

Emissions inventory data must be pre-processed for use of the CAMx modeling analysis. The SMOKE modeling system is used to develop gridded, chemically speciated, and hourly emissions for the CAMx modeling. The anthropogenic and biogenic emissions are merged into one emissions input file for CAMx. The SMOKE model is also used to separate elevated point source emissions from the ground level point source emissions using the WRF mixing heights.

Temporal Allocation of Emissions

Emissions inventories are provided at various temporal levels (i.e., season day emissions or annual emissions). SMOKE develops day-specific hourly emissions using temporal profiles.

Since the temporal profiles for EGU point sources in the 4 km domain are inappropriate, EGU temporal profiles are developed using the EPA Continuous Emissions Monitoring System (CEMS) data from the EPA 2011 AQMP v6.2. For non-EGU point sources in Maricopa County, ozone season average day emissions are temporally adjusted using the EPA hourly profile from the EPA 2011 AQMP v6.2. Pinal County non-EGU annual emissions are processed to develop hourly emissions using the EPA monthly, weekly, and diurnal temporal profiles.

For the temporal allocation of area and nonroad sources, the EPA temporal profiles are used for day-specific hourly emissions by Source Classification Code (SCC).

Spatial Allocation of Emissions

Most anthropogenic emissions, except point sources, are reported as county-level. These emissions are to be spatially allocated to grid cells for photochemical air quality modeling. For example, gridded agricultural land use is used to spatially distribute agricultural pesticide emissions.

The EPA Spatial Allocator (SA) v4.2 is used in generating geo-referenced spatial surrogates that are inputs to the SMOKE modeling system.

Three components are required for developing spatial surrogates as follows:

1. Weight shapefile: The geospatial dataset is used for allocating (or weighting) county-level emissions to grid cells. The dataset includes shapefiles for roadways, population density, or golf courses.
2. Data shapefile: The geospatial dataset includes county and municipal boundary layers.
3. Output grid or polygon: The geospatial dataset includes grids or polygons configuration for the modeling domains.

A total of 22 spatial surrogates are developed for Maricopa and Pinal Counties by using MAG GIS shapefiles for the region. For Maricopa County, the MAG GIS shapefiles include 2010 census data, 2011 MAG regional traffic data, 2012 MAG land use and land cover, and 2011 Maricopa County employment data. The recent local landuse and employment data for Pinal County are used in developing spatial surrogates for grid emissions in the area. These spatial surrogates applied to Source Classification Codes (SCC) are listed in Appendix D.

Chemical Speciation

The CAMx modeling in this study uses the most up-to-date chemical mechanism, Carbon Bond Version 6 revision 2 (CB6r2), as photochemical reactions of ozone precursor

emissions. This version of chemical mechanism has updated chemistry of isoprene and aromatic hydrocarbons and NOx recycling from the degradation of organic nitrates. The chemical mechanism contains 137 model species and 216 chemical reactions to simulate atmospheric photochemical reactions (ENVIRON, 2014). The SMOKE modeling system is used for the chemical speciation process, which converts ozone precursor emissions (i.e., VOC and NOx) to the model species emissions for ozone chemistry according to chemical speciation profiles for emission source categories. The SMOKE CB6 speciation profile is used to perform the chemical speciation process for the CAMx modeling.

6.4 Ozone Column Data

The CAMx photochemical mechanism requires ozone column and clear-sky photolysis rate data. Day-specific ozone column data are obtained from the Total Ozone Mapping Spectrometer (TOMS) satellite platform. The CAMx Tropospheric Ultraviolet Visible (TUV) radiative transfer model uses TOMS ozone column data to calculate clear-sky photolysis rates and to adjust the clear-sky photolysis rates in presence of cloud and aerosols.

6.5 Observed Ozone Data

Observed ozone concentrations collected from the air quality monitoring sites in Table 6-4 will be used in evaluating the CAMx model performance and developing the baseline design values for the monitoring sites. The locations of the monitoring sites are provided in Figure 6-1.

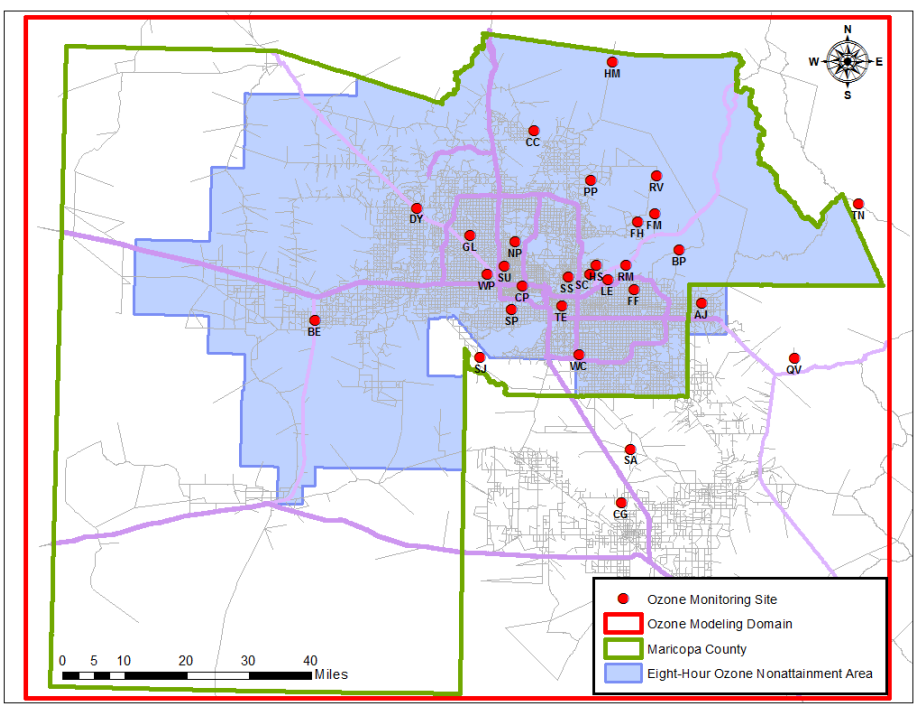

Figure 6-1 Locations of ozone monitoring sites within and near the Maricopa eight-hour ozone nonattainment area

Table 6-4 Ozone monitoring sites in the 4 km domain

AIRSID	Site Name	Site Abbr	County	Street Address	Latitude	Longitude
40070010	Tonto NM	TN	Gila	South of SR88	33.6547	-111.1074
40130019	West Phoenix	WP	Maricopa	3847 W Earll Dr, Phoenix	33.4839	-112.1426
40131004	North Phoenix	NP	Maricopa	601 E Butler Dr & 6th St, Phoenix	33.5603	-112.0663
40131010	Falcon Field	FF	Maricopa	4530 E McKellips Rd, Mesa	33.4522	-111.7333
40132001	Glendale	GL	Maricopa	6000 W Olive Ave, Glendale	33.5745	-112.1920
40132005	Pinnacle Peak	PP	Maricopa	25000 N Windy Walk, Scottsdale	33.7063	-111.8556
40133002	Central Phoenix	CP	Maricopa	1645 E Roosevelt St, Phoenix	33.4579	-112.0460
40133003	South Scottsdale	SS	Maricopa	2857 N Miller Rd, Scottsdale	33.4797	-111.9172
40134003	South Phoenix	SP	Maricopa	33 W Tamarisk Ave, Phoenix	33.4032	-112.0753
40134004	West Chandler	WC	Maricopa	275 S Ellis, Chandler	33.2990	-111.8843
40134005	Tempe	TE	Maricopa	1525 S College Ave, Tempe	33.4124	-111.9347
40134008	Cave Creek	CC	Maricopa	37019 N Lava Ln, Cave Creek	33.8217	-112.0174
40134010	Dysart	DY	Maricopa	16825 N Dysart, Surprise	33.6371	-112.3418
40134011	Buckeye	BE	Maricopa	26453 W MC85, Buckeye	33.3701	-112.6207
40135100	Fort McDowell/Yuma Frank	FM	Maricopa	18791 Yuma Frank Rd, Fort McDowell	33.6292	-111.6769
40137003	St Johns	SJ	Maricopa	4208 W Pecos, Laveen	33.2902	-112.1606
40137020	Senior Center	SC	Maricopa	10844 E Osborn Rd, Scottsdale	33.4882	-111.8557
40137021	Red Mountain	RM	Maricopa	15115 Beeline Highway, Scottsdale	33.5080	-111.7553
40137022	Lehi	LE	Maricopa	3250 N Stapley Dr, Mesa	33.4746	-111.8058
40137024	High School	HS	Maricopa	4827 N Country Club Dr, Scottsdale	33.5081	-111.8385
40139508	Humboldt Mountain	HM	Maricopa	7 Springs Rd, Tonto National Forest	33.9828	-111.7987
40139702	Blue Point	BP	Maricopa	Usery Pass Rd, Blue Point	33.5455	-111.6093
40139704	Fountain Hills	FH	Maricopa	16426 E Palisades Blvd, Fountain Hills	33.6110	-111.7253
40139706	Rio Verde	RV	Maricopa	25608 N Forest Rd, Rio Verde	33.7188	-111.6718
40139997	Super Site	SU	Maricopa	4530 N 17th Ave, Phoenix	33.5038	-112.0958
40213001	Apache Junction	AJ	Pinal	305 E Superstition Blvd, Apache Junction	33.4214	-111.5436
40213003	Casa Grande	CG	Pinal	660 W Aero Dr, Casa Grande	32.9544	-111.7623
40217001	Sacaton	SA	Pinal	35 Pima St, Sacaton	33.0801	-111.7400
40218001	Queen Valley	QV	Pinal	10 S Queen Ann, Queen Valley	33.2935	-111.2856

6.6 Photochemical Modeling Configuration

CAMx requires a namelist control file specifying input files and model configuration such as model clock control, map projection parameters, modeling grid parameters, model options, and output specifications. Table 6-5 summarizes the CAMx model configuration in this study.

Table 6-5 CAMx model configuration

Science Options	Configuration	Details
Model	CAMx v6.2	Newer version will be used if available at time of modeling
Horizontal Grid	36/12/4 km	Geographic dimensions of each cell
- 36 km domain	135 x 97 cells	36 km one-way grid nesting
- 12 km domain	113 x 86 cells	12/4 km two-way grid nesting
- 4 km domain	56 x 44 cells	12/4 km two-way grid nesting
Vertical Grid	23 vertical layers	Layer 1 (~20 m), Model top (~15 km)
Grid Interaction	36 km: one-way grid nesting 12/4 km: two-way grid nesting	Nested domain depends on outer domain for boundary and initial conditions
Initial Conditions	3-day spin-up	Smoothing out unrealistic fluctuations at start of simulation
Boundary Conditions	36 km: extracted from global chemistry model 12 km: extracted from the 36 km domain results	MOZART global chemistry model
Emissions Processing	SMOKE MOVESLINK2014 for 4 km domain	MOVESLINK2014 for 4 km onroad emissions
Gas Phase Chemistry	Carbon Bond 6, revision 2 (CB6r2)	Latest chemical reactions
Meteorological Processor	WRFCAMx v4.3	Compatible with CAMx v6.2
Horizontal Diffusion	Explicit simultaneous 2-D solver	K-theory 1st order closure
Vertical Diffusion	Kv (CMAQ method)	K-theory 1st order closure
Dry Deposition	Resistance model for gases	Zhang 2003
Wet Deposition	Scavenging model for gases and aerosols	Seinfeld and Pandis 1998
Gas Phase Chemistry Solver	Euler Backward Iterative (EBI) Solver	Most efficient solver in CAMx
Vertical Advection Scheme	Implicit backward-Euler hybrid centered/upstream solver	Eulerian continuity equation
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	Eulerian continuity equation

The CAMx configuration is set up to perform one-way grid nesting on the 36 km domain and two-way grid nesting on the 12 km and 4 km domains. Initial and boundary conditions (ICBC) for the 36 km domain are extracted from the MOZART global chemistry model using MOZART2CAMx pre-processor. ICBC for the 12 km domain are extracted from three dimensional outputs of CAMx simulations for the 36 km domain using the CAMx pre-processor BNDEXTR, and ICBC for the 4 km domain are obtained from CAMx outputs for

the 12 km domain.

For the sensitivity or source apportionment modeling, CAMx will be set up to perform two-way nesting on the three domains to evaluate contribution of ozone and its precursor emissions from upwind states, Mexico, and Canada to the Maricopa eight-hour ozone nonattainment area.

The meteorological fields developed by WRF are processed for CAMx using WRFCAMx pre-processor. The O3MAP pre-processor is used to prepare albedo/haze/ozone column inputs for CAMx from TOMS data. The photolysis inputs are prepared using TUV pre-processor.

6.7 Quality Assurance

The purpose of quality assurance is to establish that good model performance is the result of valid model inputs and assumptions, not the result of compensating errors in input data.

Prior to conducting modeling analysis, individual air quality, meteorological, and emissions data will be examined for consistency and obvious errors. Both spatial and temporal characteristics of the data will be also evaluated. Examples of quality assurance processes include;

- Air Quality - Observational data will be checked for out-of-range values.
- Meteorology - WRF modeled surface and elevated wind vectors and temperature fields will be plotted. The plotted wind vectors and temperature fields will be compared with monitoring station data and weather maps for consistent patterns. The runtime log files from MCIP and WRFCAMx programs will be examined for errors or warnings.
- Emissions - Inventories are tabulated, plotted, and reviewed for the quality assurance. The quality assurance procedures will include documentation of major assumptions, careful accounting of emissions totals throughout the emissions inventory development process, verification of spatial distribution of emissions against known emissions source locations and strengths, identification of missing or unreasonable values, and examination of inputs and outputs of the SMOKE model to assure no errors or unexpected warnings.

7.0 MODEL PERFORMANCE EVALUATION

MAG will adhere to EPA modeling guidance to assess relevant variables paired in time and space for all recommended statistical metrics for performance evaluation of WRF meteorology simulations and CAMx ozone simulations. The MATLAB program is used to evaluate the WRF and CAMx model performances. The mode performance evaluations are performed on a site-by-site and/or network aggregate basis, for any duration or frequency of interest. A list of these metrics is provided in Table 7-1.

Table 7-1 Statistical metrics used in model performance evaluation

Metric Name	Definition
Mean Bias	$\mathrm{MB} = \frac{1}{N}\sum(M_i - O_I)$
Mean Error	$\mathrm{ME} = \frac{1}{N}\sum\lvert M_i - O_i\rvert$
Root Mean Square Error	$\mathrm{RMSE} = \sqrt{\frac{\sum(M_i - O_i)^2}{N}}$
Fractional Bias	$\mathrm{FB} = 100\% \times \frac{2}{N}\sum\frac{(M_i - O_i)}{(M_i + O_i)}$
Fractional Error	$\mathrm{FE} = 100\% \times \frac{2}{N}\sum\frac{\lvert M_i - O_i\rvert}{(M_i + O_i)}$
Normalized Mean Bias	$NMB = 100\% \times \frac{\sum(M_i - O_i)}{\sum O_i}$
Normalized Mean Error	$NME = 100\% \times \frac{\sum\lvert M_i - O_i\rvert}{\sum O_i}$
Correlation Coefficient	$R^2 = \left(\frac{\sum_1^N\left((M_i - \overline{M}) \times (O_i - \overline{O})\right)}{\sqrt{\sum_1^N(M_i - \overline{M})^2 \sum_1^N(O_i - \overline{O})^2}}\right)^2$
Index of Agreement	$IoA = 1 - \frac{\sum(O_i - M_i)^2}{\sum\left(\lvert M_i - \overline{O}\rvert + \lvert O_i - \overline{O}\rvert\right)^2}$

Performance evaluation of the meteorological simulations will focus on four key meteorological variables: temperature, water vapor mixing ratio, wind speed, and wind direction. The standard NCAR/NOAA/NWS U.S. and Canada hourly surface observational database (DS472.0) will serve as the primary data set for WRF validation and performance evaluation. The DS472.0 dataset covers the entire region encompassed by the WRF domain. Alternative monitoring networks (e.g. AZMET) may be considered for validation of solar radiation at the Earth's surface. However, since measurement heights of some of these networks are non-standard, it would be more difficult to consistently compare model results with observations.

EPA guidance recommends operational and phenomenological evaluations for the model performance. Correlation coefficient, mean bias, mean error bias, root mean square error and index of agreement will be computed for each variable to satisfy the operational performance evaluation. Hourly time series plots, paired scatter-density plots, summary plots of scatter-density, diurnal box-and-whisker plots, soccer goal diagrams, and Taylor diagrams will be generated.

To satisfy the phenomenological evaluation, emphasis will be put on validation of the simulated valley breeze. Wind roses will be created for modeled and observed wind information as well as 2-D maps of wind fields overlaid on topography. If available, observed radiosonde data will be evaluated against simulated vertical profiles to assess boundary layer heights, inversion locations and wind shear.

In addition to the metrics used in meteorological performance evaluation, the CAMx model performance will be evaluated according to the following statistical metrics:

- Normalized bias test: The metric provides a measure of the ability of the model to replicate observed patterns during the times of day when available monitoring and modeled data are most likely to represent similar spatial scales. The EPA recommended range for the metric is ±15%.
- Gross error of all pairs above 60 ppb: In conjunction with bias, this metric provides overall assessment of base case performance and may be used as a reference to other modeling applications. Gross error may be interpreted as precision. EPA recommended range for the metric is ±35%.

In general, the performance metrics that fall within or below these ranges will be considered acceptable. Furthermore, the CAMx model performance evaluation may include additional numerical and graphical measures to assure the good model performance in the study.

8.0 OZONE ATTAINMENT DEMONSTRATION

8.1 Future Year Selection

EPA modeling guidance indicates that emissions reductions needed for attainment must be implemented no later than the beginning of the ozone season immediately preceding the area's attainment date. Since the attainment deadline for the moderate area is July 20, 2018, the attainment year for the modeled attainment demonstration is 2017. The modeled attainment demonstration will be performed for the full ozone season of May 1 through September 30 in 2017.

8.2 Eight-Hour Ozone Attainment Demonstration Procedures

The modeled attainment demonstration will be performed according to the methodologies and procedures provided in EPA guidance (EPA, 2014). The modeled attainment demonstration procedures are summarized as follows:

- Develop the 2011 baseline design values for monitors in the Maricopa eight-hour ozone nonattainment area. In accordance with the EPA guidance (EPA, 2007 and 2014), the 2011 baseline design value for each monitoring site is developed by averaging three design values derived from annual 4th high daily maximum ozone concentrations for the five year period of 2009 - 2013: The first design value is the average of annual 4th high daily maximum ozone concentrations for the period of 2009 - 2011, the second design value is the average of annual 4th high daily maximum ozone concentrations for the period of 2010 - 2012, and the third design value is the average of annual 4th high daily maximum ozone concentrations for the period of 2011 - 2013.
- Run CAMx model for the 2011 base year ozone concentrations at monitors in the Maricopa eight-hour ozone nonattainment area.
- Run CAMx model for the 2017 attainment year ozone concentrations at monitors in the Maricopa eight-hour ozone nonattainment area.
- Develop Relative Response Factors (RRFs) using the modeled 2011 base year and 2017 attainment year ozone concentrations at 3 by 3 grid cells around monitoring sites.
- Develop the 2017 design values at monitors by adjusting the 2011 baseline design values by RRFs. The following equation describes the procedure:

  $$DVF_i = DVB_i \times RRF_i$$

  where $_i$ is a monitoring site, DVF is Future Design Value (i.e., 2017 DV), and DVB is Baseline Design Value (i.e., 2011 DV).
- Attainment demonstration is successful if the 2017 design values for all monitors are lower than the ozone standard. If the 2017 design values are greater than the ozone standard, the 2017 emissions inventory will be revised for further emissions control measures.

8.3 Future Year Air Quality Simulations

Since EPA does not recommend the effect of long-term climate change in the attainment demonstration if the interval between base year and future year is less than 20 years (EPA, 2014), the meteorological conditions in 2011 are assumed for the attainment year 2017 for this study. All CAMx modeling inputs for the year 2017 such as photolysis rates, land use, and modeling configurations will be identical to those for the 2011 base year except for anthropogenic emissions. Therefore, the variation of ozone concentrations in the future year in this study will be a result of the change in anthropogenic emissions between the base year and future year.

Because the Maricopa eight-hour ozone nonattainment area will continue to implement the committed control measures in the MAG 2009 Ozone Maintenance Plan (MAG, 2009), the numeric credits for the committed control measures will be used in demonstrating attainment of the ozone standard in 2017. Furthermore, the federal control measures such as portable fuel container rules, Tier 3 motor vehicle emissions and fuel standards, heavy-duty engine and vehicle standards, light-duty and heavy-duty greenhouse gas rules, renewable fuel standard program, diesel recreational marine standards, small spark ignition (SI) & SI recreational marine final rule, and ICAO aircraft engine emissions standards are included in calculating area, onroad, and nonroad source emissions for the attainment demonstration. The benefits of federal and local emission control measures are embedded in the emissions inventory via the models' onroad and nonroad emissions factors for new onroad and nonroad engines, fuel requirement inputs, and fleet turnover.

8.4 Unmonitored Areas Attainment Test

The unmonitored area analysis is intended to identify areas or locations outside of the existing monitoring network where the modeling analysis indicates potential high ozone concentrations are exceeding the ozone standard. EPA recommends gradient adjusted spatial fields to get more accurate ozone estimates for unmonitored areas. Gradient adjusted spatial fields are created by the combination of interpolated spatial fields of ambient data and gridded modeled outputs. To implement gradient adjusted spatial fields, base year design values must first be interpolated to develop ambient spatial fields. Then, the spatial fields will be adjusted using base year gridded model output gradients. Finally, model derived RRFs for grids will be applied to the gradient adjusted spatial fields to create future year fields. The future year gradient adjusted spatial fields will be evaluated to determine if any predicted values in the grid cells are above the ozone standard. If violations in the unmonitored area through the analysis occur, the EPA regional office will be consulted to determine how the results of unmonitored area analysis should be used.

EPA Modeled Attainment Test Software (MATS) will be used to conduct this analysis.

9.0 SUPPLEMENTAL ANALYSES

EPA requires supplemental analyses to support the modeled attainment demonstration results since the modeling analyses may contain some uncertain modeling elements such as emission projections, meteorological input data, and science formulation adopted in models. Additionally, future design values that are very close to the ozone standard require a set of corroboratory analyses as the weight of evidence (EPA, 2014). The supplemental analyses will be performed to confirm the conclusions from the modeled attainment demonstration for the 2008 ozone NAAQS. These supplemental analyses are discussed below.

Absolute Model Forecasts

Absolute model forecast results may be useful in assessing general progress towards attainment from the baseline emissions inventory to the future emissions inventory. Absolute model forecast analysis compares the future year modeled ozone concentrations to the base year modeled ozone concentrations, and calculates the frequency, magnitude, and relative amount of ozone reductions. Metrics for the absolute model forecast analysis are as follows:

- Percent change in total amount of modeled ozone concentrations greater than or equal to 76 ppb in the nonattainment area;
- Percent change in number of grid cells greater than or equal to 76 ppb in the nonattainment area;
- Percent change in grid cell-hours greater than or equal to 76 ppb in the nonattainment area; and
- Percent change in maximum modeled eight-hour ozone concentrations in the nonattainment area.

Chemical Process Analysis

To assess which ozone precursor (e.g., VOC or NOx) will limit ozone production, the CAMx Chemical Process Analysis (CPA) will be used. This analysis provides detailed reaction rate information over groups of reactions in the chemical mechanism for a selected area. This makes it possible to quantify chemically meaningful attributes such as ozone and oxidant production/loss rates, radical initiation rates, radical propagation efficiencies, radical termination rates, hydrocarbon chaining lengths, formaldehyde production rates, and odd-nitrogen (NOy) reaction rates. This analysis will be used to determine the VOC-limited or NOx-limited area and to develop more appropriate, effective emission control strategies for the attainment of the 2008 ozone standard.

Ozone Source Apportionment Analysis

To confirm and explain the results of the CAMx modeling, other corroboratory analyses may include the CAMx Ozone Source Apportionment Technology/Anthropogenic Precursor Culpability Assessment (OSAT/APCA). These analyses will identify and quantify the contributions of multiple upwind source areas, emissions source categories, and individual

ozone precursors to local ozone concentrations.

Decoupled Direct Method

The decoupled direct method (DDM) will be used for the sensitivity analysis of emission sources. The DDM will be implemented in the evaluation of first order sensitivity coefficients with respect to predicted ozone concentrations to pollutant sources such as initial conditions, boundary conditions, top concentrations, and anthropogenic emissions. The sensitivity analysis includes an option for varying emission inputs to the CAMx model, such as scaling emissions by a factor, additively increasing emissions by a constant amount, or zeroing-out emissions by source category and geographic region.

Trends in Ambient Air Quality

Progress towards attainment of the ozone standard will be evaluated based on measured historical trends of air quality and emissions. If available, air quality trends will be established using ozone concentrations meteorologically adjusted with available techniques such as statistical modeling, filtering, probability distribution, and Classification and Regression Tree (CART) analysis.

10.0 MANAGEMENT STRUCTURE AND COMMITTEES

MAG has responsibilities for regional involvement in a number of planning issues, and has established an extensive mechanism for ensuring coordinated policy direction from elected officials, coordinated management and technical input, and advice from the appropriate agency staff, as well as direct citizen input. Figure 10-1 displays the MAG Policy Structure and Figure 10-2 presents the MAG Committee Structure. All policy committees and formal technical committees follow the Arizona open meeting law which requires, among other requirements, the posting of meeting notices and agendas at least 24 hours prior to any meeting.

The MAG Regional Council is the governing body of MAG. It is composed of elected officials from each member agency, two ex officio members representing the Arizona State Transportation Board, and a representative from the Citizens Transportation Oversight Committee. This composition of elected officials is a reflection of citizen input at the local government level. The MAG Regional Council agenda includes a call to the audience, providing the opportunity for public comments at each monthly meeting. MAG holds at least one formal public meeting prior to the adoption of any new or updated nonattainment area plan. Formal public meetings are advertised locally at least 30 days prior to the meeting date and documentation is available for public review during this 30-day period. Draft documents are distributed to appropriate federal, state, and local agencies for review and comment during this period. Comments received are analyzed with a staff response for consideration by the MAG Air Quality Technical Advisory Committee and MAG Regional Council before taking approval action. Documentation of the comments and responses are

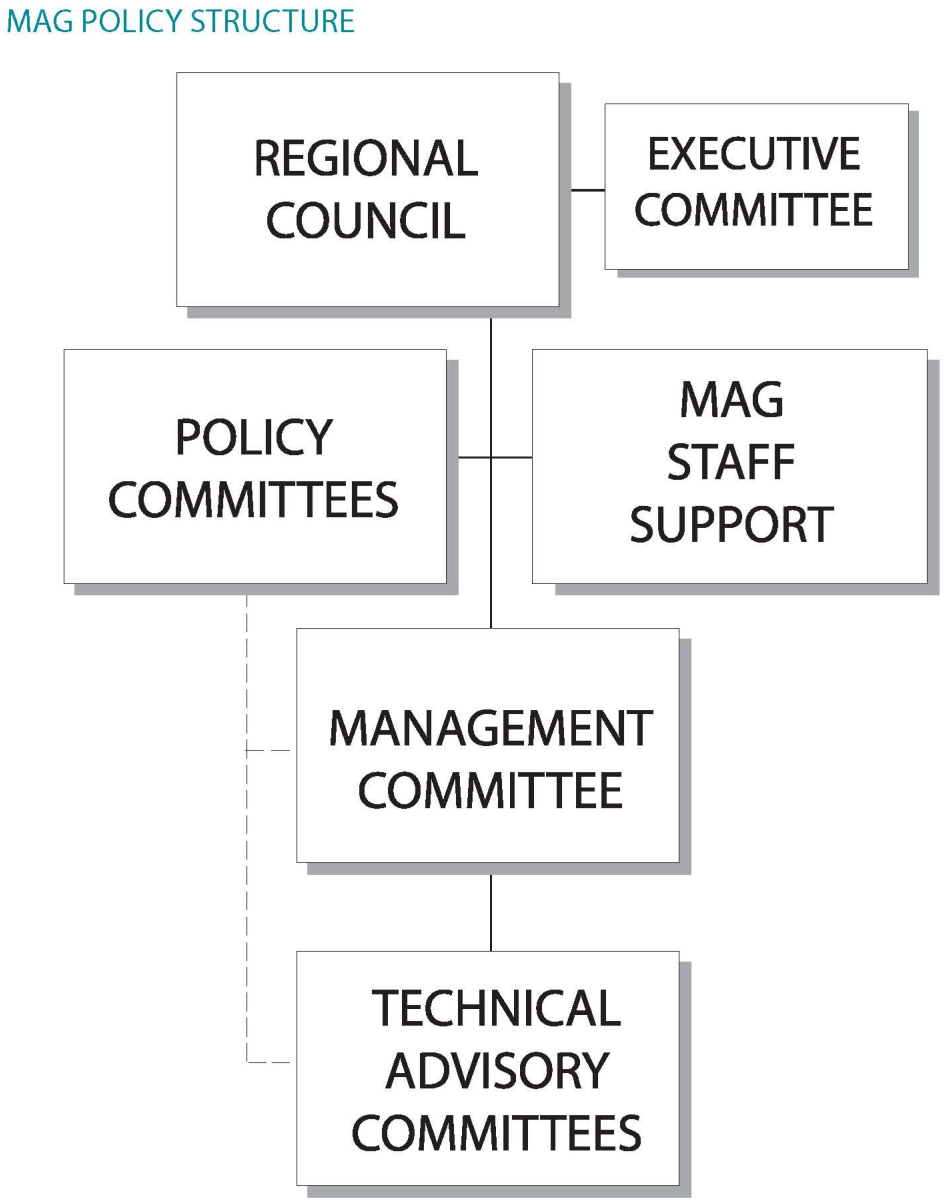

Figure 10-1 MAG policy structure

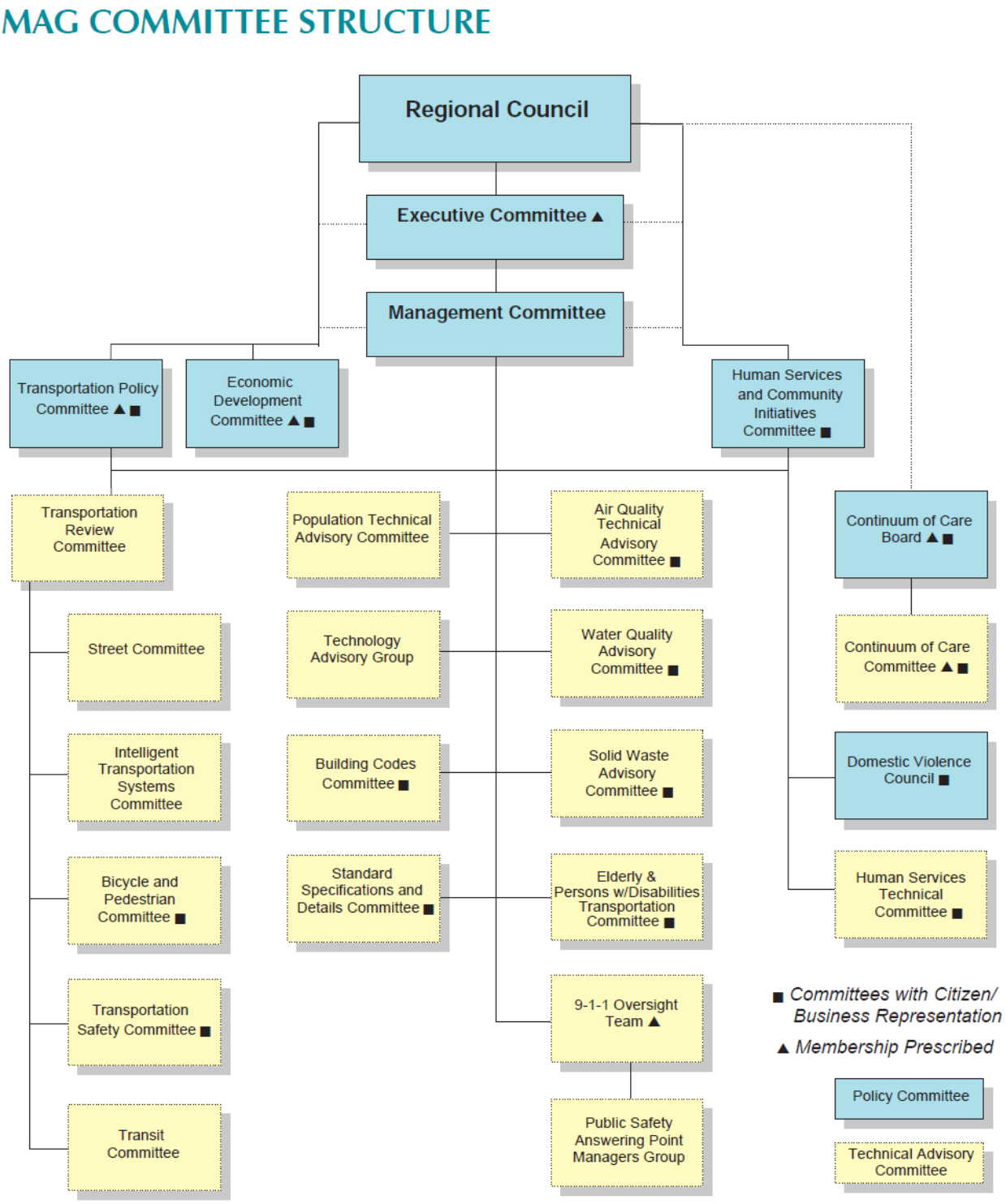

Figure 10-2 MAG committee structure

incorporated into the plan document.

Due to the technical complexity of many MAG programs, committees consisting of professional experts are often needed to assist in program development. The Air Quality Technical Advisory Committee is composed of representatives from eight MAG member agencies, citizens, environmental interests, health interests, automobile industry, fuel industry, utilities, public transit, trucking industry, rock products industry, construction firms, housing industry, architecture, agriculture, industry, business, parties to the Air Quality Memorandum of Agreement, and various State and Federal agencies. The role of the Technical Advisory Committee is to review and comment on technical information generated during the planning process and make recommendations to the MAG Management Committee.

11.0 PARTICIPATING ORGANIZATIONS

Technical oversight for this project will be provided by the Air Quality Planning Team. This team includes staff representatives from MAG, ADEQ, ADOT, and MCAQD. The Air Quality Planning Team will meet as necessary during the ozone modeling effort. Periodic reports on the status and progress of various phases of the modeling work will be presented at these meetings, and technical issues will be discussed and resolved.

12.0 PROCEDURAL REQUIREMENTS

The following items will be delivered in draft form to the EPA regional office for review and comments during the modeling study. MAG will also provide draft versions of these items to the Air Quality Planning Team for review and comments.

- The modeling protocol
- The Technical Support Document which addresses the entire modeled attainment demonstration and the supplemental analyses as the weight of evidence, and which also includes the narrative descriptions on WRF and CAMx input preparation, model performance evaluation, and modeling applications.

13.0 SCHEDULE

The ozone modeling analysis for the Maricopa eight-hour ozone nonattainment area will include the following tasks. The schedule for the tasks are presented in Table 13-1.

1. Prepare a modeling protocol document (this document) describing the historical background, modeling domain, modeling period, and procedures to be followed in the attainment modeling analysis. (Completion Date: November 2015)
2. Develop meteorology and biogenic source emissions for the base year 2011 using WRF and biogenic emissions models. (Completion Date: November 2015)

3. Evaluate WRF model performance using EPA recommended model evaluation methodologies. (Completion Date: December 2015)
4. Develop hourly gridded and chemically speciated point, area, onroad, and nonroad source emissions inventory for the years 2011 and 2017 using SMOKE modeling system. (Completion Date: January 2016)
5. Develop 2011 and 2017 initial and boundary condition data for CAMx modeling. (Completion Date: January 2016)
6. Evaluate CAMx model performance using statistical and graphical assessment methodologies. (Completion Date: February 2016)
7. Perform attainment modeling demonstration for the 2008 ozone standard. (Completion Date: March 2016)
8. Perform the supplemental modeling analysis including the evaluation of historical eight-hour ozone trends, the decoupled direct method for sensitivity analysis, chemical component analysis, and application of source apportionment technology. (Completion Date: May 2016)
9. Develop Technical Support Document (TSD). (Completion Date: July 2016)
10. Provide the draft TSD for Air Quality Planning Team review. (Completion Date: August 2016)
11. Release the Plan and draft TSD for public review. (Completion Date: September 2016)
12. Submit the Plan and draft TSD for public hearing. (Completion Date: October 2016)
13. Submit the Plan and TSD to Air Quality Technical Advisory Committee, Management Committee, and Regional Council for approval. (Completion Date: December 2016)
14. Submit the Plan and TSD to EPA. (Completion Date: December 2016)

Table 13-1 Schedule for the eight-hour ozone modeling demonstration for the Maricopa eight-hour ozone nonattainment area

	2015						2016											
Ozone Modeling Task List	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Submit modeling protocol document to EPA																		
Develop WRF meteorology and biogenic source emissions in the U.S., Mexico, and Canada																		
Evaluate WRF model performance																		
Develop point, area, onroad, and nonroad source emissions inventory for 4 km, 12 km, 36 km modeling domains in 2011 and 2017																		
Develop 2011 and 2017 initial and boundary condition data																		
Evaluate CAMx model performance																		
Perform attainment modeling demonstration																		
Perform supplemental modeling analysis																		
Develop TSD																		
Provide draft TSD for Air Quality Planning Team review																		
Provide draft plan document for public review																		
Public hearing & AQTAC Recommendation																		
Management Committee																		
Regional Council Action																		
Submit to EPA																		

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APPENDIX A

CONCEPTUAL MODEL

Ozone concentrations during the summer ozone season in the Maricopa eight-hour ozone nonattainment area are influenced by several factors: westerly transport of upwind pollutants; a favorable synoptic weather pattern featuring high pressure over the northeastern portion of the state, a low pressure center in the southwest portion, and daytime local temperatures above 100°F; and local emissions that are coincident with valley-wide stagnant and weak winds. The spatial distribution of high ozone concentrations depends on a diurnal valley breeze and directional change in winds induced by surrounding topography. Examination of the entire summer season shows how meteorological variability has strong influence on ozone formation in the nonattainment area.

Poor air quality in the area due to elevated ozone is rarely localized to a single monitor and often occurs at many monitors on the same day. The Phoenix metropolitan area includes several major cities and is the core of the nonattainment area. Networks of freeways and arterial roads and several significant point sources exist in the urban core. The edges of the nonattainment area are considered suburban or rural and monitoring sites in these zones are typically in more remote or mountainous locations. Ozone can advect downwind of the urban core to surrounding rural and suburban sites and these regions can have different profiles than those in the urban core. The coupling of the urban and downwind sites depends greatly on how the daily weather conditions interact with local emissions.

The photochemical reaction processes are essential for ozone formation. The desert yields sufficient solar radiation and high surface temperatures that promote efficient photochemical reactions of nitrogen oxides (NOx) and volatile organic carbons (VOC) to form ground level ozone. Transported ozone (international, interstate, stratospheric) can also influence local ozone levels, especially in the late spring and early summer when the transport pathways are conducive to elevated ozone. Biogenic emissions are the largest VOC source mostly from forests and agricultural area. These emissions mix with significant urban anthropogenic VOC sources. The major source of NOx is motor vehicle exhaust, but point sources such as electric generating units are also important emission sources for NOx emissions. Wildfires may be considered as temporary point sources whose short-lived plumes can disperse ozone precursors from very distant downwind locations. Several upwind wildfires during the 2011 summer ozone season influenced elevated ozone episodes.

Elevated ozone in the Maricopa eight-hour ozone nonattainment area can be influenced by long range transport or be created under local weather and emissions. The area is often downwind from source regions in Southern California and Northern Mexico. It is also aligned with the Rocky Mountains where early summer stratospheric ozone intrusions have been documented (Lin, et al., 2012, 2015; Yates, et al., 2013). Cold front storm systems associated with a southerly deviation of the late spring jet stream are conducive to these types of long range and vertical transport (Hsu, et al., 2005; Liang et al., 2004; Gettelman and Sobel, 2000). Under more localized conditions, most elevated ozone episodes occur under a distinct mesoscale meteorological pattern with a pronounced valley breeze or general stagnation. Many of the urban ozone monitors in the area are located within a basin surrounded by mountain ranges, and differential solar heating of surrounding topography often creates a thermal circulation known as the valley breeze. Under weak

large scale summer weather patterns, local winds flow calmly to the southwest late at night and into morning and then strengthen towards the northeast in the afternoon hours. Although a variety of large scale weather patterns occur in the desert southwest, favorable patterns for elevated ozone often recur throughout summer. These patterns create high temperatures, upper level winds from the south and/or west, sinking air from higher altitudes, and a sustained valley breeze circulation at the surface.

Each monitoring site within the nonattainment area exhibits a diurnal pattern in ozone levels, but the timing and magnitude depend on locations. Urban sites exhibit a more pronounced diurnal cycle in ozone, with the maximum occurring in late afternoon before sunset and the minimum just prior to sunrise. Ozone can be consumed by titration from locally generated NOx in the urban core and also removed by dry deposition during night. In contrast, maximum ozone concentrations have been measured hours later at downwind rural sites. Most anthropogenic precursors are emitted from the urban core and follow a diurnal pattern related to traffic patterns that peak twice daily with the AM and PM rush hours. Anthropogenic emissions also vary by day of week, with most sources exhibiting lower emissions on the weekends due to fewer industrial, commercial and traffic activities. Naturally occurring VOC levels vary over the course of the ozone season, and biogenic emissions highly depend on meteorology (i.e. sunlight, temperature, and relative humidity).

The Maricopa eight-hour ozone nonattainment area presently contains monitors with ozone design values over the 2008 NAAQS of 0.075 ppm, yet ozone trends have leveled off after they peaked in 2012. In the span of 2000-2009, design values decreased but increased between 2009 and 2012 (ENVIRON, 2013). EPA promulgated the 0.08 ppm of NAAQS for ozone in 1997, lowering the value to 0.075 ppm in 2008. In that span, Maricopa County has decreasing trends in ozone design values until the minimum in 2009. The number of exceedance days and total number of individual exceedances are shown for the years of 2005 - 2014 in Table A-1. Both quantities decreased sharply from more than 123 to 9 total exceedances between 2005 and 2009. Both the number of exceedance days and total exceedances in 2009 reached the minimum (four exceedance days and nine total exceedances). A number of studies indicate that the meteorology could play a key role in this lower-ozone period in 2009. However, both quantities increased between 2010 and 2012, but the years of 2013 and 2014 have demonstrated another decreasing trend.

Ozone concentrations can vary by month in the ozone season. A month-by-month analysis is possible with an observational record starting in 2005. The numbers of ozone exceedance days (with at least one exceeding monitor, relative to the 2008 ozone standard) per month are provided in Table A-1 and total exceedances per month are provided in Table A-2. A small percentage of exceedance days and total exceedances occurred before May while a much larger fraction occurred in May. The largest proportion of exceedance days and total exceedances occurred in June, followed by July and August. Only a small fraction of exceedances occurred in September. More than 80% of exceedances occurred in the period of the three months from May to July.

Table A-1 Eight-hour ozone exceedance days by month for ozone monitors in the Maricopa nonattainment area for the 2008 ozone standard (0.075 ppm)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
April	4	0	0	2	1	0	0	2	0	0	9
May	8	7	5	2	1	2	2	10	3	1	41
June	12	17	4	8	1	5	9	3	3	4	66
July	12	12	5	7	1	0	2	3	4	3	49
August	4	6	6	3	0	0	4	10	2	0	35
September	1	0	1	0	0	3	1	0	1	3	10

Table A-2 Eight-hour ozone exceedances by month for ozone monitors in the Maricopa nonattainment area for the 2008 ozone standard (0.075 ppm)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
April	11	0	0	5	1	0	0	2	0	0	19
May	21	21	16	19	4	4	17	45	11	1	159
June	33	80	7	34	2	30	39	5	7	29	266
July	47	71	11	21	2	0	4	18	27	6	207
August	10	10	24	7	0	0	12	37	3	0	103
September	1	0	1	0	0	3	5	0	4	10	24

Six sites in the Maricopa eight-hour ozone nonattainment area (West Phoenix, North Phoenix, Pinnacle Peak, Cave Creek, Red Mountain, and Super Site) were in violation of the 2008 NAAQS ozone standard (0.075 ppm) by the start of 2014. The annual 4th high concentration for each site in each year in time span of 2009-2013 is listed in Table A-3.

On average, May has relatively lower temperatures, less sunlight and stronger ventilating westerly winds, all of which typically limit ozone production. But during this time transport from Southern California and Mexico can be enhanced by cold fronts and stratospheric intrusions from late spring low pressure systems. The episode of May 24-25, 2011 was likely influenced by stratospheric intrusion, and lead to six exceeding sites on the first day and thirteen the following day. Back trajectories and weather map analyses for those days reveal westerly long-range transport. Cold fronts and associated westerly transport can recur several times before the monsoonal high pressure system begins to dominate in the region.

June is usually much warmer than May. Early in the month the air is dry prior to development of the southwestern monsoon pattern. Afternoons can be extremely hot (T > 110 °F) and dry (RH < 10%), and have the longest exposure to sunlight near the summer solstice. In June 2011, the season's highest single-day eight-hour maximum ozone concentration was recorded (0.092 ppm at Blue Point on June 9). This was also the day with the most exceeding sites in the network (14 sites). June of 2011 had the most days (nine) with at least one exceedance in the network, and the most overall exceedances (39)

than any other month in that year. By the end of the month, the monsoonal high pressure pattern begins to dominate.

Table A-3 Annual 4th high eight-hour ozone concentrations (in ppb) for the five-year period used to calculate the 2011 baseline design value (DVB)

AIRS Code	Site Name	Site Abbr	2009	2010	2011	2012	2013	DVB**
04-007-0010	Tonto NM	TN	72	70	76	78	72	73
04-013-0019	West Phoenix*	WP	68	75	78	83	76	76
04-013-1004	North Phoenix*	NP	72	79	82	83	79	79
04-013-1010	Falcon Field	FF	65	70	70	69	77	69
04-013-2001	Glendale	GL	68	74	76	78	74	74
04-013-2005	Pinnacle Peak*	PP	70	77	77	79	77	76
04-013-3002	Central Phoenix	CP	69	72	73	77	75	73
04-013-3003	South Scottsdale	SS	72	76	75	80	74	75
04-013-4003	South Phoenix	SP	67	74	76	78	75	74
04-013-4004	West Chandler	WC	70	74	74	74	70	72
04-013-4005	Tempe	TE	67	68	70	73	71	69
04-013-4008	Cave Creek*	CC	70	74	81	78	72	76
04-013-4010	Dysart	DY	69	71	70	73	74	71
04-013-4011	Buckeye	BE	62	64	67	68	60	65
04-013-5100	Fort McDowell/Yuma Frank	FM	68	66	73	73	71	70
04-013-7003	St Johns	SJ	64	74	72	72	68	70
04-013-7020	Senior Center	SC	70	73	75	76	74	73
04-013-7021	Red Mountain*	RM	72	77	79	77	75	76
04-013-7022	Lehi	LE	70	70	76	75	75	73
04-013-7024	High School	HS	69	73	75	74	74	73
04-013-9508	Humboldt Mountain	HM	67	70	77	79	73	74
04-013-9702	Blue Point	BP	69	68	81	77	75	74
04-013-9704	Fountain Hills	FH	69	74	77	77	70	74
04-013-9706	Rio Verde	RV	68	71	81	72	73	74
04-013-9997	Super Site*	SU	73	76	78	76	79	76
04-021-3001	Apache Junction	AJ	69	73	75	76	69	73

* Sites that were in violation of the 2008 NAAQS eight-hour ozone standard at the start of 2014.

** DVB is calculated as the average of three consecutive design values for 2009-2011, 2010-2012, and 2011-2013.

July and August have extremely high daytime temperatures and are influenced much more by the regional monsoon pattern. A large scale upper level high pressure feature usually aligns over the Four Corners area and pumps moist, unstable air from the southeast. While the synoptic pattern can persist for several weeks, sudden changes in mesoscale weather during this time make ozone formation more complicated. Under monsoonal steering winds, small scale thunderstorms thrive under these favorable dynamics. Days are typically more humid and can exhibit short lived severe weather (intense rain, strong winds and windblown dust). The high pressure often controls the local flow in between thunderstorm events. Stagnant winds can last long enough to combine with the extreme heat to trap pollutants and create the highest ozone of the season. Additionally, peak biogenic VOC emissions occur in August that might enhance ozone formation. In 2011, July had two days with exceeding sites (four exceeding sites total) and August had four days (12 exceeding sites total).

Elevated ozone in September can occur during the transition from humid unstable conditions to drier autumn-like conditions after the monsoon has dissipated. Elevated ozone is less severe and infrequent due to declining sunlight, a shift back to larger scale westerly wind systems, and decreasing biogenic VOC emissions. In 2011, only one day (September 1) had any exceedances in that month, which occurred at only some of the urban sites (Cave Creek, Glendale, North Phoenix, Supersite, and West Phoenix).

Because source regions of transported pollutants can vary throughout the season, the NOAA Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model (Draxler et al., 2015) was used to investigate the geographic origins of air masses. MAG used the model with the locations of each monitor for starting location (100m above the surface) to trace backwards the trajectories of the winds. Analyses of 24-hour back trajectories for every day of the 2011 ozone season reveal instances of interstate transport arriving from all directions as shown in Figure A-1. On the days of widespread exceedances (13 sites on May 25; 16 sites on June 9), air masses originated from Southern California. Of the 18 days with at least a single exceedance in the network, 14 exhibited the pattern of 24-hour back trajectories traveling over the southwestern corner of Arizona and nearby boundaries. Each type of air mass was created by unique synoptic and mesoscale conditions. To better understand how the ozone design value responds to control measures, MAG determined all types of transport conditions should be tested. By simulating the entire summer season, the simulations may capture the wide range of meteorological patterns that contribute to elevated ozone.

The influences of lightning and stratospheric ozone in the proposed attainment test may require further investigation. Lightning and stratospheric intrusions are often credited as natural sources of elevated ozone. Current air quality models are unable to accurately simulate the process of NOx emission by lightning strikes or the influence of stratospheric intrusions. Several western states (CDPHE, 2011; WDEQ, 2013) have demonstrated how stratospheric intrusions extend far enough down to the earth's surface in spring to cause exceptional events of the ozone NAAQS. The initial and boundary conditions at the top of the CAMx model are derived from the MOZART global model, which is unable to provide

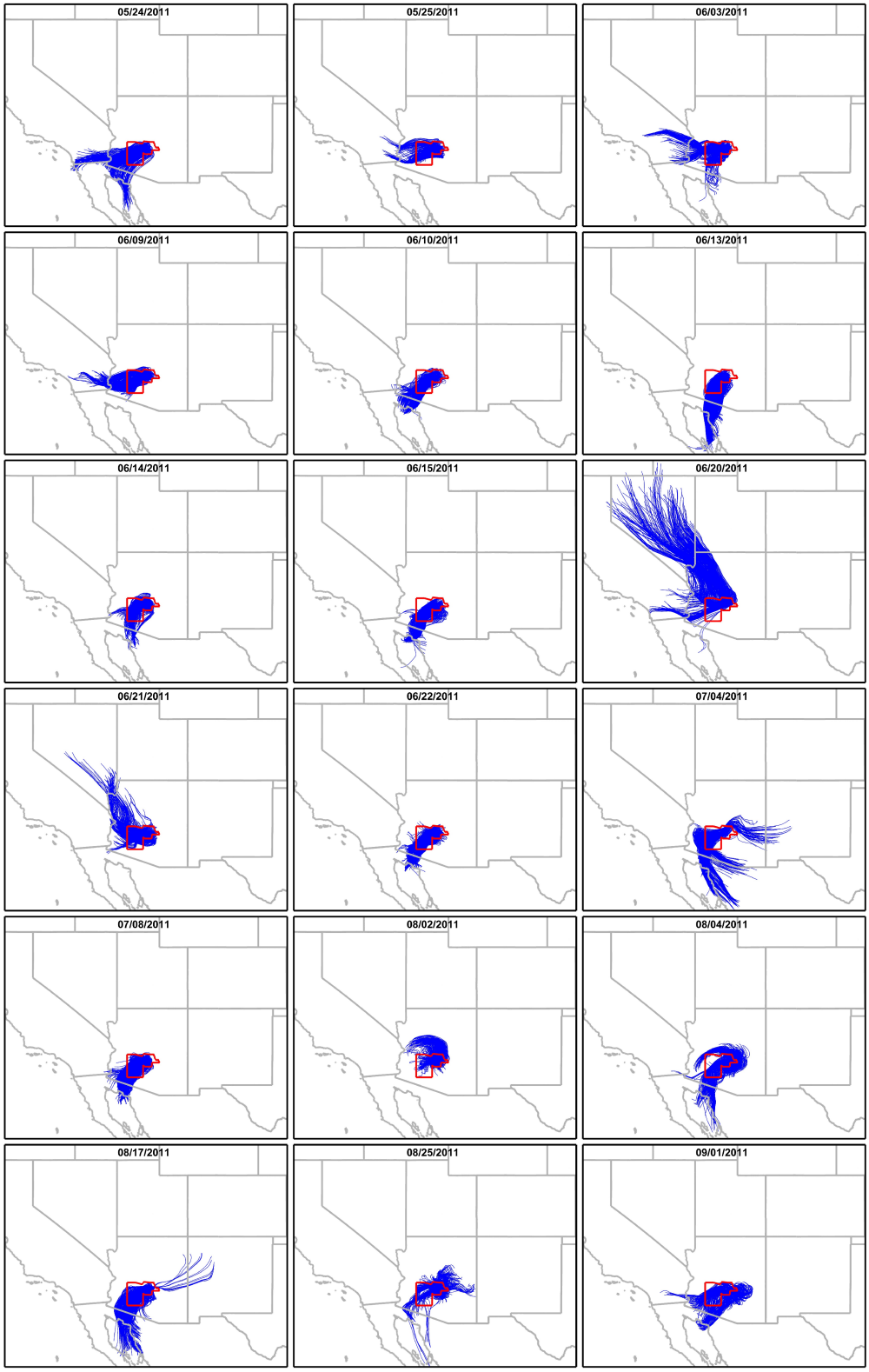

Figure A-1 Daily maps of 24-hour HYSPLIT back trajectories for each day in the 2011 ozone season with at least one exceeding monitoring site

the sufficient information about exchange between the stratosphere and troposphere. This makes calculations of transport from aloft less easy within the photochemical model.

Natural emissions can also originate from lightning. In the desert southwest, lightning is most frequent during the monsoon season. The onset of highest lightning frequency overlaps largely with the summer ozone season in the nonattainment area. Individual monsoon storms can create hundreds of lightning strikes in their short life times. It is estimated that a single flash can contribute up to 500 moles of NOx at levels of the atmosphere that otherwise have minimal concentrations of precursors (DeCaria et al., 2005). As an elevated source several thousands of feet above the surface, the lifetime of lighting NOx is much longer than surface emitted NOx. Therefore the impact on ozone chemistry of these individual sources is more widespread in higher altitudes and larger areas than the single point source which created them. A temporary influx of lightning-created NOx may result in higher concentrations that exceed the NAAQS (Allen et al., 2012). Photochemical models either lack lightning processes completely, or are too immature in development to be reliable.

In summary, this conceptual description highlights the following key elements:

(1) Ozone concentrations are elevated during the summer due to intense photochemical reactions associated with increased solar radiation, long range transport, natural and anthropogenic emissions, and synoptic and mesoscale atmospheric dynamics.

(2) Anthropogenic emissions are fairly consistent throughout the summer, but biogenic emissions substantially fluctuate depending on the weather conditions. Elevated ozone is created by combination of these meteorological conditions and ozone precursor emissions generated from anthropogenic and biogenic sources.

(3) The interaction of upwind transported and local emissions under various weather conditions characterizes elevated ozone concentrations in the region.

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APPENDIX B

DRAFT EMISSIONS INVENTORY

Point Source

Table B-1 2011 and 2017 Electric Generating Units (EGU) emissions in Maricopa County

Maricopa County EGU	2011 (metric tons/year)			2017 (metric tons/year)*		
	VOC	NOx	CO	VOC	NOx	CO
Arlington Valley LLC	0.5	35.1	21.9	11.6	68.8	52.8
Gila River Power Station	9.4	176.2	48.5	26.5	475.8	77.0
Mesquite Generating Station	20.4	174.6	20.9	26.2	220.5	51.5
Agua Fria Generating Station	1.7	95.2	23.2	6.2	449.1	88.4
West Phoenix Power Plant	25.8	541.2	73.4	32.8	600.6	94.5
Ocotillo Power Plant	4.4	75.3	14.1	5.6	143.8	26.7
Redhawk Generating Facility	5.1	136.8	153.2	10.4	168.6	159.2
Kyrene Generating Station	2.9	25.2	7.7	6.5	58.2	28.9
New Harquahala	14.1	21.1	32.0	21.7	80.0	50.2
Santan Generating Station	8.0	233.9	136.3	42.8	284.7	160.3
Buckeye Generation Center LLC**	0.0	0.0	0.0	22.5	87.0	111.8

* MCAQD provided projected power plant emissions in 2017 (e-mail from Bob Downing on July 10, 2015).

** Buckeye Generation Center LLC is planned to be operating in 2017 and the PTE emissions for the facilities are assumed for the year 2017.

Table B-2 2011 and 2017 EGU emissions in Pinal County

Pinal County EGU	2011 (metric tons/year)			2017 (metric tons/year)*		
	VOC	NOx	CO	VOC	NOx	CO
Saguaro Power Plant	0.8	4.4	1.6	4.3	1.3	0.3
Desert Basin Generating Station	5.7	27.9	316.8	6.1	34.5	245.8
Coolidge Generation Station	0.6	7.0	4.1	0.7	8.4	4.9
Sundance Power Plant	2.2	20.3	7.1	2.2	20.3	7.1

* PCAQCD provided projected power plant emissions in 2017 (e-mail from Scott DiBiase on June 10, 2015).

Table B-3 2011 and 2017 point source (non-EGU) emissions in Maricopa County

Maricopa County	Growth Index	2011 (metric tons/year)			2017 (metric tons/year)		
		VOC	NOx	CO	VOC	NOx	CO
CMC Steel Fabricators	Industrial Employment	21.4	30.9	413.6	25.1	36.1	483.9
Luke AFB - 56th Fighter Wing	Number of Aircrafts	7.3	9.1	4.9	7.1	8.8	4.7
New Wincup Holdings Inc	Industrial Employment	114.3	10.7	1.9	133.7	12.6	2.2
Oak Canyon Manufacturing Inc	Industrial Employment	57.0	0.0	0.0	66.7	0.0	0.0
REXAM Beverage Can Company	Industrial Employment	90.3	4.0	3.3	105.6	4.6	3.9
SFPP LP Phoenix Terminal	Industrial Employment	91.8	4.4	5.0	107.4	5.2	5.9
Northwest Regional Landfill	Total Population	2.2	8.8	4.7	2.5	9.7	5.2
Trendwood Inc	Industrial Employment	116.7	0.0	0.0	136.5	0.0	0.0
OFFSET Emission Credit	(no change)	203.2	13.3	13.9	203.2	13.3	13.9

Table B-4 2011 and 2017 point source (non-EGU) emissions in Pinal County

Pinal County	Growth Index	2011 (metric tons/year)			2017 (metric tons/year)		
		VOC	NOx	CO	VOC	NOx	CO
Ray Complex	Industrial Employment	10.3	190.5	736.9	9.8	182.1	704.3
Casa Grande Compressor Station	Industrial Employment	0.1	10.8	2.2	0.1	10.3	2.1
Oracle Compressor Station	Industrial Employment	0.4	89.8	0.2	0.4	85.8	0.2
Hexcel Corporation	Industrial Employment	118.4	10.7	9.0	113.2	10.2	8.6
Frito-Lay	Industrial Employment	3.5	25.3	34.2	3.3	24.2	32.7
Arizona Environmental Container Corp	Industrial Employment	6.8	0.0	0.0	6.5	0.0	0.0
Prowall Building Products Casa Grande Plant	Industrial Employment	55.6	0.3	0.3	53.1	0.3	0.3
Republic Plastic Eloy Foam Manfacturing Plant	Industrial Employment	116.0	0.0	0.0	110.9	0.0	0.0

Area Source

Table B-5 2011 and 2017 ozone season daily average area source emissions in Maricopa County

No.	SCC	Description	2011 (lbs/day)			2017 (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
1	2102004001	Industrial distillate oil: Boilers	3.9	390.2	97.5	4.6	456.5	114.1
2	2102004002	Industrial distillate oil: Engines	0.0	11,783.7	2,536.2	0.0	13,784.8	2,966.9
3	2102006000	Industrial natural gas	217.8	4,303.8	2,680.8	254.8	5,034.7	3,136.1
4	2103004001	Commercial/institutional distillate oil: Boilers	0.0	0.8	0.2	0.0	0.9	0.2
5	2103004002	Commercial/institutional distillate oil: Engines	0.0	23.8	5.1	0.0	26.3	5.7
6	2103006000	Commercial/institutional natural gas	252.0	4,998.0	3,065.4	277.9	5,513.2	3,381.4
7	2104006000	Residential natural gas	119.6	2,044.2	869.9	131.9	2,254.9	959.5
8	2301000000	Chemical manufacturing	599.0	0.0	0.0	700.8	0.0	0.0
9	2302002100	Commercial cooking - Conveyorized charbroiling	136.8	0.0	481.6	150.9	0.0	531.2
10	2302002200	Commercial cooking - Underfired charbroiling	470.6	0.0	1,531.6	519.1	0.0	1,689.5
11	2302003000	Commercial cooking - Deep fat frying	143.0	0.0	0.0	157.8	0.0	0.0
12	2302003100	Commercial cooking - Flat griddle frying	67.4	0.0	143.9	74.4	0.0	158.8
13	2302003200	Commercial cooking - Clamshell griddle frying	2.6	0.0	0.0	2.9	0.0	0.0
14	2302050000	Bakeries	547.8	0.0	0.0	604.2	0.0	0.0
15	2304000000	Secondary metal production	306.4	107.9	697.4	358.5	126.2	815.9
16	2308000000	Rubber/Plastic product mfg.	14,171.0	0.0	0.0	15,632.0	0.0	0.0
17	2312000000	Machinery (electrical)	746.2	135.8	16.4	872.9	158.9	19.2
18	2399000000	Industrial processes, not elsewhere classified (NEC)	325.6	1,245.8	525.2	380.9	1,457.4	614.4
19	2401001000	Architectural coatings	30,622.9	0.0	0.0	33,780.0	0.0	0.0
20	2401005000	Auto refinishing	10,255.9	0.0	0.0	11,313.2	0.0	0.0
21	2401008000	Traffic markings	1,823.6	0.0	0.0	1,871.0	0.0	0.0
22	2401015000	Factory finished wood	1,396.7	0.0	0.0	1,540.7	0.0	0.0
23	2401020000	Wood furniture	3,434.7	0.0	0.0	3,788.8	0.0	0.0
24	2401075000	Aircraft surface coatings	473.1	0.0	0.0	497.0	0.0	0.0

No.	SCC	Description	2011 (lbs/day)			2017 (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
25	2401090000	Miscellaneous surface coatings	2,450.5	0.0	0.0	2,703.2	0.0	0.0
26	2415000000	Degreasing	1,451.4	0.0	0.0	1,601.0	0.0	0.0
27	2420000000	Dry cleaning	178.1	0.0	0.0	196.4	0.0	0.0
28	2425000000	Graphics arts	2,225.7	0.0	0.0	2,455.1	0.0	0.0
29	2440000000	Misc. Ind. Solvent use	5,126.6	0.0	0.0	5,997.2	0.0	0.0
30	2460100000	Personal care products	21,496.8	0.0	0.0	23,713.0	0.0	0.0
31	2460200000	Household products	20,365.4	0.0	0.0	22,464.9	0.0	0.0
32	2460400000	Automotive aftermarket products	15,387.2	0.0	0.0	16,973.5	0.0	0.0
33	2460500000	Coatings and related products	10,748.4	0.0	0.0	11,856.5	0.0	0.0
34	2460600000	Adhesives and sealants	6,449.0	0.0	0.0	7,113.9	0.0	0.0
35	2460800000	FIFRA related products	20,139.1	0.0	0.0	22,215.3	0.0	0.0
36	2460900000	Miscellaneous products, NEC	792.0	0.0	0.0	873.6	0.0	0.0
37	2461021000	Cutback Asphalt	4,567.4	0.0	0.0	4,686.1	0.0	0.0
38	2461022000	Emulsified Asphalt	4,732.6	0.0	0.0	4,855.6	0.0	0.0
39	2461023000	Roofing Asphalt	23.4	0.0	0.0	25.9	0.0	0.0
40	2461850000	Agricultural Pesticides	2,903.4	0.0	0.0	2,832.7	0.0	0.0
41	2501011011	Residential Permeation	4,861.7	0.0	0.0	311.4	0.0	0.0
42	2501011012	Residential Evaporation	9,492.2	0.0	0.0	608.0	0.0	0.0
43	2501011013	Residential Spill in Transport	1,238.6	0.0	0.0	1,214.2	0.0	0.0
44	2501011014	Residential Vapor Displacement	454.1	0.0	0.0	472.1	0.0	0.0
45	2501011015	Residential Spill at Pump	36.1	0.0	0.0	40.6	0.0	0.0
46	2501012011	Commercial Permeation	155.3	0.0	0.0	9.9	0.0	0.0
47	2501012012	Commercial Evaporation	303.2	0.0	0.0	19.4	0.0	0.0
48	2501012013	Commercial Spill in Transport	1,689.6	0.0	0.0	1,656.3	0.0	0.0
49	2501012014	Commercial Vapor Displacement	875.1	0.0	0.0	909.8	0.0	0.0
50	2501012015	Commercial Spill at Pump	69.5	0.0	0.0	78.2	0.0	0.0

No.	SCC	Description	2011 (lbs/day)			2017 (lbs/day)		
			VOC	NOx	CO	VOC	NOx	CO
51	2501055120	Bulk plants	659.3	0.0	0.0	597.1	0.0	0.0
52	2501060051	Gasoline Service Stations Stage 1: Submerged Filling	528.7	0.0	0.0	478.8	0.0	0.0
53	2501060053	Gasoline Service Stations Stage 1: Balanced Submerged Filling	1,426.8	0.0	0.0	1,292.0	0.0	0.0
54	2501060201	Gasoline Service Stations Underground Tank: Breathing and Emptying	4,138.6	0.0	0.0	3,747.6	0.0	0.0
55	2501080050	Airports : Aviation Gasoline Stage 1: Total	1,904.5	0.0	0.0	1,724.6	0.0	0.0
56	2501080100	Airports : Aviation Gasoline Stage 2: Total	98.8	0.0	0.0	89.5	0.0	0.0
57	2505030120	Truck: Gasoline (Tank Trucks in Transit)	315.8	0.0	0.0	285.9	0.0	0.0
58	2505040120	Pipeline Gasoline	94.5	0.0	0.0	85.5	0.0	0.0
59	2510000000	Volatile organic liquid (VOL) storage and transport	182.7	0.0	0.0	201.5	0.0	0.0
60	2601000000	Onsite incineration	1.1	21.4	5.3	1.2	23.6	5.9
61	2610000500	Land clearing debris	20.5	9.1	193.8	22.6	10.1	213.8
62	2620000000	Landfills	200.7	167.4	596.4	221.4	184.7	657.9
63	2630020000	Publicly owned treatment works	577.1	0.0	0.0	636.6	0.0	0.0
64	2650000000	Other waste	10.9	122.8	431.4	12.0	135.5	475.9
65	2660000000	Leaking underground storage tanks	32.3	0.0	0.0	29.3	0.0	0.0
66	2801500000	Agricultural Field burning (ditchbank & fence row)	804.2	357.4	7,595.5	784.6	348.7	7,410.4
67	2810030000	Structure Fires	72.4	9.2	395.2	72.4	9.2	395.2
68	2810040000	Aircraft engine testing	26.1	259.3	91.2	27.4	272.4	95.8
69	2810050000	Vehicle Fires	50.8	6.4	198.5	50.8	6.4	198.5
70	2810060100	Crematories	51.1	88.5	17.3	56.4	97.6	19.1
71	2830001000	Accidental releases	2.1	0.0	0.0	2.1	0.0	0.0
72	2850000000	Hospitals (Total: All Operations)	52.3	0.0	0.0	57.7	0.0	0.0

Table B-6 2011 and 2017 annual area source emissions in Pinal County

No.	SCC	Description	2011 (metric tons/year)			2017 (metric tons/year)		
			VOC	NOx	CO	VOC	NOx	CO
1	2103008000	Commercial/institutional wood	0.3	3.6	9.8	0.3	3.4	9.3
2	2104004000	Residential distillate oil	0.0	0.1	0.0	0.0	0.1	0.0
3	2104006000	Residential natural gas	3.1	53.1	22.6	3.6	61.5	26.2
4	2104007000	Residential liquefied petroleum gas (LPG)	0.8	20.4	11.4	0.9	23.6	13.2
5	2285002006	Locomotives Line Haul Class I	63.8	1,243.1	183.9	47.0	916.2	135.5
6	2285002007	Line Haul Locomotives: Class II / III Operations	5.1	131.6	13.0	3.8	97.0	9.6
7	2302002100	Commercial cooking - Conveyorized charbroiling	1.5	0.00	5.1	1.8	0.0	5.9
8	2302002200	Commercial cooking - Under-fired charbroiling	5.2	0.0	17.0	6.0	0.0	19.7
9	2302003000	Commercial cooking - Deep fat frying	0.8	0.0	0.0	0.9	0.0	0.0
10	2302003100	Commercial cooking - Flat griddle frying	0.7	0.0	1.4	0.8	0.0	1.7
11	2302003200	Commercial cooking - Clamshell griddle frying	0.0	0.0	0.0	0.0	0.0	0.0
12	2401001000	Architectural coatings	40.0	0.0	0.0	46.3	0.0	0.0
13	2401005000	Auto refinishing	20.7	0.0	0.0	24.0	0.0	0.0
14	2401008000	Traffic markings	0.7	0.0	0.0	0.7	0.0	0.0
15	2401015000	Factory finished wood	2.9	0.0	0.0	3.3	0.0	0.0
16	2401020000	Wood furniture	8.0	0.0	0.0	9.2	0.0	0.0
17	2401055000	Machinery and Equipment coatings	0.8	0.0	0.0	0.7	0.0	0.0
18	2401065000	Electronic and Other Electrical coatings	0.6	0.0	0.0	0.6	0.0	0.0
19	2401070000	Motor Vehicles coatings	5.9	0.0	0.0	6.8	0.0	0.0
20	2401075000	Aircraft surface coatings	0.1	0.0	0.0	0.1	0.0	0.0
21	2401090000	Miscellaneous surface coatings	0.4	0.0	0.0	0.5	0.0	0.0
22	2401100000	Surface Coating, Industrial Maintenance Coatings	28.2	0.0	0.0	26.9	0.0	0.0
23	2401200000	Surface Coating, Other Special Purpose Coatings	12.0	0.0	0.0	11.5	0.0	0.0
24	2415000000	Degreasing	37.7	0.0	0.0	43.7	0.0	0.0
25	2420000000	Dry cleaning	0.2	0.0	0.0	0.3	0.0	0.0
26	2460100000	Personal care products	357.0	0.0	0.0	413.2	0.0	0.0

No.	SCC	Description	2011 (metric tons/year)			2017 (metric tons/year)		
			VOC	NOx	CO	VOC	NOx	CO
27	2460200000	Household products	338.2	0.0	0.0	391.4	0.0	0.0
28	2460400000	Automotive aftermarket products	255.5	0.0	0.0	295.7	0.0	0.0
29	2460500000	Coatings and related products	178.5	0.0	0.0	206.6	0.0	0.0
30	2460600000	Adhesives and sealants	107.1	0.0	0.0	123.9	0.0	0.0
31	2460800000	FIFRA related products	334.4	0.0	0.0	387.1	0.0	0.0
32	2460900000	Miscellaneous products, NEC	13.2	0.0	0.0	15.2	0.0	0.0
33	2461021000	Cutback Asphalt	93.5	0.0	0.0	95.6	0.0	0.0
34	2461022000	Emulsified Asphalt	77.1	0.0	0.0	78.8	0.0	0.0
35	2461850000	Agricultural Pesticides	631.6	0.0	0.0	628.8	0.0	0.0
36	2501011011	Permeation	32.2	0.0	0.0	2.1	0.0	0.0
37	2501011012	Evaporation (includes Diurnal losses)	62.8	0.0	0.0	4.0	0.0	0.0
38	2501011013	Spillage During Transport	8.2	0.0	0.0	8.0	0.0	0.0
39	2501011014	Refilling at the Pump - Vapor Displacement	3.0	0.0	0.0	3.1	0.0	0.0
40	2501011015	Refilling at the Pump - Spillage	0.2	0.0	0.0	0.3	0.0	0.0
41	2501012011	Permeation	1.0	0.0	0.0	0.1	0.0	0.0
42	2501012012	Evaporation (includes Diurnal losses)	2.0	0.0	0.0	0.1	0.0	0.0
43	2501012013	Spillage During Transport	11.2	0.0	0.0	11.0	0.0	0.0
44	2501012014	Refilling at the Pump - Vapor Displacement	5.8	0.0	0.0	6.0	0.0	0.0
45	2501012015	Refilling at the Pump - Spillage	0.5	0.0	0.0	0.5	0.0	0.0
46	2501060051	Gasoline Service Stations Stage 1: Submerged Filling	346.3	0.0	0.0	313.6	0.0	0.0
47	2501060052	Gasoline Service Stations Stage 1: Splash Filling	79.8	0.0	0.0	72.2	0.0	0.0
48	2501060201	Gasoline Service Stations Underground Tank: Breathing and Emptying	83.8	0.0	0.0	75.8	0.0	0.0
49	2501080050	Airports : Aviation Gasoline Stage 1: Total	32.6	0.0	0.0	29.5	0.0	0.0
50	2501080100	Airports : Aviation Gasoline Stage 2: Total	1.7	0.0	0.0	1.5	0.0	0.0
51	2505030120	Truck: Gasoline (Tank Trucks in Transit)	5.5	0.0	0.0	5.0	0.0	0.0
52	2505040120	Pipeline Gasoline	2.0	0.0	0.0	1.8	0.0	0.0
53	2610000500	Land clearing debris	19.5	8.7	183.8	22.6	10.1	212.7

No.	SCC	Description	2011 (metric tons/year)			2017 (metric tons/year)		
			VOC	NOx	CO	VOC	NOx	CO
54	2610030000	Household waste	35.0	24.5	347.4	40.5	28.4	402.1
55	2620000000	Landfills	51.6	0.7	1.9	59.7	0.8	2.2
56	2630020000	Publicly owned treatment works	6.2	0.0	0.0	7.2	0.0	0.0
57	2810060100	Crematories	0.0	0.1	0.1	0.0	0.1	0.1

Onroad Source

Draft onroad mobile source emissions are calculated using MOVES2014.

Table B-7 Draft monthly onroad mobile source emissions for Maricopa County in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	1,900.3	3,697.9	18,644.0	1,267.7	2,053.8	13,795.1
June	2,113.7	3,771.7	20,249.7	1,393.2	2,042.7	15,044.4
July	2,207.6	3,414.5	20,641.3	1,453.3	1,840.0	15,337.6
August	2,322.8	3,542.3	22,061.8	1,523.8	1,920.9	16,432.2
September	2,082.9	3,532.5	20,050.9	1,371.3	1,915.4	14,872.2
Total	10,627.3	17,958.9	101,647.7	7,009.3	9,772.8	75,481.5

Table B-8 Draft monthly onroad mobile source emissions for the Maricopa eight-hour ozone nonattainment area in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	1,936.6	3,698.9	19,021.6	1,291.1	2,040.7	14,067.5
June	2,154.4	3,775.3	20,655.0	1,419.0	2,029.5	15,337.3
July	2,250.3	3,419.1	21,049.0	1,480.6	1,829.7	15,632.7
August	2,368.2	3,549.2	22,507.2	1,552.7	1,911.5	16,755.6
September	2,123.2	3,538.8	20,459.3	1,397.0	1,905.1	15,167.4
Total	10,832.7	17,981.3	103,692.1	7,140.4	9,716.5	76,960.5

Table B-9 Draft average daily onroad mobile source emissions for the period of May 1 through September 30 for Maricopa County in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
69.5	117.4	664.4	45.8	63.9	493.3

Table B-10 Draft average daily onroad mobile source emissions for the period of May 1 through September 30 for the Maricopa eight-hour ozone nonattainment area in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
70.8	117.5	677.7	46.7	63.5	503.0

Nonroad Source

Draft nonroad mobile source emissions are calculated using NONROAD2008a and EDMS models.

Table B-11 Draft monthly nonroad source emissions for Maricopa County in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	945.4	1,630.9	10,452.6	724.7	1,114.8	9,639.8
June	1,135.3	1,756.4	11,858.4	845.4	1,194.8	10,985.1
July	1,167.1	1,696.9	11,859.1	854.8	1,160.2	10,976.2
August	1,180.1	1,762.0	12,008.3	857.5	1,197.0	11,115.2
September	1,003.0	1,619.4	10,663.0	749.7	1,100.4	9,845.1
Total	5,430.9	8,465.6	56,841.4	4,032.1	5,767.2	52,561.4

Table B-12 Draft monthly nonroad source emissions for Pinal County in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	138.8	234.4	903.6	117.1	179.6	895.7
June	178.4	246.9	1,095.6	144.2	187.6	1,080.2
July	188.7	244.4	1,130.4	151.3	187.1	1,116.3
August	184.5	250.7	1,114.3	148.3	190.9	1,099.5
September	145.3	231.6	923.3	120.7	176.9	913.0
Total	835.7	1,208.0	5,167.3	681.6	922.2	5,104.7

Table B-13 Draft average daily nonroad source emissions for the period of May 1 through September 30 for Maricopa County in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
35.5	55.3	371.5	26.4	37.7	343.5

Table B-14 Draft average daily nonroad source emissions for the period of May 1 through September 30 for Pinal County in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
5.5	7.9	33.8	4.5	6.0	33.4

Biogenic Source

Table B-15 Monthly biogenic source emissions for Maricopa County in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	14,044.9	70.6	1,806.5	14,044.9	70.6	1,806.5
June	30,821.7	129.1	3,931.0	30,821.7	129.1	3,931.0
July	35,304.4	165.6	4,432.7	35,304.4	165.6	4,432.7
August	38,050.8	178.6	4,725.3	38,050.8	178.6	4,725.3
September	21,442.9	112.4	2,619.3	21,442.9	112.4	2,619.3
Total	139,664.7	656.3	17,514.8	139,664.7	656.3	17,514.8

Table B-16 Monthly biogenic source emissions for the Maricopa eight-hour ozone nonattainment area in 2011 and 2017

Month	2011 (metric tons/month)			2017 (metric tons/month)		
	VOC	NOx	CO	VOC	NOx	CO
May	7,981.0	43.0	1,059.9	7,981.0	43.0	1,059.9
June	17,351.5	78.3	2,301.7	17,351.5	78.3	2,301.7
July	20,178.2	101.4	2,630.9	20,178.2	101.4	2,630.9
August	20,971.5	107.1	2,720.0	20,971.5	107.1	2,720.0
September	11,364.1	64.3	1,455.5	11,364.1	64.3	1,455.5
Total	77,846.3	394.1	10,168.0	77,846.3	394.1	10,168.0

Table B-17 Average daily biogenic source emissions for the period of May 1 through September 30 for Maricopa County in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
912.3	4.3	114.4	912.3	4.3	114.4

Table B-18 Average daily biogenic source emissions for the period of May 1 through September 30 for the Maricopa eight-hour ozone nonattainment area in 2011 and 2017

2011 (metric tons/day)			2017 (metric tons/day)		
VOC	NOx	CO	VOC	NOx	CO
508.4	2.6	66.4	508.4	2.6	66.4

APPENDIX C

GROWTH FACTORS

Table C-1 Area source growth factors for Maricopa County

No.	SCC	Description	Growth Index	Growth Factor
1	2102004001	Industrial distillate oil: Boilers	Industrial Employment	1.17
2	2102004002	Industrial distillate oil: Engines	Industrial Employment	1.17
3	2102006000	Industrial natural gas	Industrial Employment	1.17
4	2103004001	Commercial/institutional distillate oil: Boilers	Population	1.10
5	2103004002	Commercial/institutional distillate oil: Engines	Population	1.10
6	2103006000	Commercial/institutional natural gas	Population	1.10
7	2104006000	Residential natural gas	Population	1.10
8	2301000000	Chemical manufacturing	Industrial Employment	1.17
9	2302002100	Commercial cooking - Conveyorized charbroiling	Population	1.10
10	2302002200	Commercial cooking - Underfired charbroiling	Population	1.10
11	2302003000	Commercial cooking - Deep fat frying	Population	1.10
12	2302003100	Commercial cooking - Flat griddle frying	Population	1.10
13	2302003200	Commercial cooking - Clamshell griddle frying	Population	1.10
14	2302050000	Bakeries	Population	1.10
15	2304000000	Secondary metal production	Industrial Employment	1.17
16	2308000000	Rubber/Plastic product mfg.	Population	1.10
17	2312000000	Machinery (electrical)	Industrial Employment	1.17
18	2399000000	Industrial processes, not elsewhere classified (NEC)	Industrial Employment	1.17
19	2401001000	Architectural coatings	Population	1.10
20	2401005000	Auto refinishing	Population	1.10
21	2401008000	Traffic markings	Roadway Lane Miles	1.03
22	2401015000	Factory finished wood	Population	1.10
23	2401020000	Wood furniture	Population	1.10
24	2401075000	Aircraft surface coatings	Airport Operations	1.05
25	2401090000	Miscellaneous surface coatings	Population	1.10
26	2415000000	Degreasing	Population	1.10
27	2420000000	Dry cleaning	Population	1.10
28	2425000000	Graphics arts	Population	1.10
29	2440000000	Miscellaneous Industrial Solvent use	Industrial Employment	1.17
30	2460100000	Personal care products	Population	1.10
31	2460200000	Household products	Population	1.10
32	2460400000	Automotive aftermarket products	Population	1.10
33	2460500000	Coatings and related products	Population	1.10
34	2460600000	Adhesives and sealants	Population	1.10
35	2460800000	FIFRA related products	Population	1.10
36	2460900000	Miscellaneous products, NEC	Population	1.10
37	2461021000	Cutback Asphalt	Roadway Lane Miles	1.03
38	2461022000	Emulsified Asphalt	Roadway Lane Miles	1.03
39	2461023000	Roofing Asphalt	Population	1.10
40	2461850000	Agricultural Pesticides	Agricultural Acres	0.98

No.	SCC	Description	Growth Index	Growth Factor
41	2501011011	Residential Permeation	Gas Can Rule	0.06
42	2501011012	Residential Evaporation	Gas Can Rule	0.06
43	2501011013	Residential Spill in Transport	Gas Can Rule	0.98
44	2501011014	Residential Vapor Displacement	Gas Can Rule	1.04
45	2501011015	Residential Spill at Pump	Gas Can Rule	1.12
46	2501012011	Commercial Permeation	Gas Can Rule	0.06
47	2501012012	Commercial Evaporation	Gas Can Rule	0.06
48	2501012013	Commercial Spill in Transport	Gas Can Rule	0.98
49	2501012014	Commercial Vapor Displacement	Gas Can Rule	1.04
50	2501012015	Commercial Spill at Pump	Gas Can Rule	1.12
51	2501055120	Bulk plants	Gasoline Consumption	0.91
52	2501060051	Gasoline Service Stations Stage 1: Submerged Filling	Gasoline Consumption	0.91
53	2501060053	Gasoline Service Stations Stage 1: Balanced Submerged Filling	Gasoline Consumption	0.91
54	2501060201	Gasoline Service Stations Underground Tank: Breathing and Emptying	Gasoline Consumption	0.91
55	2501080050	Airports : Aviation Gasoline Stage 1: Total	Gasoline Consumption	0.91
56	2501080100	Airports : Aviation Gasoline Stage 2: Total	Gasoline Consumption	0.91
57	2505030120	Truck: Gasoline (Tank Trucks in Transit)	Gasoline Consumption	0.91
58	2505040120	Pipeline Gasoline	Gasoline Consumption	0.91
59	2510000000	Volatile organic liquid (VOL) storage and transport	Population	1.10
60	2601000000	Onsite incineration	Population	1.10
61	2610000500	Land clearing debris	Population	1.10
62	2620000000	Landfills	Population	1.10
63	2630020000	Publicly owned treatment works	Population	1.10
64	2650000000	Other waste	Population	1.10
65	2660000000	Leaking underground storage tanks	Gasoline Consumption	0.91
66	2801500000	Agricultural Field burning (ditchbank & fence row)	Agricultural Acres	0.98
67	2810030000	Structure Fires	No Growth	1.00
68	2810040000	Aircraft engine testing	Airport Operations	1.05
69	2810050000	Vehicle Fires	No Growth	1.00
70	2810060100	Crematories	Population	1.10
71	2830001000	Accidental releases	No Growth	1.00
72	2850000000	Hospitals (Total: All Operations)	Population	1.10

Table C-2 Area source growth factors for Pinal County

No.	SCC	Description	Growth Index	Growth Factor
1	2103008000	Commercial/institutional wood	Industrial Employment	0.96
2	2104004000	Residential distillate oil	Population	1.16
3	2104006000	Residential natural gas	Population	1.16
4	2104007000	Residential liquefied petroleum gas (LPG)	Population	1.16
5	2285002006	Locomotives Line Haul Class I	Locomotive Diesel Usage	0.74
6	2285002007	Line Haul Locomotives: Class II / III Operations	Locomotive Diesel Usage	0.74
7	2302002100	Commercial cooking - Conveyorized charbroiling	Population	1.16
8	2302002200	Commercial cooking - Under-fired charbroiling	Population	1.16
9	2302003000	Commercial cooking - Deep fat frying	Population	1.16
10	2302003100	Commercial cooking - Flat griddle frying	Population	1.16
11	2302003200	Commercial cooking - Clamshell griddle frying	Population	1.16
12	2401001000	Architectural coatings	Population	1.16
13	2401005000	Auto refinishing	Population	1.16
14	2401008000	Traffic markings	Roadway Lane Miles	1.02
15	2401015000	Factory finished wood	Population	1.16
16	2401020000	Wood furniture	Population	1.16
17	2401055000	Machinery and Equipment coatings	Industrial Employment	0.96
18	2401065000	Electronic and Other Electrical coatings	Industrial Employment	0.96
19	2401070000	Motor Vehicles coatings	Population	1.16
20	2401075000	Aircraft surface coatings	Airport Operations	1.05
21	2401090000	Miscellaneous surface coatings	Population	1.16
22	2401100000	Surface Coating, Industrial Maintenance Coatings	Industrial Employment	0.96
23	2401200000	Surface Coating, Other Special Purpose Coatings	Industrial Employment	0.96
24	2415000000	Degreasing	Population	1.16
25	2420000000	Dry cleaning	Population	1.16
26	2460100000	Personal care products	Population	1.16
27	2460200000	Household products	Population	1.16
28	2460400000	Automotive aftermarket products	Population	1.16
29	2460500000	Coatings and related products	Population	1.16
30	2460600000	Adhesives and sealants	Population	1.16
31	2460800000	FIFRA related products	Population	1.16
32	2460900000	Miscellaneous products, NEC	Population	1.16
33	2461021000	Cutback Asphalt	Roadway Lane Miles	1.02
34	2461022000	Emulsified Asphalt	Roadway Lane Miles	1.02
35	2461850000	Agricultural Pesticides	Agricultural Acres	1.00
36	2501011011	Permeation	Gas Can Rule	0.06
37	2501011012	Evaporation (includes Diurnal losses)	Gas Can Rule	0.06
38	2501011013	Spillage During Transport	Gas Can Rule	0.98
39	2501011014	Refilling at the Pump - Vapor Displacement	Gas Can Rule	1.04
40	2501011015	Refilling at the Pump - Spillage	Gas Can Rule	1.12

No.	SCC	Description	Growth Index	Growth Factor
41	2501012011	Permeation	Gas Can Rule	0.06
42	2501012012	Evaporation (includes Diurnal losses)	Gas Can Rule	0.06
43	2501012013	Spillage During Transport	Gas Can Rule	0.98
44	2501012014	Refilling at the Pump - Vapor Displacement	Gas Can Rule	1.04
45	2501012015	Refilling at the Pump - Spillage	Gas Can Rule	1.12
46	2501060051	Gasoline Service Stations Stage 1: Submerged Filling	Gasoline Consumption	0.91
47	2501060052	Gasoline Service Stations Stage 1: Splash Filling	Gasoline Consumption	0.91
48	2501060201	Gasoline Service Stations Underground Tank: Breathing and Emptying	Gasoline Consumption	0.91
49	2501080050	Airports : Aviation Gasoline Stage 1: Total	Gasoline Consumption	0.91
50	2501080100	Airports : Aviation Gasoline Stage 2: Total	Gasoline Consumption	0.91
51	2505030120	Truck: Gasoline (Tank Trucks in Transit)	Gasoline Consumption	0.91
52	2505040120	Pipeline Gasoline	Gasoline Consumption	0.91
53	2610000500	Land clearing debris	Population	1.16
54	2610030000	Household waste	Population	1.16
55	2620000000	Landfills	Population	1.16
56	2630020000	Publicly owned treatment works	Population	1.16
57	2810060100	Crematories	Population	1.16

APPENDIX D

MAPPING OF SPATIAL SURROGATES

Table D-1 Configurations of Spatial Tools for generating 22 spatial surrogates in Maricopa County and Pinal County*

No.	Surrogate	Surrogate Code	Data Shapefile	Weight Attribute	Filter Function
1	Population	100	MAG_Maricopa_Pinal_2010Census_latlon	TOTAL_POP	
2	Construction	141	MAG_Residential_construction_completed_2011 [PINAL_Residential_completed_2011_ll]	SQFT	
3	Total Road Miles	240	MAG_2011_Traffic_data_latlon	LANE_LENGT	
4	NTAD Total Railroad Density	261	ARIZONA_RAILROAD_latlon	NONE	
5	Agriculture	309	MAG_landuse_2012_latlon [nlcd2011az_80s_250m_nos_v2_latlon]	NONE	LONG_DISPL = 1 [GRID_CODE = 81,82]
6	Water	350	Maricopa_only_lakes_latlon	NONE	
7	Open Land	401	MAG_landuse_2012_latlon [pophu_bg2010_AZ4]	NONE	LONG_DISPL = 15,16,28 [AREA_CODE = 2,3,4]
8	Commercial Land	500	MAG_landuse_2012_latlon [fema_bsf_2002bnd]	NONE	LONG_DISPL = 3,9,21,22 [COM1+COM2+COM3+COM4+COM5+COM6+COM7+COM8+COM9]
9	Aircraft Engine Manufacturers	504	Maricopa_2011_employers_latlon	EMPLOYEES	NAICS = 336412
10	Industrial Land	505	MAG_landuse_2012_latlon [fema_bsf_2002bnd]	NONE	LONG_DISPL = 10 [IND1+IND2+IND3+IND4+IND5+IND6]
11	Commercial plus Industrial	510	MAG_landuse_2012_latlon [fema_bsf_2002bnd]	NONE	LONG_DISPL = 3,9,10,21,22 [COM1+COM2+COM3+COM4+COM5+COM6+COM7+COM8+COM9+IND1+IND2+IND3+IND4+IND5+IND6]
12	Commercial plus Institutional Land	515	MAG_landuse_2012_latlon [fema_bsf_2002bnd]	NONE	LONG_DISPL = 3,9,20,21,22 [COM1+COM2+COM3+COM4+COM5+COM6+COM7+COM8+COM9+RES5+RES6+EDU1+EDU2+REL1]
13	Residential	531	MAG_landuse_2012_latlon [Pinal_2011_all_residential_norural_II]	NONE	LONG_DISPL = 12,23,24,25 [None]
14	Residential + Commercial + Industrial + Institutional + Government	535	MAG_landuse_2012_latlon [Pinal_Resd_Comme_Indus_Insti_Goven]]	NONE	LONG_DISPL = 3,9,10,14,20,12,21,22,23,24,25 [None]

No.	Surrogate	Surrogate Code	Data Shapefile	Weight Attribute	Filter Function
15	Auto refinish	544	Maricopa_2011_employers_latlon [CAAG_2010_employment_II]	EMPLOYEES [JOBS2010]	NAICS = 811121 [NAICS_= 811121]
16	Hospital (COM6)	560	AZ_all_hospital_latlon	CAPACITY	
17	Fuel Dispensing Facility	601	XY_Fueling_Facilities_MC_and_PC_latlon	NONE	
18	Airport Points	710	MC_15_airports_latlon	GA_OPS	
19	Golf Courses	850	Maricopa_Pinal_golf_latlon	NONE	
20	Wastewater Treatment Facilities	870	MC_wastewater_treatment_latlon [CAAG_2010_employment_II]	Capacity [JOBS2010]	[NAICS = 221320]
21	Landfills	871	AZ_landfill_except_NW_latlon	NONE	
22	Crematories	872	Maricopa_2011_employers_latlon [CAAG_2010_employment_II]	EMPLOYEES [JOBS2010]	NAICS = 812220 [NAICS = 812220]

* All options for Pinal County are presented in the brackets.

Table D-2 Spatial surrogates used for area sources in the 4 km modeling domain

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
1	2102004001	Stationary Source Fuel Combustion	Industrial	Distillate Oil	All Boiler Types	505	Industrial Land
2	2102004002	Stationary Source Fuel Combustion	Industrial	Distillate Oil	All IC Engine Types	505	Industrial Land
3	2102006000	Stationary Source Fuel Combustion	Industrial	Natural Gas	Total: Boilers and IC Engines	505	Industrial Land
4	2103004001	Stationary Source Fuel Combustion	Commercial/Institutional	Distillate Oil	Boilers	515	Commercial plus Institutional Land
5	2103004002	Stationary Source Fuel Combustion	Commercial/Institutional	Distillate Oil	IC Engines	515	Commercial plus Institutional Land
6	2103006000	Stationary Source Fuel Combustion	Commercial/Institutional	Natural Gas	Total: Boilers and IC Engines	515	Commercial plus Institutional Land
7	2104001000	Stationary Source Fuel Combustion	Residential	Anthracite Coal	Total: All Combustor Types	531	Residential
8	2104002000	Stationary Source Fuel Combustion	Residential	Bituminous/Subbituminous Coal	Total: All Combustor Types	531	Residential
9	2104004000	Stationary Source Fuel Combustion	Residential	Distillate Oil	Total: All Combustor Types	531	Residential
10	2104006000	Stationary Source Fuel Combustion	Residential	Natural Gas	Total: All Combustor Types	531	Residential
11	2104007000	Stationary Source Fuel Combustion	Residential	Liquified Petroleum Gas (LPG)	Total: All Combustor Types	531	Residential
12	2104008100	Stationary Source Fuel Combustion	Residential	Wood	Fireplace: general	531	Residential
13	2104008210	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; non-EPA certified	531	Residential
14	2104008220	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; non-catalytic	531	Residential
15	2104008230	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; catalytic	531	Residential
16	2104008310	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, non-EPA certified	531	Residential
17	2104008320	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, non-catalytic	531	Residential
18	2104008330	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, catalytic	531	Residential
19	2104008400	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: pellet-fired, general (freestanding or FP insert)	531	Residential
20	2104008610	Stationary Source Fuel Combustion	Residential	Wood	Hydronic heater: outdoor	531	Residential

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
21	2104008700	Stationary Source Fuel Combustion	Residential	Wood	Outdoor wood burning device, NEC (fire-pits, chimeas, etc)	531	Residential
22	2104009000	Stationary Source Fuel Combustion	Residential	Firelog	Total: All Combustor Types	531	Residential
23	2104011000	Stationary Source Fuel Combustion	Residential	Kerosene	Total: All Heater Types	531	Residential
24	2301000000	Industrial Processes	Chemical Manufacturing: SIC 28	All Processes	Total	505	Industrial Land
25	2302002100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Conveyorized Charbroiling	500	Commercial Land
26	2302002200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Under-fired Charbroiling	500	Commercial Land
27	2302003000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Deep Fat Fying	500	Commercial Land
28	2302003100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Flat Griddle Frying	500	Commercial Land
29	2302003200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Clamshell Griddle Frying	500	Commercial Land
30	2302050000	Industrial Processes	Food and Kindred Products: SIC 20	Bakery Products	Total	500	Commercial Land
31	2304000000	Industrial Processes	Secondary Metal Production: SIC 33	All Processes	Total	505	Industrial Land
32	2308000000	Industrial Processes	Rubber/Plastics: SIC 30	All Processes	Total	505	Industrial Land
33	2312000000	Industrial Processes	Machinery: SIC 35	All Processes	Total	505	Industrial Land
34	2399000000	Industrial Processes	Industrial Processes: NEC	Industrial Processes: NEC	Total	505	Industrial Land
35	2401001000	Solvent Utilization	Surface Coating	Architectural Coatings	Total: All Solvent Types	535	Residential + Commercial + Industrial + Institutional + Government
36	2401005000	Solvent Utilization	Surface Coating	Auto Refinishing: SIC 7532	Total: All Solvent Types	544	Auto refinish
37	2401008000	Solvent Utilization	Surface Coating	Traffic Markings	Total: All Solvent Types	240	Total Road Miles
38	2401015000	Solvent Utilization	Surface Coating	Factory Finished Wood: SIC 2426 thru 242	Total: All Solvent Types	505	Industrial Land
39	2401020000	Solvent Utilization	Surface Coating	Wood Furniture: SIC 25	Total: All Solvent Types	505	Industrial Land
40	2401075000	Solvent Utilization	Surface Coating	Aircraft: SIC 372	Total: All Solvent Types	505	Industrial Land
41	2401090000	Solvent Utilization	Surface Coating	Miscellaneous Manufacturing	Total: All Solvent Types	505	Industrial Land
42	2415000000	Solvent Utilization	Degreasing	All Processes/All Industries	Total: All Solvent Types	510	Commercial plus Industrial
43	2420000000	Solvent Utilization	Dry Cleaning	All Processes	Total: All Solvent Types	500	Commercial Land
44	2425000000	Solvent Utilization	Graphic Arts	All Processes	Total: All Solvent Types	500	Commercial Land

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
45	2440000000	Solvent Utilization	Miscellaneous Industrial	All Processes	Total: All Solvent Types	500	Commercial Land
46	2460100000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Personal Care Products	Total: All Solvent Types	531	Residential
47	2460200000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Household Products	Total: All Solvent Types	531	Residential
48	2460400000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Automotive Aftermarket Products	Total: All Solvent Types	531	Residential
49	2460500000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Coatings and Related Products	Total: All Solvent Types	531	Residential
50	2460600000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All Adhesives and Sealants	Total: All Solvent Types	531	Residential
51	2460800000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	All FIFRA Related Products	Total: All Solvent Types	531	Residential
52	2460900000	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Commercial	Miscellaneous Products (Not Otherwise Covered)	Total: All Solvent Types	531	Residential
53	2461021000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Cutback Asphalt	Total: All Solvent Types	240	Total Road Miles
54	2461022000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Emulsified Asphalt	Total: All Solvent Types	240	Total Road Miles
55	2461023000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Asphalt Roofing	Total: All Solvent Types	531	Residential
56	2461850000	Solvent Utilization	Miscellaneous Non-industrial: Commercial	Pesticide Application: Agricultural	All Processes	309	Agriculture
57	2501011011	Storage and Transport	Petroleum and Petroleum Product Storage	Residential Portable Gas Cans	Permeation	531	Residential
58	2501011012	Storage and Transport	Petroleum and Petroleum Product Storage	Residential Portable Gas Cans	Evaporation (includes Diurnal losses)	531	Residential
59	2501011013	Storage and Transport	Petroleum and Petroleum Product Storage	Residential Portable Gas Cans	Spillage During Transport	531	Residential
60	2501011014	Storage and Transport	Petroleum and Petroleum Product Storage	Residential Portable Gas Cans	Refilling at the Pump - Vapor Displacement	601	Fuel Dispensing Facility

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
61	2501011015	Storage and Transport	Petroleum and Petroleum Product Storage	Residential Portable Gas Cans	Refilling at the Pump - Spillage	601	Fuel Dispensing Facility
62	2501012011	Storage and Transport	Petroleum and Petroleum Product Storage	Commercial Portable Gas Cans	Permeation	500	Commercial Land
63	2501012012	Storage and Transport	Petroleum and Petroleum Product Storage	Commercial Portable Gas Cans	Evaporation (includes Diurnal losses)	500	Commercial Land
64	2501012013	Storage and Transport	Petroleum and Petroleum Product Storage	Commercial Portable Gas Cans	Spillage During Transport	500	Commercial Land
65	2501012014	Storage and Transport	Petroleum and Petroleum Product Storage	Commercial Portable Gas Cans	Refilling at the Pump - Vapor Displacement	601	Fuel Dispensing Facility
66	2501012015	Storage and Transport	Petroleum and Petroleum Product Storage	Commercial Portable Gas Cans	Refilling at the Pump - Spillage	601	Fuel Dispensing Facility
67	2501050120	Storage and Transport	Petroleum and Petroleum Product Storage	Bulk Terminals: All Evaporative Losses	Gasoline	601	Fuel Dispensing Facility
68	2501055120	Storage and Transport	Petroleum and Petroleum Product Storage	Bulk Plants: All Evaporative Losses	Gasoline	601	Fuel Dispensing Facility
69	2501060051	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 1: Submerged Filling	601	Fuel Dispensing Facility
70	2501060053	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 1: Balanced Submerged Filling	601	Fuel Dispensing Facility
71	2501060100	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Stage 2: Total	601	Fuel Dispensing Facility
72	2501060201	Storage and Transport	Petroleum and Petroleum Product Storage	Gasoline Service Stations	Underground Tank: Breathing and Emptying	601	Fuel Dispensing Facility
73	2501080050	Storage and Transport	Petroleum and Petroleum Product Storage	Airports : Aviation Gasoline	Stage 1: Total	710	Airport Points
74	2501080100	Storage and Transport	Petroleum and Petroleum Product Storage	Airports : Aviation Gasoline	Stage 2: Total	710	Airport Points
75	2505030120	Storage and Transport	Petroleum and Petroleum Product Transport	Truck	Gasoline	240	Total Road Miles

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
76	2505040120	Storage and Transport	Petroleum and Petroleum Product Transport	Pipeline	Gasoline	240	Total Road Miles
77	2510000000	Storage and Transport	Organic Chemical Storage	All Storage Types: Breathing Loss	Total: All Products	505	Industrial Land
78	2601000000	Waste Disposal, Treatment, and Recovery	On-site Incineration	All Categories	Total	505	Industrial Land
79	2610000100	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Leaf Species Unspecified	531	Residential
80	2610000300	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Weed Species Unspecified (incl Grass)	531	Residential
81	2610000400	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Brush Species Unspecified	531	Residential
82	2610000500	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)	531	Residential
83	2620000000	Waste Disposal, Treatment, and Recovery	Landfills	All Categories	Total	871	Landfills
84	2630020000	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Total Processed	870	Wastewater Treatment Facilities
85	2650000000	Waste Disposal, Treatment, and Recovery	Scrap and Waste Materials	Scrap and Waste Materials	Total: All Processes	505	Industrial Land
86	2660000000	Waste Disposal, Treatment, and Recovery	Leaking Underground Storage Tanks	Leaking Underground Storage Tanks	Total: All Storage Types	505	Industrial Land
87	2801500000	Miscellaneous Area Sources	Agriculture Production - Crops	Agricultural Field Burning - whole field set on fire	Unspecified	309	Agriculture
88	2810030000	Miscellaneous Area Sources	Other Combustion	Structure Fires	Unspecified	535	Residential + Commercial + Industrial + Institutional + Government
89	2810040000	Miscellaneous Area Sources	Other Combustion	Aircraft/Rocket Engine Firing and Testing	Total	504	Aircraft Engine Manufacturers
90	2810050000	Miscellaneous Area Sources	Other Combustion	Motor Vehicle Fires	Unspecified	240	Total Road Miles
91	2810060100	Miscellaneous Area Sources	Other Combustion	Cremation	Humans	872	Crematories
92	2830001000	Miscellaneous Area Sources	Catastrophic/Accidental Releases	Industrial Accidents	Total	505	Industrial Land
93	2850000000	Miscellaneous Area Sources	Health Services	Hospitals	Total: All Operations	560	Hospital (COM6)
94	2260001010	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Motorcycles: Off-road	401	Open Land
95	2260001020	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Snowmobiles	401	Open Land

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
96	2260001030	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	All Terrain Vehicles	401	Open Land
97	2260001060	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Specialty Vehicles/Carts	401	Open Land
98	2260002006	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Tampers/Rammers	141	Construction
99	2260002009	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Plate Compactors	141	Construction
100	2260002021	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Paving Equipment	141	Construction
101	2260002027	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Signal Boards/Light Plants	141	Construction
102	2260002039	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Concrete/Industrial Saws	141	Construction
103	2260002054	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Construction and Mining Equipment	Crushing/Processing Equipment	141	Construction
104	2260003030	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Industrial Equipment	Sweepers/Scrubbers	505	Industrial Land
105	2260003040	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Industrial Equipment	Other General Industrial Equipment	505	Industrial Land
106	2260004015	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Rotary Tillers < 6 HP (Residential)	531	Residential
107	2260004016	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Rotary Tillers < 6 HP (Commercial)	500	Commercial Land
108	2260004020	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Chain Saws < 6 HP (Residential)	531	Residential
109	2260004021	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Chain Saws < 6 HP (Commercial)	500	Commercial Land
110	2260004025	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Residential)	531	Residential
111	2260004026	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Commercial)	500	Commercial Land
112	2260004030	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Leafblowers/Vacuums (Residential)	531	Residential
113	2260004031	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)	500	Commercial Land
114	2260004035	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Snowblowers (Residential)	531	Residential
115	2260004036	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Snowblowers (Commercial)	500	Commercial Land
116	2260004071	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Turf Equipment (Commercial)	500	Commercial Land
117	2260005035	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Agricultural Equipment	Sprayers	309	Agriculture

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
118	2260006005	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Commercial Equipment	Generator Sets	500	Commercial Land
119	2260006010	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Commercial Equipment	Pumps	500	Commercial Land
120	2260006015	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Commercial Equipment	Air Compressors	500	Commercial Land
121	2260006035	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Commercial Equipment	Hydro-power Units	500	Commercial Land
122	2265001010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Motorcycles: Off-road	401	Open Land
123	2265001030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	All Terrain Vehicles	401	Open Land
124	2265001050	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Golf Carts	850	Golf Courses
125	2265001060	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Specialty Vehicles/Carts	401	Open Land
126	2265002003	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Pavers	141	Construction
127	2265002006	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Tampers/Rammers	141	Construction
128	2265002009	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Plate Compactors	141	Construction
129	2265002015	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Rollers	141	Construction
130	2265002021	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Paving Equipment	141	Construction
131	2265002024	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Surfacing Equipment	141	Construction
132	2265002027	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Signal Boards/Light Plants	141	Construction
133	2265002030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Trenchers	141	Construction
134	2265002033	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Bore/Drill Rigs	141	Construction
135	2265002039	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Concrete/Industrial Saws	141	Construction
136	2265002042	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Cement and Mortar Mixers	141	Construction
137	2265002045	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Cranes	141	Construction
138	2265002054	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Crushing/Processing Equipment	141	Construction
139	2265002057	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Rough Terrain Forklifts	141	Construction

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
140	2265002060	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Rubber Tire Loaders	141	Construction
141	2265002066	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Tractors/Loaders/Backhoes	141	Construction
142	2265002072	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Skid Steer Loaders	141	Construction
143	2265002078	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Dumpers/Tenders	141	Construction
144	2265002081	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Construction and Mining Equipment	Other Construction Equipment	141	Construction
145	2265003010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Aerial Lifts	505	Industrial Land
146	2265003020	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Forklifts	505	Industrial Land
147	2265003030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Sweepers/Scrubbers	505	Industrial Land
148	2265003040	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Other General Industrial Equipment	505	Industrial Land
149	2265003050	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Other Material Handling Equipment	505	Industrial Land
150	2265003060	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	AC\Refrigeration	505	Industrial Land
151	2265003070	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Industrial Equipment	Terminal Tractors	505	Industrial Land
152	2265004010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn Mowers (Residential)	531	Residential
153	2265004011	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn Mowers (Commercial)	500	Commercial Land
154	2265004015	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Rotary Tillers < 6 HP (Residential)	531	Residential
155	2265004016	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Rotary Tillers < 6 HP (Commercial)	500	Commercial Land
156	2265004025	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Residential)	531	Residential
157	2265004026	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Commercial)	500	Commercial Land
158	2265004030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Leafblowers/Vacuums (Residential)	531	Residential
159	2265004031	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)	500	Commercial Land
160	2265004035	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Snowblowers (Residential)	531	Residential
161	2265004036	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Snowblowers (Commercial)	500	Commercial Land

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
162	2265004040	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Rear Engine Riding Mowers (Residential)	531	Residential
163	2265004041	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Rear Engine Riding Mowers (Commercial)	500	Commercial Land
164	2265004046	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Front Mowers (Commercial)	500	Commercial Land
165	2265004051	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Shredders < 6 HP (Commercial)	531	Residential
166	2265004055	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn and Garden Tractors (Residential)	500	Commercial Land
167	2265004056	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn and Garden Tractors (Commercial)	500	Commercial Land
168	2265004066	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Chippers/Stump Grinders (Commercial)	500	Commercial Land
169	2265004071	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Turf Equipment (Commercial)	500	Commercial Land
170	2265004075	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Other Lawn and Garden Equipment (Residential)	531	Residential
171	2265004076	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Other Lawn and Garden Equipment (Commercial)	500	Commercial Land
172	2265005010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	2-Wheel Tractors	309	Agriculture
173	2265005015	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Agricultural Tractors	309	Agriculture
174	2265005020	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Combines	309	Agriculture
175	2265005025	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Balers	309	Agriculture
176	2265005030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Agricultural Mowers	309	Agriculture
177	2265005035	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Sprayers	309	Agriculture
178	2265005040	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Tillers : 6 HP	309	Agriculture
179	2265005045	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Swathers	309	Agriculture
180	2265005055	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Other Agricultural Equipment	309	Agriculture
181	2265005060	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Irrigation Sets	309	Agriculture
182	2265006005	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Generator Sets	500	Commercial Land
183	2265006010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Pumps	500	Commercial Land

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
184	2265006015	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Air Compressors	500	Commercial Land
185	2265006025	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Welders	500	Commercial Land
186	2265006030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Pressure Washers	500	Commercial Land
187	2265006035	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Hydro-power Units	500	Commercial Land
188	2267001060	Mobile Sources	LPG	Recreational Equipment	Specialty Vehicles/Carts	401	Open Land
189	2267002003	Mobile Sources	LPG	Construction and Mining Equipment	Pavers	141	Construction
190	2267002015	Mobile Sources	LPG	Construction and Mining Equipment	Rollers	141	Construction
191	2267002021	Mobile Sources	LPG	Construction and Mining Equipment	Paving Equipment	141	Construction
192	2267002024	Mobile Sources	LPG	Construction and Mining Equipment	Surfacing Equipment	141	Construction
193	2267002030	Mobile Sources	LPG	Construction and Mining Equipment	Trenchers	141	Construction
194	2267002033	Mobile Sources	LPG	Construction and Mining Equipment	Bore/Drill Rigs	141	Construction
195	2267002039	Mobile Sources	LPG	Construction and Mining Equipment	Concrete/Industrial Saws	141	Construction
196	2267002045	Mobile Sources	LPG	Construction and Mining Equipment	Cranes	141	Construction
197	2267002054	Mobile Sources	LPG	Construction and Mining Equipment	Crushing/Processing Equipment	141	Construction
198	2267002057	Mobile Sources	LPG	Construction and Mining Equipment	Rough Terrain Forklifts	141	Construction
199	2267002060	Mobile Sources	LPG	Construction and Mining Equipment	Rubber Tire Loaders	141	Construction
200	2267002066	Mobile Sources	LPG	Construction and Mining Equipment	Tractors/Loaders/Backhoes	141	Construction
201	2267002072	Mobile Sources	LPG	Construction and Mining Equipment	Skid Steer Loaders	141	Construction
202	2267002081	Mobile Sources	LPG	Construction and Mining Equipment	Other Construction Equipment	141	Construction
203	2267003010	Mobile Sources	LPG	Industrial Equipment	Aerial Lifts	505	Industrial Land
204	2267003020	Mobile Sources	LPG	Industrial Equipment	Forklifts	505	Industrial Land
205	2267003030	Mobile Sources	LPG	Industrial Equipment	Sweepers/Scrubbers	505	Industrial Land
206	2267003040	Mobile Sources	LPG	Industrial Equipment	Other General Industrial Equipment	505	Industrial Land

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
207	2267003050	Mobile Sources	LPG	Industrial Equipment	Other Material Handling Equipment	505	Industrial Land
208	2267003070	Mobile Sources	LPG	Industrial Equipment	Terminal Tractors	505	Industrial Land
209	2267004066	Mobile Sources	LPG	Lawn and Garden Equipment	Chippers/Stump Grinders (Commercial)	500	Commercial Land
210	2267005055	Mobile Sources	LPG	Agricultural Equipment	Other Agricultural Equipment	309	Agriculture
211	2267005060	Mobile Sources	LPG	Agricultural Equipment	Irrigation Sets	309	Agriculture
212	2267006005	Mobile Sources	LPG	Commercial Equipment	Generator Sets	500	Commercial Land
213	2267006010	Mobile Sources	LPG	Commercial Equipment	Pumps	500	Commercial Land
214	2267006015	Mobile Sources	LPG	Commercial Equipment	Air Compressors	500	Commercial Land
215	2267006025	Mobile Sources	LPG	Commercial Equipment	Welders	500	Commercial Land
216	2267006030	Mobile Sources	LPG	Commercial Equipment	Pressure Washers	500	Commercial Land
217	2267006035	Mobile Sources	LPG	Commercial Equipment	Hydro-power Units	500	Commercial Land
218	2268002081	Mobile Sources	CNG	Construction and Mining Equipment	Other Construction Equipment	141	Construction
219	2268003020	Mobile Sources	CNG	Industrial Equipment	Forklifts	505	Industrial Land
220	2268003030	Mobile Sources	CNG	Industrial Equipment	Sweepers/Scrubbers	505	Industrial Land
221	2268003040	Mobile Sources	CNG	Industrial Equipment	Other General Industrial Equipment	505	Industrial Land
222	2268003060	Mobile Sources	CNG	Industrial Equipment	AC\Refrigeration	505	Industrial Land
223	2268003070	Mobile Sources	CNG	Industrial Equipment	Terminal Tractors	505	Industrial Land
224	2268005055	Mobile Sources	CNG	Agricultural Equipment	Other Agricultural Equipment	309	Agriculture
225	2268005060	Mobile Sources	CNG	Agricultural Equipment	Irrigation Sets	309	Agriculture
226	2268006005	Mobile Sources	CNG	Commercial Equipment	Generator Sets	500	Commercial Land
227	2268006010	Mobile Sources	CNG	Commercial Equipment	Pumps	500	Commercial Land
228	2268006015	Mobile Sources	CNG	Commercial Equipment	Air Compressors	500	Commercial Land
229	2268006020	Mobile Sources	CNG	Commercial Equipment	Gas Compressors	500	Commercial Land
230	2268006035	Mobile Sources	CNG	Commercial Equipment	Hydro-power Units	500	Commercial Land
231	2270001060	Mobile Sources	Off-highway Vehicle Diesel	Recreational Equipment	Specialty Vehicles/Carts	500	Commercial Land
232	2270002003	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Pavers	141	Construction

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
233	2270002006	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Tampers/Rammers	141	Construction
234	2270002009	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Plate Compactors	141	Construction
235	2270002015	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rollers	141	Construction
236	2270002018	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Scrapers	141	Construction
237	2270002021	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Paving Equipment	141	Construction
238	2270002024	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Surfacing Equipment	141	Construction
239	2270002027	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Signal Boards/Light Plants	141	Construction
240	2270002030	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Trenchers	141	Construction
241	2270002033	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Bore/Drill Rigs	141	Construction
242	2270002036	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Excavators	141	Construction
243	2270002039	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Concrete/Industrial Saws	141	Construction
244	2270002042	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Cement and Mortar Mixers	141	Construction
245	2270002045	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Cranes	141	Construction
246	2270002048	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Graders	141	Construction
247	2270002051	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Off-highway Trucks	141	Construction
248	2270002054	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Crushing/Processing Equipment	141	Construction
249	2270002057	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rough Terrain Forklifts	141	Construction
250	2270002060	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rubber Tire Loaders	141	Construction
251	2270002066	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Tractors/Loaders/Backhoes	141	Construction
252	2270002069	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Crawler Tractor/Dozers	141	Construction
253	2270002072	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Skid Steer Loaders	141	Construction
254	2270002075	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Off-highway Tractors	141	Construction

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
255	2270002078	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Dumpers/Tenders	141	Construction
256	2270002081	Mobile Sources	Off-highway Vehicle Diesel	Construction and Mining Equipment	Other Construction Equipment	141	Construction
257	2270003010	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Aerial Lifts	505	Industrial Land
258	2270003020	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Forklifts	505	Industrial Land
259	2270003030	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Sweepers/Scrubbers	505	Industrial Land
260	2270003040	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Other General Industrial Equipment	505	Industrial Land
261	2270003050	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Other Material Handling Equipment	505	Industrial Land
262	2270003060	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	AC\Refrigeration	505	Industrial Land
263	2270003070	Mobile Sources	Off-highway Vehicle Diesel	Industrial Equipment	Terminal Tractors	505	Industrial Land
264	2270004031	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)	500	Commercial Land
265	2270004036	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Snowblowers (Commercial)	500	Commercial Land
266	2270004046	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Front Mowers (Commercial)	500	Commercial Land
267	2270004056	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Lawn and Garden Tractors (Commercial)	500	Commercial Land
268	2270004066	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Chippers/Stump Grinders (Commercial)	500	Commercial Land
269	2270004071	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Turf Equipment (Commercial)	500	Commercial Land
270	2270004076	Mobile Sources	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Other Lawn and Garden Equipment (Commercial)	500	Commercial Land
271	2270005010	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	2-Wheel Tractors	309	Agriculture
272	2270005015	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Tractors	309	Agriculture
273	2270005020	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Combines	309	Agriculture
274	2270005025	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Balers	309	Agriculture
275	2270005030	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Mowers	309	Agriculture
276	2270005035	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Sprayers	309	Agriculture

NO.	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Spatial Surrogate	Surrogate Name
277	2270005040	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Tillers : 6 HP	309	Agriculture
278	2270005045	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Swathers	309	Agriculture
279	2270005055	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Other Agricultural Equipment	309	Agriculture
280	2270005060	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Irrigation Sets	309	Agriculture
281	2270006005	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Generator Sets	500	Commercial Land
282	2270006010	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Pumps	500	Commercial Land
283	2270006015	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Air Compressors	500	Commercial Land
284	2270006020	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Gas Compressors	500	Commercial Land
285	2270006025	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Welders	500	Commercial Land
286	2270006030	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Pressure Washers	500	Commercial Land
287	2270006035	Mobile Sources	Off-highway Vehicle Diesel	Commercial Equipment	Hydro-power Units	500	Commercial Land
288	2282005010	Mobile Sources	Pleasure Craft	Gasoline 2-Stroke	Outboard	350	Water
289	2282005015	Mobile Sources	Pleasure Craft	Gasoline 2-Stroke	Personal Water Craft	350	Water
290	2282010005	Mobile Sources	Pleasure Craft	Gasoline 4-Stroke	Inboard/Sterndrive	350	Water
291	2282020005	Mobile Sources	Pleasure Craft	Diesel	Inboard/Sterndrive	350	Water
292	2282020010	Mobile Sources	Pleasure Craft	Diesel	Outboard	350	Water
293	2285002006	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations	261	NTAD Total Railroad Density
294	2285002008	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Passenger Trains (Amtrak)	261	NTAD Total Railroad Density
295	2285002010	Mobile Sources	Railroad Equipment	Diesel	Yard Locomotives	261	NTAD Total Railroad Density
296	2285002015	Mobile Sources	Railroad Equipment	Diesel	Railway Maintenance	261	NTAD Total Railroad Density
297	2285004015	Mobile Sources	Railroad Equipment	Gasoline, 4-Stroke	Railway Maintenance	261	NTAD Total Railroad Density
298	2285006015	Mobile Sources	Railroad Equipment	LPG	Railway Maintenance	261	NTAD Total Railroad Density

APPENDIX E

MEXICO AND CANADA EMISSIONS

TECHNICAL DOCUMENTATION FOR YEAR 2011 AND YEAR 2017 OZONE PRECURSOR EMISSION INVENTORIES FOR MEXICO AND CANADA

Final

Prepared for:

Maricopa Association of Governments
302 North 1st Avenue, Suite 300
Phoenix, AZ 85003

August 31, 2015

ERG No. 3923.00.002.004
MAG Contract No. 476-C
Task Order No. 002

TECHNICAL DOCUMENTATION FOR YEAR 2011 AND YEAR 2017 OZONE PRECURSOR EMISSION INVENTORIES FOR MEXICO AND CANADA

Final

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1.0 INTRODUCTION

In support of air quality modeling associated with the Maricopa County 8-hour ozone nonattainment area, the Maricopa Association of Governments (MAG) contracted with Eastern Research Group, Inc. (ERG) to develop Year 2011 and Year 2017 ozone precursor emissions inventories for the portions of Mexico and Canada that lie within the CMAQ 36-km modeling domain. The emissions inventory will be used by MAG to develop ozone boundary and initial condition data. This technical documentation report contains detailed documentation of the methodologies used to develop these emissions inventories.

2.0 INVENTORY SCOPE

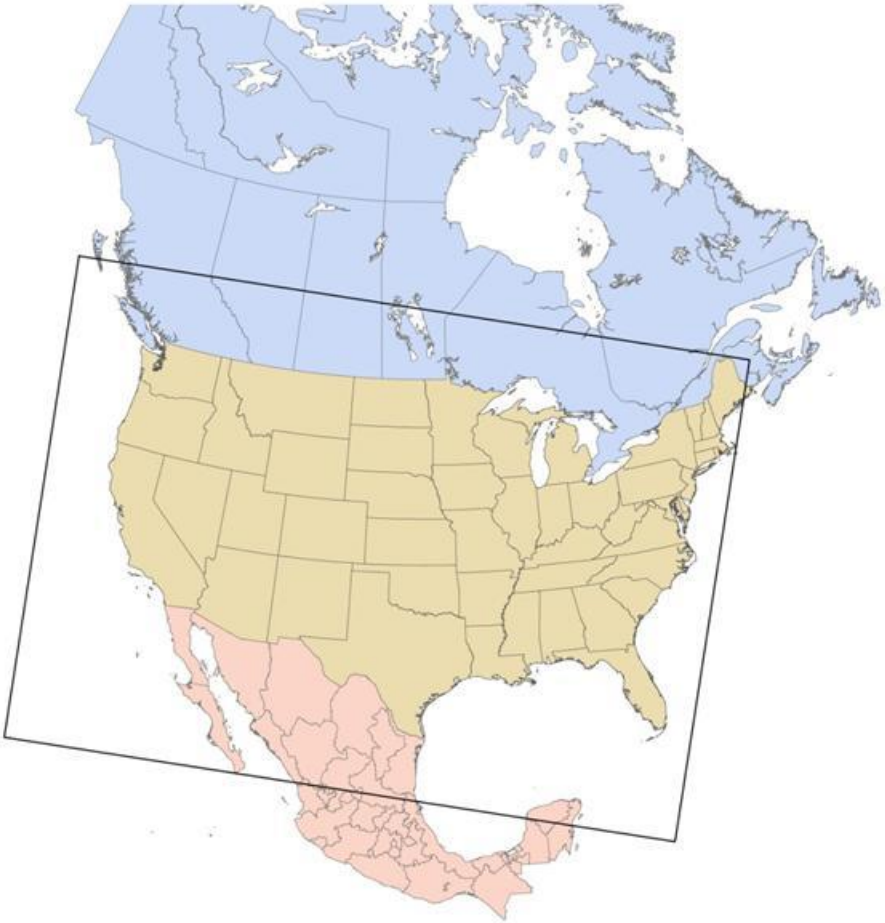
The ozone modeling being conducted by MAG requires three different emission inventories for three different modeling domains:

- 4-km (covering primarily Maricopa County only)
- 12-km (including the Southwest and northwest portions of Mexico)
- 36-km (covering the entire U.S., southern portions of Canada, and northern portions of Mexico)

MAG will develop the emissions inventories for the 4-km domain in-house. ERG's scope of work focused on the 36-km domain, which also encompasses the 12-km domain. The 36-km domain is presented in Figure 2-1. The scope of the emissions inventory is as follows:

- Inventory year – 2011 and 2017 projected emissions (Mexico and Canada).
- Pollutant sources – Point, area, on-road mobile, and nonroad mobile source emissions. Biogenic and wildfire emissions will not be estimated or included.
- Pollutants – Ozone precursors: nitrogen oxides (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO).
- Geographic domain and spatial resolution – Mexico and Canada emissions within the 36-km CAMx/CMAQ domain (as shown in Figure 2-1) resolved at the following resolution: Mexico – municipality (county-equivalent); and Canada – province (state-equivalent). Point source emissions were located using facility coordinates.
- Temporal resolution – Ozone season day (for May through September) emissions. For point, area, and nonroad mobile sources, emissions were estimated as average ozone season day emissions. For on-road motor vehicles, emissions were estimated as weekday and weekend day ozone season day emissions.

Figure 2-1. MAG 36-km domain.



3.0 DEVELOPMENT OF MEXICO EMISSIONS FOR 2011 AND 2017

ERG developed the 2011 and 2017 ozone precursor emission inventories for the portions of Mexico within the 36-km domain using the municipality-level emission files from the 2008 Mexico National Emissions Inventory (MNEI) (SEMARNAT, 2014). ERG previously used these municipality-level emission files from the 2008 MNEI in the development of Year 2018, 2025, and 2030 projected inventories for the entire country of Mexico for U.S. EPA (ERG, 2014). As part of the project for U.S. EPA, ERG conducted a number of preparatory steps before projecting emissions forward to the future years. Some additional preparatory steps were performed before developing the 2011 and 2017 inventories for MAG.

3.1 Preparatory Steps

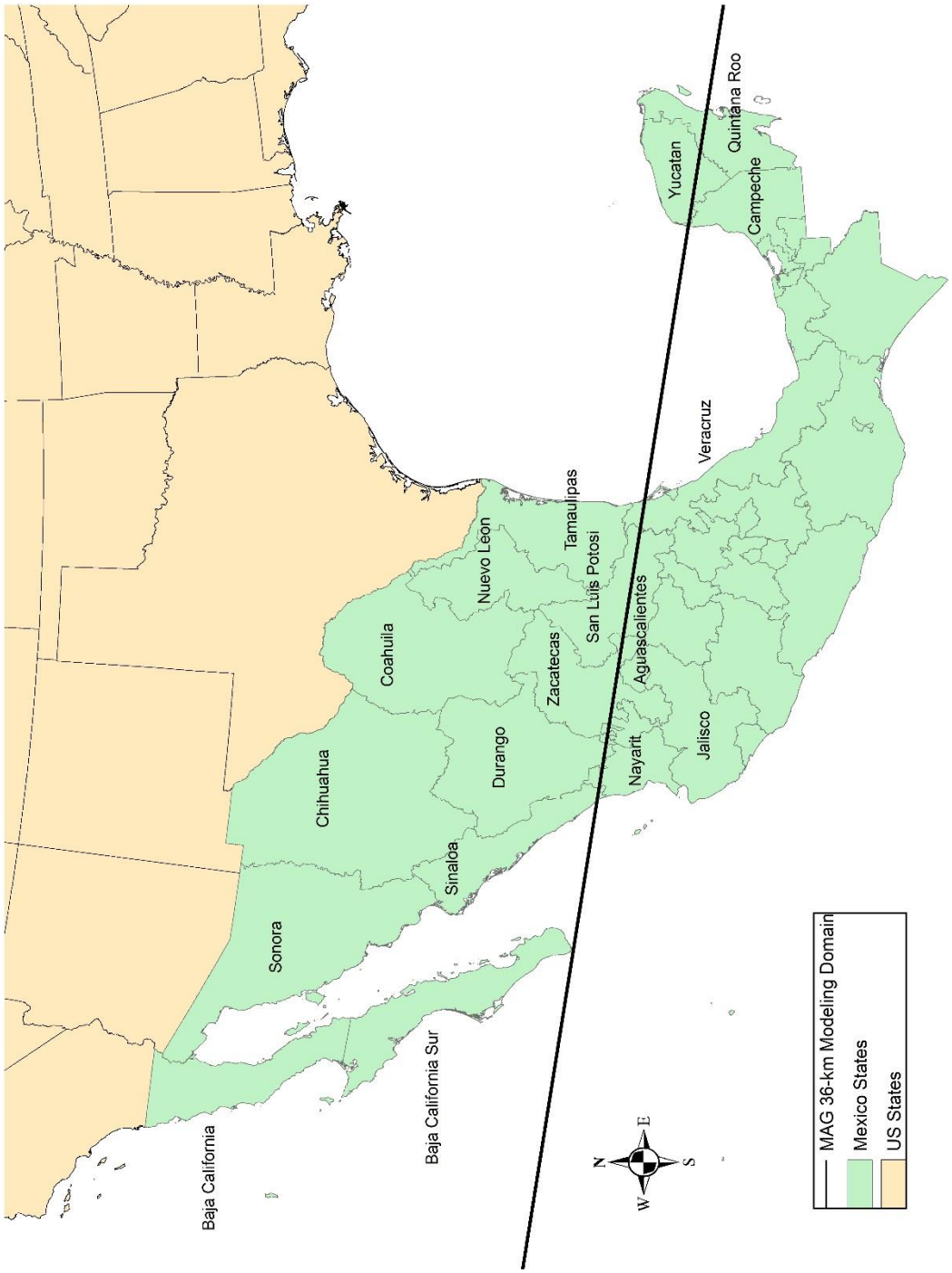
First, ERG excluded all non-ozone precursor emissions from the initial 2008 MNEI file; the remaining ozone precursor pollutants were nitrogen oxides (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO). All emissions were then converted from metric tons to U.S. tons by multiplying by a factor of 1.1023. All point source stack parameters were also converted to the units of measure required by the FF10 file format (i.e., meters to feet, degrees Celsius to degrees Fahrenheit, etc.).

ERG then excluded all Mexico municipalities from the inventory file that were not located within the 36-km modeling domain. Mexico is comprised of 32 federal "entities" or jurisdictions (i.e., 31 states and the Federal District). A total of 18 states lie entirely or partially within the 36-km domain; a map showing these states is presented in Figure 3-1. Visual analysis of the 36-km domain using GIS indicated the following:

- Nine states (i.e., Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, Sinaloa, Sonora, and Tamaulipas) were located entirely within the modeling domain – all municipalities from these states were included in the inventory;
- Nine states (i.e., Aguascalientes, Campeche, Jalisco, Nayarit, Quintana Roo, San Luis Potosí, Veracruz, Yucatán, and Zacatecas) straddled the southern boundary of the modeling domain. Additional visual analysis of the individual municipalities in these states was used to determine whether or not to include each municipality in the inventory. If any portion of a particular municipality was located within the modeling domain, then that municipality was included in the inventory.

A detailed listing of the Mexican municipalities included in the inventory domain is provided in Appendix A.

Figure 3-1. Mexican States Within 36-km Modeling Domain



After identifying all municipalities located outside the 36-km modeling domain, ERG then removed the area source, on-road motor vehicle, and nonroad mobile source emission records for those municipalities from the 2008 MNEI file. ERG also removed all point source emission records with location coordinates located outside the 36-km modeling domain from the 2008 MNEI file. In conjunction with this, ERG also conducted some additional quality assurance (QA) of the point source coordinates located within the 36-km modeling domain. Specifically, ERG plotted point source coordinates on a state-by-state basis. As part of the U.S. EPA project cited earlier, ERG examined the geographic locations of all point sources in the entire country. As a result of this effort, ERG corrected the coordinates for over 100 point source facilities. Specific details regarding ERG's QA activities performed for the U.S. EPA project can be found in the final inventory documentation (ERG, 2014). Prior to developing the Year 2011 and Year 2017 projected inventories, ERG conducted some more intensive QA of the point source locations. Based on this QA, ERG identified and corrected an additional 23 point source facilities in the states of Coahuila (1 facility), Durango (20 facilities), and Tamaulipas (2 facilities). For each of these 23 point sources, the facility coordinates were revised to the urban locality coordinates for each municipality.

Area and nonroad source data were also quality assured for the U.S. EPA project; additional details can be found in the final inventory documentation submitted to U.S. EPA (ERG, 2014).

Finally, because 2011 and 2017 Mexico on-road motor vehicle emissions were estimated using the MOVES model (as described in Section 3.6), rather than estimated using surrogate projections, ERG removed all on-road motor vehicle emissions located within the 36-km modeling domain.

3.2 Projections Methodology

In general, ERG projected the 2011 Mexico emissions by multiplying the base year 2008 emissions by a projection factor as shown in the following equation:

$$E_{2011,s} = E_{2008,s} \times P_s$$

Where: $E_{2011,s}$ = projected future year emissions for 2011 for source *s*;
$E_{2008,s}$ = estimated base year emissions for 2008 for source *s*; and
P_s = projection factor for source *s*.

Similarly, ERG projected the 2017 Mexico emissions by multiplying the base year 2008 emissions by a projection factor as shown in the following equation:

$$E_{2017,s} = E_{2008,s} \times P_s$$

Where: $E_{2017,s}$ = projected future year emissions for 2017 for source *s*;
$E_{2008,s}$ = estimated base year emissions for 2008 for source *s*; and
P_s = projection factor for source *s*.

A projection factor greater than 1.0 represented increasing emissions, while a projection factor less than 1.0 represented decreasing emissions. A projection factor of 1.0 represented a situation of no growth (i.e., projected emissions were equal to base year emissions). The projection factors were based on "surrogates" for all sources except on-road motor vehicles, as explained below.

3.3 Point Sources

ERG used the following data sources as surrogates to develop point source projections for Mexico:

- Electricity generation sector:
  - Residual fuel oil usage (regional-level) (SENER, 2014a)
  - Distillate fuel oil usage (regional-level) (SENER, 2014a)
  - Natural gas usage (regional-level) (SENER, 2014b)
  - Petroleum coke usage (national-level) (SENER, 2014a)
  - Coal usage (national-level) (SENER, 2014c)
- Oil and natural gas sector:
  - Crude oil production (national-level) (SENER, 2014a)
  - Crude oil refining (regional-level) (SENER, 2014a)
  - Natural gas demand (regional-level) (SENER, 2014b)
- All other sectors:
  - Gross domestic product (GDP) (national-level) (PCIF, 2014)

The regional divisions used by SENER are defined as follows:

- Noroeste (Northwest) – Baja California, Baja California Sur, Sinaloa, and Sonora
- Noreste (Northeast) – Coahuila, Chihuahua, Durango, Nuevo León, and Tamaulipas
- Centro-Occidente (Central-West) – Aguascalientes, Jalisco, Nayarit, San Luis Potosí, Zacatecas (and excluded states of Colima, Guanajuato, Michoacán, and Querétaro)
- Centro (Central) – (excluded states of Distrito Federal, Hidalgo, México, Morelos, Puebla, and Tlaxcala)
- Sur-Sureste (South-Southeast) – Campeche, Quintana Roo, Veracruz, Yucatán (and excluded states of Chiapas, Guerrero, Oaxaca, and Tabasco)

The assignment of surrogates to point source SCIAN (*Sistema de Clasificación Industrial de América del Norte*) codes is provided in Appendix B; the projection factors developed from these surrogates are presented in Appendix C.

It should be noted that projection factors were applied to the reported emissions for existing point sources in the 2008 MNEI. No attempt was made to anticipate the location of future point sources (e.g., planned electricity generation projects, etc.). In addition, reductions from potential future control measures were not accounted for.

3.4 Area Sources

ERG used the following data sources as surrogates to develop area source projections for Mexico:

- Population data:
  - Census data (municipality-level) (INEGI, 2010)
  - Intracensal data (municipality-level) (INEGI, 2005)
  - Population projections (municipality-level) (CONAPO, 2012)
- Fuel usage:
  - Petroleum product usage (regional-level) (SENER, 2014a)
  - Natural gas and LPG usage (regional-level) (SENER, 2014b)
  - Residential wood usage (national-level) (SENER, 2014c)
- GDP estimates (national-level) (PCIF, 2014)
- Agricultural acreage (SAGARPA, 2014a):
  - Total (state-level)
  - Sugarcane (state-level)

- Cattle head counts (state-level) (SAGARPA, 2014b)

The assignment of surrogates to Mexico area source categories is provided in Appendix D. The population-based projection factors are presented in Appendix E, while all other area source projection factors are included in Appendix F.

Future year population projections were available from CONAPO for each of the 527 municipalities within the domain. However, in order to apply the 2017 population projections, an estimate of 2008 population was needed for each municipality. ERG derived 2008 population estimates using linear interpolation between the 2005 intracensal populations (INEGI, 2005) and the 2010 census populations (INEGI, 2010).

Agricultural acreage (both total and sugarcane) and livestock head count data were only available through 2014; the 2011 projection factors were based on historical data for 2011, while the 2017 projection factors were based upon the 15-year average from 2000 to 2014.

3.5 Nonroad Mobile Sources

Nonroad mobile sources in Mexico included commercial marine vessels, locomotives, aircraft, and nonroad equipment (i.e., airport ground support equipment, construction and mining equipment, and agricultural equipment). ERG used diesel and jet fuel (*turbosina*) usage statistics (SENER, 2014a) and agricultural acreage statistics (SAGARPA, 2014a) as surrogates for projecting emissions from nonroad mobile sources in Mexico. The assignment of surrogates to Mexico nonroad mobile source categories is provided in Appendix H, while the projection factors are included in Appendix I.

3.6 On-Road Motor Vehicles

Instead of using projection methodologies, Mexico on-road motor vehicle emissions were generated using a version of the U.S. EPA vehicle emissions model MOVES, updated to reflect conditions in those countries. MOVES2014 was the most recent version of the model available at the time of the analysis, and reflects U.S. EPA's latest estimate of vehicle emissions and default U.S. activity data (U.S. EPA, 2014c).

Generating the on-road motor vehicles emissions required determining the best approach for updating the model, culling data on vehicle fleet and activity data to replace U.S. defaults where possible, and reflecting significant differences in emission standards from the U.S. Updated MOVES databases were developed for Mexico to allow estimation of emissions in calendar years 2011 and 2017. Mexico emissions were generated at the municipality-level. Appendix O provides a detailed discussion of the MOVES adaption for both Mexico and Canada.

3.7 Results

A summary of the 2011 projected Mexico emissions for the ozone season (May through September) is presented in Table 3-1; a summary of the 2017 projected Mexico emissions for the ozone season (May through September) is presented in Table 3-2.

Table 3-1. Projected Mexico Emissions (tons) for the 2011 Ozone Season (May – September)

	NO_X (tons)	VOC (tons)	CO (tons)
Point	186,155	39,492	87,654
Area	83,061	325,747	180,181
Nonroad	54,659	7,114	33,753
Onroad	199,365	90,345	1,342,309
Total	**523,239**	**462,698**	**1,643,898**

Table 3-2. Projected Mexico Emissions (tons) for the 2017 Ozone Season (May – September)

	NO_X (tons)	VOC (tons)	CO (tons)
Point	182,152	48,181	116,239
Area	85,431	340,119	179,093
Nonroad	56,185	7,487	37,272
Onroad	171,100	61,506	995,242
Total	**494,867**	**457,293**	**1,327,845**

4.0 DEVELOPMENT OF CANADA EMISSIONS FOR 2011 AND 2017

ERG developed the 2011 and 2017 ozone precursor emission inventory using the Canada emissions contained within the emissions inventories from U.S. EPA's 2011 and 2018 Emissions Modeling Platforms (U.S. EPA, 2014a; U.S. EPA, 2014b). These emissions were based on a 2010 national emissions inventory provided by Environment Canada with a few point source updates addressing recent industrial plant closures. Although the Canada emissions

were contained in U.S. EPA's 2011 and 2018 Emissions Modeling Platform emissions inventories, these emissions had not been projected and still represented 2010 emissions.

Because the 36-km domain did not include the entire country of Canada, ERG conducted a number of preparatory steps before projecting the 2010 Canada inventory to 2011 and 2017.

4.1 Preparatory Steps

First, ERG excluded all non-ozone precursor emissions from the initial 2010 inventory file; the remaining ozone precursor pollutants were NO_x, VOC, and CO.

The 36-km modeling domain included portions of seven Canadian provinces (i.e., British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, and New Brunswick). A map showing these provinces is presented in Figure 4-1. ERG determined that U.S. EPA's processing of the 2010 Environment Canada inventory only included province-level emissions from area sources, on-road motor vehicles, and nonroad mobile sources and eliminated all other geographic data identifiers. Because of this elimination of geographic identifiers, U.S. EPA's version of the 2010 Environment Canada inventory contained multiple records for the same source categories. In order to resolve this duplication, ERG summed the source category-specific records to the province-level. It was assumed that all province-level emissions for area sources, on-road motor vehicles, and nonroad mobile sources were located within the 36-km modeling domain. This is a reasonable assumption because all major population centers in the seven provinces are located within the 36-km modeling domain.

Figure 4-1. Canadian Provinces Within 36-km Modeling Domain

ERG removed all point sources emission records with location coordinates located outside the 36-km modeling domain from the U.S. EPA version of the 2010 Environment Canada inventory. In addition, ERG removed all Category 3 (C3) marine vessel emissions (treated as point source releases in the inventory) located outside of the 36-km modeling domain. A map showing the Canadian point sources is presented in Figure 4-2.

Finally, because 2011 and 2017 on-road motor vehicle emissions were estimated using the MOVES model (as described in Section 3.6 and Appendix B), rather than estimated using surrogate projections, ERG removed all on-road motor vehicle emissions located within the 36-km modeling domain.

4.2 Projections Methodology

In general, ERG projected the 2011 and 2017 emissions by multiplying the base year 2010 emissions by a projection factor as shown in the following equation:

$$E_{2011,s} = E_{2010,s} \times P_s$$

Where: $E_{2011,s}$ = projected future year emissions for 2011 for source *s*;
$E_{2010,s}$ = estimated base year emissions for 2010 for source *s*; and
P_s = projection factor for source *s*.

Similarly, ERG projected the 2017 emissions by multiplying the base year 2010 emissions by a projection factor as shown in the following equation:

$$E_{2017,s} = E_{2010,s} \times P_s$$

Where: $E_{2017,s}$ = projected future year emissions for 2017 for source *s*;
$E_{2010,s}$ = estimated base year emissions for 2010 for source *s*; and
P_s = projection factor for source *s*.

The projection factors were based upon relevant activity surrogates.

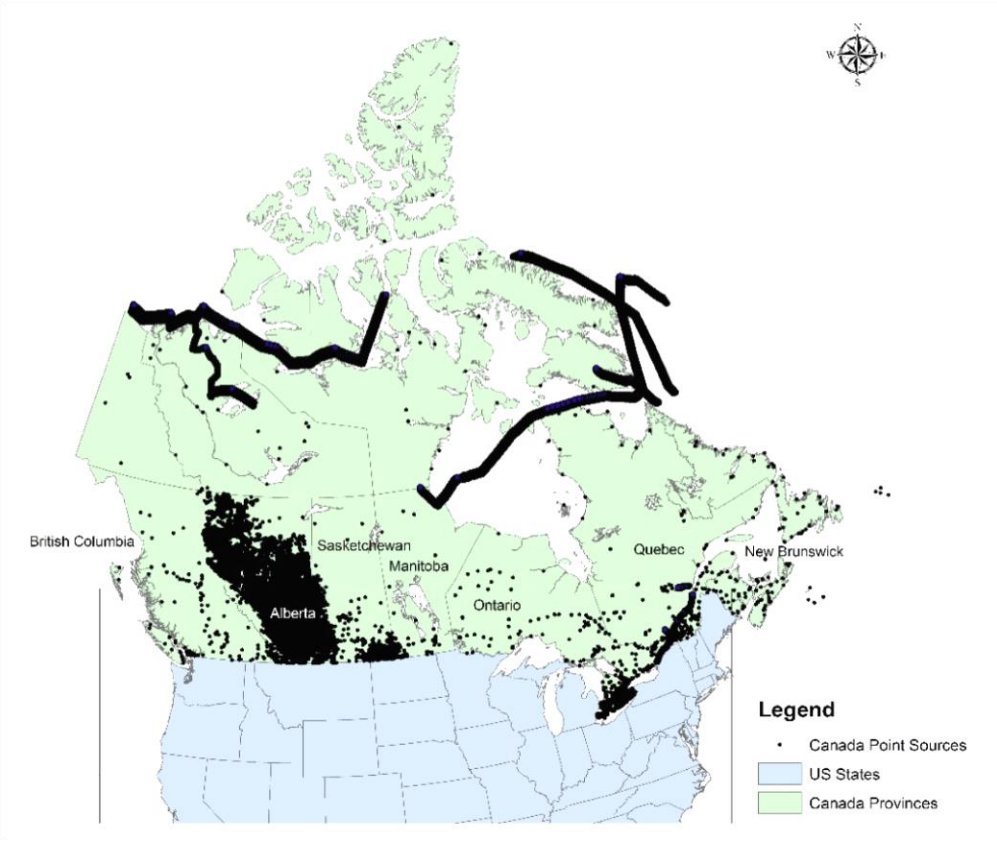
4.3 Point Sources

ERG used the following data sources as surrogates to develop point source projections for Canada:

- Historical and projected energy production (NEB, 2013):
  - Crude oil (province-level)
  - Natural gas (province-level)
  - Coal (national-level)
- Historical and projected electricity generation (NEB, 2013):
  - Coal (province-level)
  - Heavy fuel oil (province-level)
  - Natural gas (province-level)
- GDP estimates (province-level) (SC, 2014a)

The assignment of surrogates to Canada point sources is provided in Appendix I. The point source projection factors are included in Appendix J.

Figure 4-2. Canadian Point Sources



4.4 Area Sources

ERG used the following data sources as surrogates to develop area source projections for Canada:

- Population data (province-level):
  - Historical data (SC, 2010)
  - Population projections (SC, 2014b)
- Historical and projected fuel demand (province-level) (NEB, 2013):
  - Coal (utility)
  - Refined petroleum product (RPP)/LPG (utility, residential)
  - Natural gas (utility, residential)
  - Gasoline (transportation)
  - Biomass (residential)
- GDP estimates (province-level) (SC, 2014a)

The assignment of surrogates to Canada area source categories is provided in Appendix K. The area source projection factors are included in Appendix L.

Future year population projections were based upon a growth scenario with medium growth following historical trends from 1981 to 2008 (i.e., Projection Scenario M1) (SC, 2014a). A projection factor of 1.0000 was assigned for a few categories for which a suitable basis for a projection factor could not be determined.

4.5 Nonroad Mobile Sources

Nonroad mobile sources in Canada included commercial marine vessels, locomotives, aircraft, as well as a wide range of nonroad equipment powered by gasoline, diesel, LPG, and compressed natural gas (CNG). ERG used fuel-specific demand projections for the transportation sector to generate projection factors (NEB, 2013). The assignment of surrogates to Canada nonroad mobile source categories is provided in Appendix M, while the projection factors are included in Appendix N.

4.6 On-Road Motor Vehicles

Instead of using projection methodologies, Canada on-road motor vehicle emissions were generated using a version of the U.S. EPA vehicle emissions model MOVES, updated to

reflect conditions in those countries. MOVES2014 was the most recent version of the model available at the time of the analysis, and reflects U.S. EPA's latest estimate of vehicle emissions and default U.S. activity data (U.S. EPA, 2014c).

Generating the on-road motor vehicles emissions required determining the best approach for updating the model, culling data on vehicle fleet and activity data to replace U.S. defaults where possible, and reflecting significant differences in emission standards from the U.S. Updated MOVES databases were developed for Canada to allow estimation of emissions in calendar years 2011 and 2017. Canada emissions were generated at the municipality-level. A detailed discussion of the MOVES adaption for both Canada and Mexico is provided in Appendix O.

4.7 Results

A summary of the 2011 projected Canada emissions for the ozone season (May through September) is presented in Table 4-1; a summary of the 2017 projected Canada emissions for the ozone season (May through September) is presented in Table 4-2.

Table 4-1. Projected Canada Emissions (tons) for the 2011 Ozone Season (May – September)

	NO_x (tons)	VOC (tons)	CO (tons)
Point	144,187	183,751	161,329
Area	46,753	406,986	467,853
Nonroad	210,615	115,611	1,217,920
Onroad	192,092	80,956	786,639
Total	**593,647**	**787,304**	**2,633,741**

Table 4-2. Projected Canada Emissions (tons) for the 2017 Ozone Season (May – September)

	NO_x (tons)	VOC (tons)	CO (tons)
Point	152,552	202,300	181,716
Area	53,279	435,425	509,983
Nonroad	253,046	111,369	1,211,405
Onroad	103,889	46,174	507,821
Total	**562,766**	**795,268**	**2,410,925**

5.0 DEVELOPMENT OF EMISSION DATA FILES

ERG developed the emission data files in U.S. EPA's FF10 (Flat File 2010) format. The FF10 format supports storing annual and monthly emissions in a single file. Additionally, FF10 files can also support daily and hourly point and nonpoint emission inventories. ERG developed FF10 files for all applicable source types (i.e., point sources, area sources, on-road motor vehicles, and nonroad mobile sources) to support daily ozone season emission inventories. ERG developed FF10 files, by source type for Mexico and Canada.

The ozone season was defined by MAG as consisting of the months May through September. Individual OSD files were developed for each month in U.S. tons per day. All emissions were converted to U.S. tons (i.e., short tons) and all stack parameters were converted to recommended FF10 units (e.g., feet, feet/second, degrees Fahrenheit, etc.). Additionally, ERG also developed annual FF10 files for the Mexico and Canada point source Inventories. This is due to the fact that the daily FF10 format for point sources does not include stack parameters and geographic coordinate information.

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Appendix A
Mexico Municipalities Included and Excluded from Inventory Domain

Mexico Municipalities Included and Excluded from Inventory Domain

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
01	Aguascalientes	01001	Aguascalientes		X
		01002	Asientos		X
		01003	Calvillo		X
		01004	Cosío	X	
		01005	Jesús María		X
		01006	Pabellón de Arteaga		X
		01007	Rincón de Romos		X
		01008	San José de Gracia		X
		01009	Tepezalá		X
		01010	El Llano		X
		01011	San Francisco de los Romo		X
02	Baja California	(All 5 municipalities)		X	
03	Baja California Sur	(All 5 municipalities)		X	
04	Campeche	04001	Calkiní	X	
		04002	Campeche		X
		04003	Carmen		X
		04004	Champotón		X
		04005	Hecelchakán		X
		04006	Hopelchén		X
		04007	Palizada		X
		04008	Tenabo		X
		04009	Escárcega		X
		04010	Calakmul		X
		04011	Candelaria		X
05	Coahuila	(All 38 municipalities)		X	
06	Colima	(All 10 municipalities)			X
07	Chiapas	(All 119 municipalities)			X
08	Chihuahua	(All 67 municipalities)		X	
09	Distrito Federal	(All 16 municipalities)			X
10	Durango	(All 39 municipalities)		X	
11	Guanajuato	(All 46 municipalities)			X
12	Guerrero	(All 81 municipalities)			X
13	Hidalgo	(All 84 municipalities)			X
14	Jalisco	14001	Acatic		X
		14002	Acatlán de Juárez		X
		14003	Ahualulco de Mercado		X
		14004	Amacueca		X
		14005	Amatitán		X
		14006	Ameca		X
		14007	San Juanito de Escobedo		X
		14008	Arandas		X
		14009	El Arenal		X
		14010	Atemajac de Brizuela		X
		14011	Atengo		X
		14012	Atenguillo		X
		14013	Atotonilco el Alto		X
		14014	Atoyac		X
		14015	Autlán de Navarro		X
		14016	Ayotlán		X
		14017	Ayutla		X
		14018	La Barca		X
		14019	Bolaños		X
		14020	Cabo Corrientes		X
		14021	Casimiro Castillo		X
		14022	Cihuatlán		X
		14023	Zapotlán el Grande		X
		14024	Cocula		X
		14025	Colotlán		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		14026	Concepción de Buenos Aires		X
		14027	Cuautitlán de García Barragán		X
		14028	Cuautla		X
		14029	Cuquío		X
		14030	Chapala		X
		14031	Chimaltitán		X
		14032	Chiquilistlán		X
		14033	Degollado		X
		14034	Ejutla		X
		14035	Encarnación de Díaz		X
		14036	Etzatlán		X
		14037	El Grullo		X
		14038	Guachinango		X
		14039	Guadalajara		X
		14040	Hostotipaquillo		X
		14041	Huejúcar		X
		14042	Huejuquilla el Alto	X	
		14043	La Huerta		X
		14044	Ixtlahuacán de los Membrillos		X
		14045	Ixtlahuacán del Río		X
		14046	Jalostotitlán		X
		14047	Jamay		X
		14048	Jesús María		X
		14049	Jilotlán de los Dolores		X
		14050	Jocotepec		X
		14051	Juanacatlán		X
		14052	Juchitlán		X
		14053	Lagos de Moreno		X
		14054	El Limón		X
		14055	Magdalena		X
		14056	Santa María del Oro		X
		14057	La Manzanilla de la Paz		X
		14058	Mascota		X
		14059	Mazamitla		X
		14060	Mexticacán		X
		14061	Mezquitic	X	
		14062	Mixtlán		X
		14063	Ocotlán		X
		14064	Ojuelos de Jalisco		X
		14065	Pihuamo		X
		14066	Poncitlán		X
		14067	Puerto Vallarta		X
		14068	Villa Purificación		X
		14069	Quitupan		X
		14070	El Salto		X
		14071	San Cristóbal de la Barranca		X
		14072	San Diego de Alejandría		X
		14073	San Juan de los Lagos		X
		14074	San Julián		X
		14075	San Marcos		X
		14076	San Martín de Bolaños		X
		14077	San Martín Hidalgo		X
		14078	San Miguel el Alto		X
		14079	Gómez Farías		X
		14080	San Sebastián del Oeste		X
		14081	Santa María de los Ángeles		X
		14082	Sayula		X
		14083	Tala		X
		14084	Talpa de Allende		X
		14085	Tamazula de Gordiano		X
		14086	Tapalpa		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		14087	Tecalitlán		X
		14088	Tecolotlán		X
		14089	Techaluta de Montenegro		X
		14090	Tenamaxtlán		X
		14091	Teocaltiche		X
		14092	Teocuitatlán de Corona		X
		14093	Tepatitlán de Morelos		X
		14094	Tequila		X
		14095	Teuchitlán		X
		14096	Tizapán el Alto		X
		14097	Tlajomulco de Zúñiga		X
		14098	Tlaquepaque		X
		14099	Tolimán		X
		14100	Tomatlán		X
		14101	Tonalá		X
		14102	Tonaya		X
		14103	Tonila		X
		14104	Totatiche		X
		14105	Tototlán		X
		14106	Tuxcacuesco		X
		14107	Tuxcueca		X
		14108	Tuxpan		X
		14109	Unión de San Antonio		X
		14110	Unión de Tula		X
		14111	Valle de Guadalupe		X
		14112	Valle de Juárez		X
		14113	San Gabriel		X
		14114	Villa Corona		X
		14115	Villa Guerrero		X
		14116	Villa Hidalgo		X
		14117	Cañadas de Obregón		X
		14118	Yahualica de González Gallo		X
		14119	Zacoalco de Torres		X
		14120	Zapopan		X
		14121	Zapotiltic		X
		14122	Zapotitlán de Vadillo		X
		14123	Zapotlán del Rey		X
		14124	Zapotlanejo		X
		14125	San Ignacio Cerro Gordo		X
15	México	(All 125 municipalities)			X
16	Michoacán	(All 113 municipalities)			X
17	Morelos	(All 33 municipalities)			X
18	Nayarit	18001	Acaponeta	X	
		18002	Ahuacatlán		X
		18003	Amatlán de Cañas		X
		18004	Compostela		X
		18005	Huajicori	X	
		18006	Ixtlán del Río		X
		18007	Jala		X
		18008	Xalisco		X
		18009	Del Nayar	X	
		18010	Rosamorada		X
		18011	Ruíz		X
		18012	San Blas		X
		18013	San Pedro Lagunillas		X
		18014	Santa María del Oro		X
		18015	Santiago Ixcuintla		X
		18016	Tecuala		X
		18017	Tepic		X
		18018	Tuxpan		X
		18019	La Yesca		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		18020	Bahía de Banderas		X
19	Nuevo León	(All 51 municipalities)		X	
20	Oaxaca	(All 570 municipalities)			X
21	Puebla	(All 217 municipalities)			X
22	Querétaro	(All 18 municipalities)			X
23	Quintana Roo	23001	Cozumel	X	
		23002	Felipe Carrillo Puerto	X	
		23003	Isla Mujeres	X	
		23004	Othón P. Blanco		X
		23005	Benito Juárez	X	
		23006	José María Morelos	X	
		23007	Lázaro Cárdenas	X	
		23008	Solidaridad	X	
		23009	Tulum	X	
		23010	Bacalar		X
24	San Luis Potosí	24001	Ahualulco	X	
		24002	Alaquines	X	
		24003	Aquismón		X
		24004	Armadillo de los Infante	X	
		24005	Cárdenas		X
		24006	Catorce	X	
		24007	Cedral	X	
		24008	Cerritos	X	
		24009	Cerro de San Pedro		X
		24010	Ciudad del Maíz	X	
		24011	Ciudad Fernández		X
		24012	Tancanhuitz		X
		24013	Ciudad Valles	X	
		24014	Coxcatlán		X
		24015	Charcas	X	
		24016	Ebano	X	
		24017	Guadalcázar	X	
		24018	Huehuetlán		X
		24019	Lagunillas		X
		24020	Matehuala	X	
		24021	Mexquitic de Carmona	X	
		24022	Moctezuma	X	
		24023	Rayón		X
		24024	Rioverde	X	
		24025	Salinas	X	
		24026	San Antonio		X
		24027	San Ciro de Acosta		X
		24028	San Luis Potosí	X	
		24029	San Martín Chalchicuautla		X
		24030	San Nicolás Tolentino	X	
		24031	Santa Catarina		X
		24032	Santa María del Río		X
		24033	Santo Domingo	X	
		24034	San Vicente Tancuayalab		X
		24035	Soledad de Graciano Sánchez	X	
		24036	Tamasopo	X	
		24037	Tamazunchale		X
		24038	Tampacán		X
		24039	Tampamolón Corona		X
		24040	Tamuín	X	
		24041	Tanlajás		X
		24042	Tanquián de Escobedo		X
		24043	Tierra Nueva		X
		24044	Vanegas	X	
		24045	Venado	X	
		24046	Villa de Arriaga		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		24047	Villa de Guadalupe	X	
		24048	Villa de la Paz	X	
		24049	Villa de Ramos	X	
		24050	Villa de Reyes		X
		24051	Villa Hidalgo	X	
		24052	Villa Juárez	X	
		24053	Axtla de Terrazas		X
		24054	Xilitla		X
		24055	Zaragoza		X
		24056	Villa de Arista	X	
		24057	Matlapa		X
		24058	El Naranjo	X	
25	Sinaloa	(All 18 municipalities)		X	
26	Sonora	(All 72 municipalities)		X	
27	Tabasco	(All 17 municipalities)			X
28	Tamaulipas	(All 43 municipalities)		X	
29	Tlaxcala	(All 60 municipalities)			X
30	Veracruz	30001	Acajete		X
		30002	Acatlán		X
		30003	Acayucan		X
		30004	Actopan		X
		30005	Acula		X
		30006	Acultzingo		X
		30007	Camarón de Tejeda		X
		30008	Alpatláhuac		X
		30009	Alto Lucero de Gutiérrez Barrios		X
		30010	Altotonga		X
		30011	Alvarado		X
		30012	Amatitlán		X
		30013	Naranjos Amatlán		X
		30014	Amatlán de los Reyes		X
		30015	Angel R. Cabada		X
		30016	La Antigua		X
		30017	Apazapan		X
		30018	Aquila		X
		30019	Astacinga		X
		30020	Atlahuilco		X
		30021	Atoyac		X
		30022	Atzacan		X
		30023	Atzalan		X
		30024	Tlaltetela		X
		30025	Ayahualulco		X
		30026	Banderilla		X
		30027	Benito Juárez		X
		30028	Boca del Río		X
		30029	Calcahualco		X
		30030	Camerino Z. Mendoza		X
		30031	Carrillo Puerto		X
		30032	Catemaco		X
		30033	Cazones de Herrera		X
		30034	Cerro Azul		X
		30035	Citlaltépetl		X
		30036	Coacoatzintla		X
		30037	Coahuitlán		X
		30038	Coatepec		X
		30039	Coatzacoalcos		X
		30040	Coatzintla		X
		30041	Coetzala		X
		30042	Colipa		X
		30043	Comapa		X
		30044	Córdoba		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		30045	Cosamaloapan de Carpio		X
		30046	Cosautlán de Carvajal		X
		30047	Coscomatepec		X
		30048	Cosoleacaque		X
		30049	Cotaxtla		X
		30050	Coxquihui		X
		30051	Coyutla		X
		30052	Cuichapa		X
		30053	Cuitláhuac		X
		30054	Chacaltianguis		X
		30055	Chalma		X
		30056	Chiconamel		X
		30057	Chiconquiaco		X
		30058	Chicontepec		X
		30059	Chinameca		X
		30060	Chinampa de Gorostiza		X
		30061	Las Choapas		X
		30062	Chocamán		X
		30063	Chontla		X
		30064	Chumatlán		X
		30065	Emiliano Zapata		X
		30066	Espinal		X
		30067	Filomeno Mata		X
		30068	Fortín		X
		30069	Gutiérrez Zamora		X
		30070	Hidalgotitlán		X
		30071	Huatusco		X
		30072	Huayacocotla		X
		30073	Hueyapan de Ocampo		X
		30074	Huiloapan de Cuauhtémoc		X
		30075	Ignacio de la Llave		X
		30076	Ilamatlán		X
		30077	Isla		X
		30078	Ixcatepec		X
		30079	Ixhuacán de los Reyes		X
		30080	Ixhuatlán del Café		X
		30081	Ixhuatlancillo		X
		30082	Ixhuatlán del Sureste		X
		30083	Ixhuatlán de Madero		X
		30084	Ixmatlahuacan		X
		30085	Ixtaczoquitlán		X
		30086	Jalacingo		X
		30087	Xalapa		X
		30088	Jalcomulco		X
		30089	Jáltipan		X
		30090	Jamapa		X
		30091	Jesús Carranza		X
		30092	Xico		X
		30093	Jilotepec		X
		30094	Juan Rodríguez Clara		X
		30095	Juchique de Ferrer		X
		30096	Landero y Coss		X
		30097	Lerdo de Tejada		X
		30098	Magdalena		X
		30099	Maltrata		X
		30100	Manlio Fabio Altamirano		X
		30101	Mariano Escobedo		X
		30102	Martínez de la Torre		X
		30103	Mecatlán		X
		30104	Mecayapan		X
		30105	Medellín		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		30106	Miahuatlán		X
		30107	Las Minas		X
		30108	Minatitlán		X
		30109	Misantla		X
		30110	Mixtla de Altamirano		X
		30111	Moloacán		X
		30112	Naolinco		X
		30113	Naranjal		X
		30114	Nautla		X
		30115	Nogales		X
		30116	Oluta		X
		30117	Omealca		X
		30118	Orizaba		X
		30119	Otatitlán		X
		30120	Oteapan		X
		30121	Ozuluama de Mascareñas	X	
		30122	Pajapan		X
		30123	Pánuco	X	
		30124	Papantla		X
		30125	Paso del Macho		X
		30126	Paso de Ovejas		X
		30127	La Perla		X
		30128	Perote		X
		30129	Platón Sánchez		X
		30130	Playa Vicente		X
		30131	Poza Rica de Hidalgo		X
		30132	Las Vigas de Ramírez		X
		30133	Pueblo Viejo	X	
		30134	Puente Nacional		X
		30135	Rafael Delgado		X
		30136	Rafael Lucio		X
		30137	Los Reyes		X
		30138	Río Blanco		X
		30139	Saltabarranca		X
		30140	San Andrés Tenejapan		X
		30141	San Andrés Tuxtla		X
		30142	San Juan Evangelista		X
		30143	Santiago Tuxtla		X
		30144	Sayula de Alemán		X
		30145	Soconusco		X
		30146	Sochiapa		X
		30147	Soledad Atzompa		X
		30148	Soledad de Doblado		X
		30149	Soteapan		X
		30150	Tamalín		X
		30151	Tamiahua		X
		30152	Tampico Alto	X	
		30153	Tancoco		X
		30154	Tantima		X
		30155	Tantoyuca		X
		30156	Tatatila		X
		30157	Castillo de Teayo		X
		30158	Tecolutla		X
		30159	Tehuipango		X
		30160	Álamo Temapache		X
		30161	Tempoal		X
		30162	Tenampa		X
		30163	Tenochtitlán		X
		30164	Teocelo		X
		30165	Tepatlaxco		X
		30166	Tepetlán		X

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		30167	Tepetzintla		X
		30168	Tequila		X
		30169	José Azueta		X
		30170	Texcatepec		X
		30171	Texhuacán		X
		30172	Texistepec		X
		30173	Tezonapa		X
		30174	Tierra Blanca		X
		30175	Tihuatlán		X
		30176	Tlacojalpan		X
		30177	Tlacolulan		X
		30178	Tlacotalpan		X
		30179	Tlacotepec de Mejía		X
		30180	Tlachichilco		X
		30181	Tlalixcoyan		X
		30182	Tlalnelhuayocan		X
		30183	Tlapacoyan		X
		30184	Tlaquilpa		X
		30185	Tlilapan		X
		30186	Tomatlán		X
		30187	Tonayán		X
		30188	Totutla		X
		30189	Tuxpan		X
		30190	Tuxtilla		X
		30191	Ursulo Galván		X
		30192	Vega de Alatorre		X
		30193	Veracruz		X
		30194	Villa Aldama		X
		30195	Xoxocotla		X
		30196	Yanga		X
		30197	Yecuatla		X
		30198	Zacualpan		X
		30199	Zaragoza		X
		30200	Zentla		X
		30201	Zongolica		X
		30202	Zontecomatlán de López y Fuentes		X
		30203	Zozocolco de Hidalgo		X
		30204	Agua Dulce		X
		30205	El Higo		X
		30206	Nanchital de Lázaro Cárdenas del Río		X
		30207	Tres Valles		X
		30208	Carlos A. Carrillo		X
		30209	Tatahuicapan de Juárez		X
		30210	Uxpanapa		X
		30211	San Rafael		X
		30212	Santiago Sochiapan		X
31	Yucatán	31001	Abalá	X	
		31002	Acanceh	X	
		31003	Akil		X
		31004	Baca	X	
		31005	Bokobá	X	
		31006	Buctzotz	X	
		31007	Cacalchén	X	
		31008	Calotmul	X	
		31009	Cansahcab	X	
		31010	Cantamayec	X	
		31011	Celestún	X	
		31012	Cenotillo	X	
		31013	Conkal	X	
		31014	Cuncunul	X	
		31015	Cuzamá	X	

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		31016	Chacsinkín		X
		31017	Chankom	X	
		31018	Chapab	X	
		31019	Chemax	X	
		31020	Chicxulub Pueblo	X	
		31021	Chichimilá	X	
		31022	Chikindzonot	X	
		31023	Chocholá	X	
		31024	Chumayel	X	
		31025	Dzán	X	
		31026	Dzemul	X	
		31027	Dzidzantún	X	
		31028	Dzilam de Bravo	X	
		31029	Dzilam González	X	
		31030	Dzitás	X	
		31031	Dzoncauich	X	
		31032	Espita	X	
		31033	Halachó	X	
		31034	Hocabá	X	
		31035	Hoctún	X	
		31036	Homún	X	
		31037	Huhí	X	
		31038	Hunucmá	X	
		31039	Ixil	X	
		31040	Izamal	X	
		31041	Kanasín	X	
		31042	Kantunil	X	
		31043	Kaua	X	
		31044	Kinchil	X	
		31045	Kopomá	X	
		31046	Mama	X	
		31047	Maní	X	
		31048	Maxcanú	X	
		31049	Mayapán	X	
		31050	Mérida	X	
		31051	Mocochá	X	
		31052	Motul	X	
		31053	Muna	X	
		31054	Muxupip	X	
		31055	Opichén	X	
		31056	Oxkutzcab		X
		31057	Panabá	X	
		31058	Peto	X	
		31059	Progreso	X	
		31060	Quintana Roo	X	
		31061	Río Lagartos	X	
		31062	Sacalum	X	
		31063	Samahil	X	
		31064	Sanahcat	X	
		31065	San Felipe	X	
		31066	Santa Elena		X
		31067	Seyé	X	
		31068	Sinanché	X	
		31069	Sotuta	X	
		31070	Sucilá	X	
		31071	Sudzal	X	
		31072	Suma	X	
		31073	Tahdziú	X	
		31074	Tahmek	X	
		31075	Teabo	X	
		31076	Tecoh	X	

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		31077	Tekal de Venegas	X	
		31078	Tekantó	X	
		31079	Tekax	X	
		31080	Tekit	X	
		31081	Tekom	X	
		31082	Telchac Pueblo	X	
		31083	Telchac Puerto	X	
		31084	Temax	X	
		31085	Temozón	X	
		31086	Tepakán	X	
		31087	Tetiz	X	
		31088	Teya	X	
		31089	Ticul	X	
		31090	Timucuy	X	
		31091	Tinum	X	
		31092	Tixcacalcupul	X	
		31093	Tixkokob	X	
		31094	Tixmehuac	X	
		31095	Tixpéhual	X	
		31096	Tizimín	X	
		31097	Tunkás	X	
		31098	Tzucacab		X
		31099	Uayma	X	
		31100	Ucú	X	
		31101	Umán	X	
		31102	Valladolid	X	
		31103	Xocchel	X	
		31104	Yaxcabá	X	
		31105	Yaxkukul	X	
		31106	Yobaín	X	
32	Zacatecas	32001	Apozol		X
		32002	Apulco		X
		32003	Atolinga		X
		32004	Benito Juárez		X
		32005	Calera	X	
		32006	Cañitas de Felipe Pescador	X	
		32007	Concepción del Oro	X	
		32008	Cuauhtémoc	X	
		32009	Chalchihuites	X	
		32010	Fresnillo	X	
		32011	Trinidad García de la Cadena		X
		32012	Genaro Codina	X	
		32013	General Enrique Estrada	X	
		32014	General Francisco R. Murguía	X	
		32015	El Plateado de Joaquín Amaro		X
		32016	General Pánfilo Natera	X	
		32017	Guadalupe	X	
		32018	Huanusco		X
		32019	Jalpa		X
		32020	Jerez	X	
		32021	Jiménez del Teul	X	
		32022	Juan Aldama	X	
		32023	Juchipila		X
		32024	Loreto		X
		32025	Luis Moya	X	
		32026	Mazapil	X	
		32027	Melchor Ocampo	X	
		32028	Mezquital del Oro		X
		32029	Miguel Auza	X	
		32030	Momax		X
		32031	Monte Escobedo	X	

State Code	State Name	Municipality Code	Municipality Name	Included	Excluded
		32032	Morelos	X	
		32033	Moyahua de Estrada		X
		32034	Nochistlán de Mejía		X
		32035	Noria de Ángeles	X	
		32036	Ojocaliente	X	
		32037	Pánuco	X	
		32038	Pinos	X	
		32039	Río Grande	X	
		32040	Sain Alto	X	
		32041	El Salvador	X	
		32042	Sombrerete	X	
		32043	Susticacán	X	
		32044	Tabasco		X
		32045	Tepechitlán		X
		32046	Tepetongo	X	
		32047	Teúl de González Ortega		X
		32048	Tlaltenango de Sánchez Román		X
		32049	Valparaíso	X	
		32050	Vetagrande	X	
		32051	Villa de Cos	X	
		32052	Villa García		X
		32053	Villa González Ortega	X	
		32054	Villa Hidalgo	X	
		32055	Villanueva	X	
		32056	Zacatecas	X	
		32057	Trancoso	X	
		32058	Santa María de la Paz		X

Appendix B
Mexico Point Source Surrogate Assignments

Mexico Point Source Surrogate Assignments

NAICS	SCC	NAICS Definition	Surrogate
32419	All	Other petroleum and coal products manufacturing	Crude Oil Refining
211110	All	Oil and gas extraction	Crude Oil Production
221110	10100401	Electric power generation, transmission and distribution	Electricity - Residual
221110	10100405	Electric power generation, transmission and distribution	Electricity - Residual
221110	10100501	Electric power generation, transmission and distribution	Electricity - Distillate
221110	10100601	Electric power generation, transmission and distribution	Electricity - Natural Gas
221110	10200221	Electric power generation, transmission and distribution	Electricity - Coal
221110	10200401	Electric power generation, transmission and distribution	Electricity - Residual
221110	10200501	Electric power generation, transmission and distribution	Electricity - Distillate
221110	10200601	Electric power generation, transmission and distribution	Electricity - Natural Gas
221110	10200802	Electric power generation, transmission and distribution	Electricity - Coke
221110	20100101	Electric power generation, transmission and distribution	Electricity - Distillate
221110	20100102	Electric power generation, transmission and distribution	Electricity - Distillate
221110	20100201	Electric power generation, transmission and distribution	Electricity - Natural Gas
221110	20200101	Electric power generation, transmission and distribution	Electricity - Distillate
221110	20200201	Electric power generation, transmission and distribution	Electricity - Natural Gas
221110	30300310	Electric power generation, transmission and distribution	Electricity - Coke
221110	30300312	Electric power generation, transmission and distribution	Electricity - Coke
324110	All	Petroleum refining	Crude Oil Refining
324120	All	Asphalt products manufacturing	Crude Oil Refining
324191	All	Lubricating oils and greases manufacturing	Crude Oil Refining
324199	All	Coke and other products derived from refined petroleum and coal, manufacturing	Crude Oil Refining
486110	All	Pipeline transportation of crude oil	Crude Oil Refining
486210	All	Pipeline transportation of natural gas	Natural Gas Pipelines
486910	All	Pipeline transportation of refined petroleum products	Crude Oil Refining
All Others	All		GDP

Appendix C
Mexico Point Source Projection Factors

Mexico Point Source Projection Factors

State Code	State	Surrogate	2011 Projection Factor	2017 Projection Factor
01	Aguascalientes	Electricity Generation - Residual	0.6668	0.0574
02	Baja California	Electricity Generation - Residual	1.2402	0.4023
03	Baja California Sur	Electricity Generation - Residual	1.2402	0.4023
04	Campeche	Electricity Generation - Residual	0.9611	0.7883
05	Coahuila	Electricity Generation - Residual	0.7445	0.7262
08	Chihuahua	Electricity Generation - Residual	0.7445	0.7262
10	Durango	Electricity Generation - Residual	0.7445	0.7262
14	Jalisco	Electricity Generation - Residual	0.6668	0.0574
18	Nayarit	Electricity Generation - Residual	0.6668	0.0574
19	Nuevo León	Electricity Generation - Residual	0.7445	0.7262
23	Quintana Roo	Electricity Generation - Residual	0.9611	0.7883
24	San Luis Potosí	Electricity Generation - Residual	0.6668	0.0574
25	Sinaloa	Electricity Generation - Residual	1.2402	0.4023
26	Sonora	Electricity Generation - Residual	1.2402	0.4023
28	Tamaulipas	Electricity Generation - Residual	0.7445	0.7262
30	Veracruz	Electricity Generation - Residual	0.9611	0.7883
31	Yucatán	Electricity Generation - Residual	0.9611	0.7883
32	Zacatecas	Electricity Generation - Residual	0.6668	0.0574
01	Aguascalientes	Electricity Generation - Distillate	0.9609	1.1542
02	Baja California	Electricity Generation - Distillate	2.0729	1.1144
03	Baja California Sur	Electricity Generation - Distillate	2.0729	1.1144
04	Campeche	Electricity Generation - Distillate	0.9669	1.9882
05	Coahuila	Electricity Generation - Distillate	2.0162	2.2799
08	Chihuahua	Electricity Generation - Distillate	2.0162	2.2799
10	Durango	Electricity Generation - Distillate	2.0162	2.2799
14	Jalisco	Electricity Generation - Distillate	0.9609	1.1542
18	Nayarit	Electricity Generation - Distillate	0.9609	1.1542
19	Nuevo León	Electricity Generation - Distillate	2.0162	2.2799
23	Quintana Roo	Electricity Generation - Distillate	0.9669	1.9882
24	San Luis Potosí	Electricity Generation - Distillate	0.9609	1.1542
25	Sinaloa	Electricity Generation - Distillate	2.0729	1.1144
26	Sonora	Electricity Generation - Distillate	2.0729	1.1144
28	Tamaulipas	Electricity Generation - Distillate	2.0162	2.2799
30	Veracruz	Electricity Generation - Distillate	0.9669	1.9882
31	Yucatán	Electricity Generation - Distillate	0.9669	1.9882
32	Zacatecas	Electricity Generation - Distillate	0.9609	1.1542
01	Aguascalientes	Electricity Generation - Natural Gas	1.0579	2.2552
02	Baja California	Electricity Generation - Natural Gas	0.9040	1.8247
03	Baja California Sur	Electricity Generation - Natural Gas	0.9040	1.8247
04	Campeche	Electricity Generation - Natural Gas	0.8641	0.9616
05	Coahuila	Electricity Generation - Natural Gas	1.2750	1.5928
08	Chihuahua	Electricity Generation - Natural Gas	1.2750	1.5928

State Code	State	Surrogate	2011 Projection Factor	2017 Projection Factor
10	Durango	Electricity Generation - Natural Gas	1.2750	1.5928
14	Jalisco	Electricity Generation - Natural Gas	1.0579	2.2552
18	Nayarit	Electricity Generation - Natural Gas	1.0579	2.2552
19	Nuevo León	Electricity Generation - Natural Gas	1.2750	1.5928
23	Quintana Roo	Electricity Generation - Natural Gas	0.8641	0.9616
24	San Luis Potosí	Electricity Generation - Natural Gas	1.0579	2.2552
25	Sinaloa	Electricity Generation - Natural Gas	0.9040	1.8247
26	Sonora	Electricity Generation - Natural Gas	0.9040	1.8247
28	Tamaulipas	Electricity Generation - Natural Gas	1.2750	1.5928
30	Veracruz	Electricity Generation - Natural Gas	0.8641	0.9616
31	Yucatán	Electricity Generation - Natural Gas	0.8641	0.9616
32	Zacatecas	Electricity Generation - Natural Gas	1.0579	2.2552
01	Aguascalientes	Electricity Generation - Coke	1.1886	1.4010
02	Baja California	Electricity Generation - Coke	1.1886	1.4010
03	Baja California Sur	Electricity Generation - Coke	1.1886	1.4010
04	Campeche	Electricity Generation - Coke	1.1886	1.4010
05	Coahuila	Electricity Generation - Coke	1.1886	1.4010
08	Chihuahua	Electricity Generation - Coke	1.1886	1.4010
10	Durango	Electricity Generation - Coke	1.1886	1.4010
14	Jalisco	Electricity Generation - Coke	1.1886	1.4010
18	Nayarit	Electricity Generation - Coke	1.1886	1.4010
19	Nuevo León	Electricity Generation - Coke	1.1886	1.4010
23	Quintana Roo	Electricity Generation - Coke	1.1886	1.4010
24	San Luis Potosí	Electricity Generation - Coke	1.1886	1.4010
25	Sinaloa	Electricity Generation - Coke	1.1886	1.4010
26	Sonora	Electricity Generation - Coke	1.1886	1.4010
28	Tamaulipas	Electricity Generation - Coke	1.1886	1.4010
30	Veracruz	Electricity Generation - Coke	1.1886	1.4010
31	Yucatán	Electricity Generation - Coke	1.1886	1.4010
32	Zacatecas	Electricity Generation - Coke	1.1886	1.4010
01	Aguascalientes	Electricity Generation - Coal	1.6135	1.4282
02	Baja California	Electricity Generation - Coal	1.6135	1.4282
03	Baja California Sur	Electricity Generation - Coal	1.6135	1.4282
04	Campeche	Electricity Generation - Coal	1.6135	1.4282
05	Coahuila	Electricity Generation - Coal	1.6135	1.4282
08	Chihuahua	Electricity Generation - Coal	1.6135	1.4282
10	Durango	Electricity Generation - Coal	1.6135	1.4282
14	Jalisco	Electricity Generation - Coal	1.6135	1.4282
18	Nayarit	Electricity Generation - Coal	1.6135	1.4282
19	Nuevo León	Electricity Generation - Coal	1.6135	1.4282
23	Quintana Roo	Electricity Generation - Coal	1.6135	1.4282
24	San Luis Potosí	Electricity Generation - Coal	1.6135	1.4282
25	Sinaloa	Electricity Generation - Coal	1.6135	1.4282
26	Sonora	Electricity Generation - Coal	1.6135	1.4282

State Code	State	Surrogate	2011 Projection Factor	2017 Projection Factor
28	Tamaulipas	Electricity Generation - Coal	1.6135	1.4282
30	Veracruz	Electricity Generation - Coal	1.6135	1.4282
31	Yucatán	Electricity Generation - Coal	1.6135	1.4282
32	Zacatecas	Electricity Generation - Coal	1.6135	1.4282
01	Aguascalientes	Refining	0.8836	0.9842
02	Baja California	Refining	1.0000	1.0000
03	Baja California Sur	Refining	1.0000	1.0000
04	Campeche	Refining	0.9737	1.1148
05	Coahuila	Refining	0.7464	1.1052
08	Chihuahua	Refining	0.7464	1.1052
10	Durango	Refining	0.7464	1.1052
14	Jalisco	Refining	0.8836	0.9842
18	Nayarit	Refining	0.8836	0.9842
19	Nuevo León	Refining	0.7464	1.1052
23	Quintana Roo	Refining	0.9737	1.1148
24	San Luis Potosí	Refining	0.8836	0.9842
25	Sinaloa	Refining	1.0000	1.0000
26	Sonora	Refining	1.0000	1.0000
28	Tamaulipas	Refining	0.7464	1.1052
30	Veracruz	Refining	0.9737	1.1148
31	Yucatán	Refining	0.9737	1.1148
32	Zacatecas	Refining	0.8836	0.9842
01	Aguascalientes	Crude Oil Production	0.9144	0.9491
02	Baja California	Crude Oil Production	0.9144	0.9491
03	Baja California Sur	Crude Oil Production	0.9144	0.9491
04	Campeche	Crude Oil Production	0.9144	0.9491
05	Coahuila	Crude Oil Production	0.9144	0.9491
08	Chihuahua	Crude Oil Production	0.9144	0.9491
10	Durango	Crude Oil Production	0.9144	0.9491
14	Jalisco	Crude Oil Production	0.9144	0.9491
18	Nayarit	Crude Oil Production	0.9144	0.9491
19	Nuevo León	Crude Oil Production	0.9144	0.9491
23	Quintana Roo	Crude Oil Production	0.9144	0.9491
24	San Luis Potosí	Crude Oil Production	0.9144	0.9491
25	Sinaloa	Crude Oil Production	0.9144	0.9491
26	Sonora	Crude Oil Production	0.9144	0.9491
28	Tamaulipas	Crude Oil Production	0.9144	0.9491
30	Veracruz	Crude Oil Production	0.9144	0.9491
31	Yucatán	Crude Oil Production	0.9144	0.9491
32	Zacatecas	Crude Oil Production	0.9144	0.9491
01	Aguascalientes	Natural Gas Pipelines	1.0339	1.8701
02	Baja California	Natural Gas Pipelines	0.9310	1.8186
03	Baja California Sur	Natural Gas Pipelines	0.9310	1.8186
04	Campeche	Natural Gas Pipelines	0.9602	1.2161

State Code	State	Surrogate	2011 Projection Factor	2017 Projection Factor
05	Coahuila	Natural Gas Pipelines	1.2276	1.6285
08	Chihuahua	Natural Gas Pipelines	1.2276	1.6285
10	Durango	Natural Gas Pipelines	1.2276	1.6285
14	Jalisco	Natural Gas Pipelines	1.0339	1.8701
18	Nayarit	Natural Gas Pipelines	1.0339	1.8701
19	Nuevo León	Natural Gas Pipelines	1.2276	1.6285
23	Quintana Roo	Natural Gas Pipelines	0.9602	1.2161
24	San Luis Potosí	Natural Gas Pipelines	1.0339	1.8701
25	Sinaloa	Natural Gas Pipelines	0.9310	1.8186
26	Sonora	Natural Gas Pipelines	0.9310	1.8186
28	Tamaulipas	Natural Gas Pipelines	1.2276	1.6285
30	Veracruz	Natural Gas Pipelines	0.9602	1.2161
31	Yucatán	Natural Gas Pipelines	0.9602	1.2161
32	Zacatecas	Natural Gas Pipelines	1.0339	1.8701
01	Aguascalientes	GDP	1.0419	1.2386
02	Baja California	GDP	1.0419	1.2386
03	Baja California Sur	GDP	1.0419	1.2386
04	Campeche	GDP	1.0419	1.2386
05	Coahuila	GDP	1.0419	1.2386
08	Chihuahua	GDP	1.0419	1.2386
10	Durango	GDP	1.0419	1.2386
14	Jalisco	GDP	1.0419	1.2386
18	Nayarit	GDP	1.0419	1.2386
19	Nuevo León	GDP	1.0419	1.2386
23	Quintana Roo	GDP	1.0419	1.2386
24	San Luis Potosí	GDP	1.0419	1.2386
25	Sinaloa	GDP	1.0419	1.2386
26	Sonora	GDP	1.0419	1.2386
28	Tamaulipas	GDP	1.0419	1.2386
30	Veracruz	GDP	1.0419	1.2386
31	Yucatán	GDP	1.0419	1.2386
32	Zacatecas	GDP	1.0419	1.2386

Appendix D
Mexico Area Source Surrogate Assignments

Mexico Area Source Surrogate Assignments

SCC	Source_Category	Surrogate
2102004000	Industrial fuel combustion - Diesel	Diesel - Industrial
2102007000	Industrial fuel combustion - LPG	LPG - Industrial
2103006000	Commercial fuel combustion - Natural Gas	Natural Gas - Commercial
2103007000	Commercial fuel combustion - LPG	LPG - Commercial
2104006000	Residential fuel combustion - Natural Gas	Natural Gas - Residential
2104007000	Residential Fuel Combustion - LPG	LPG - Residential
2104008001	Residential Fuel Combustion - Wood	Wood - Residential
2104011000	Residential Fuel Combustion - Kerosene	Population
2202420000	Bus Terminals	Gasoline - Transportation
2222222222	Border Crossings	Gasoline - Transportation
2302002000	Charbroiling	Population
2302050000	Bakeries	Population
2401001000	Architectural Surface Coatings	Population
2401005000	Autobody Refinishing	Population
2401008000	Traffic Markings	Unchanged
2401990000	Industrial Surface Coatings	GDP
2415000000	Degreasing	GDP
2420000055	Drycleaning	Population
2425000000	Graphic Arts	Population
2461020000	Asphalt Application	Unchanged
2461850000	Pesticides	Agricultural Acreage
2465000000	Consumer Solvent Use	Population
2501060000	Gasoline Distribution	Gasoline - Transportation
2630030000	Residential Wastewater, treated	Population
2630090000	Residential Wastewater, untreated	Population
2801500250	Agricultural Burning - Sugarcane	Sugarcane Acreage
2801520004	Agricultural Fuel Combustion - Diesel	Agricultural Acreage
2801520010	Agricultural Fuel Combustion - LPG	LPG - Agricultural
2801520020	Agricultural Fuel Combustion - Kerosene	Agricultural Acreage
2801700000	Fertilizer Application	Agricultural Acreage
2810030000	Structure Fires	Population
2850000010	Hospitals - Sterilization Operations	Population
3333333333	LPG Distribution	LPG - Overall

Appendix E
Mexico Population-Based Area Source Projection Factors

Mexico Population-Based Area Source Projection Factors

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
01004	Aguascalientes	Cosío	1.0597	1.1440
02001	Baja California	Ensenada	1.0913	1.2018
02002	Baja California	Mexicali	1.0732	1.1638
02003	Baja California	Tecate	1.0804	1.1755
02004	Baja California	Tijuana	1.0787	1.1823
02005	Baja California	Playas de Rosarito	1.1421	1.3011
03001	Baja California Sur	Comondú	1.0788	1.2241
03002	Baja California Sur	Mulegé	1.0855	1.2454
03003	Baja California Sur	La Paz	1.0994	1.2783
03008	Baja California Sur	Los Cabos	1.2320	1.5724
03009	Baja California Sur	Loreto	1.2179	1.5168
04001	Campeche	Calkiní	1.0567	1.1471
05001	Coahuila	Abasolo	1.0567	1.1089
05002	Coahuila	Acuña	1.0533	1.1305
05003	Coahuila	Allende	1.0769	1.1646
05004	Coahuila	Arteaga	1.0867	1.1741
05005	Coahuila	Candela	1.0480	1.0888
05006	Coahuila	Castaños	1.0568	1.1263
05007	Coahuila	Cuatro Ciénegas	1.0449	1.0974
05008	Coahuila	Escobedo	1.0358	1.0802
05009	Coahuila	Francisco I. Madero	1.0532	1.1229
05010	Coahuila	Frontera	1.0493	1.1152
05011	Coahuila	General Cepeda	1.0275	1.0598
05012	Coahuila	Guerrero	1.0650	1.1324
05013	Coahuila	Hidalgo	1.1158	1.2391
05014	Coahuila	Jiménez	1.0193	1.0561
05015	Coahuila	Juárez	1.0912	1.1922
05016	Coahuila	Lamadrid	1.0489	1.0865
05017	Coahuila	Matamoros	1.0488	1.1142
05018	Coahuila	Monclova	1.0545	1.1237
05019	Coahuila	Morelos	1.0809	1.1683
05020	Coahuila	Múzquiz	1.0454	1.1029
05021	Coahuila	Nadadores	1.0573	1.1195
05022	Coahuila	Nava	1.0506	1.1205
05023	Coahuila	Ocampo	1.0511	1.1116
05024	Coahuila	Parras	1.0196	1.0597
05025	Coahuila	Piedras Negras	1.0423	1.1051
05026	Coahuila	Progreso	1.0257	1.0648
05027	Coahuila	Ramos Arizpe	1.1685	1.3450
05028	Coahuila	Sabinas	1.0880	1.1837
05029	Coahuila	Sacramento	1.0736	1.1493

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
05030	Coahuila	Saltillo	1.0730	1.1630
05031	Coahuila	San Buenaventura	1.0798	1.1674
05032	Coahuila	San Juan de Sabinas	1.0318	1.0744
05033	Coahuila	San Pedro	1.0599	1.1272
05034	Coahuila	Sierra Mojada	1.1201	1.2497
05035	Coahuila	Torreón	1.0687	1.1529
05036	Coahuila	Viesca	1.0611	1.1303
05037	Coahuila	Villa Unión	1.0217	1.0551
05038	Coahuila	Zaragoza	1.0235	1.0623
08001	Chihuahua	Ahumada	1.0215	1.0483
08002	Chihuahua	Aldama	1.1029	1.1955
08003	Chihuahua	Allende	1.0485	1.0820
08004	Chihuahua	Aquiles Serdán	1.3365	1.6660
08005	Chihuahua	Ascensión	1.0707	1.1365
08006	Chihuahua	Bachíniva	1.0565	1.0887
08007	Chihuahua	Balleza	1.0779	1.1496
08008	Chihuahua	Batopilas	1.0725	1.1410
08009	Chihuahua	Bocoyna	1.0141	1.0478
08010	Chihuahua	Buenaventura	1.0834	1.1536
08011	Chihuahua	Camargo	1.0555	1.1091
08012	Chihuahua	Carichí	1.0579	1.1087
08013	Chihuahua	Casas Grandes	1.1681	1.3085
08014	Chihuahua	Coronado	1.1018	1.1802
08015	Chihuahua	Coyame del Sotol	1.1211	1.1968
08016	Chihuahua	La Cruz	1.1170	1.2099
08017	Chihuahua	Cuauhtémoc	1.1159	1.2263
08018	Chihuahua	Cusihuiriachi	1.1011	1.1734
08019	Chihuahua	Chihuahua	1.0845	1.1693
08020	Chihuahua	Chínipas	1.1017	1.1958
08021	Chihuahua	Delicias	1.0853	1.1653
08022	Chihuahua	Dr. Belisario Domínguez	1.1053	1.1375
08023	Chihuahua	Galeana	1.2921	1.5913
08024	Chihuahua	Santa Isabel	1.0579	1.0999
08025	Chihuahua	Gómez Farías	1.1120	1.1988
08026	Chihuahua	Gran Morelos	1.0614	1.0806
08027	Chihuahua	Guachochi	1.0770	1.1550
08028	Chihuahua	Guadalupe	0.8411	0.7586
08029	Chihuahua	Guadalupe y Calvo	1.0479	1.1026
08030	Chihuahua	Guazapares	1.0983	1.1862
08031	Chihuahua	Guerrero	1.0718	1.1326
08032	Chihuahua	Hidalgo del Parral	1.0593	1.1202
08033	Chihuahua	Huejotitán	1.0508	1.0826
08034	Chihuahua	Ignacio Zaragoza	1.0617	1.1017

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
08035	Chihuahua	Janos	1.1973	1.3739
08036	Chihuahua	Jiménez	1.0480	1.0934
08037	Chihuahua	Juárez	1.0433	1.0938
08038	Chihuahua	Julimes	1.0920	1.1511
08039	Chihuahua	López	1.0522	1.0771
08040	Chihuahua	Madera	0.9911	0.9944
08041	Chihuahua	Maguarichi	0.9809	0.9781
08042	Chihuahua	Manuel Benavides	1.0347	1.0406
08043	Chihuahua	Matachí	1.0243	1.0371
08044	Chihuahua	Matamoros	1.0646	1.1065
08045	Chihuahua	Meoqui	1.0693	1.1323
08046	Chihuahua	Morelos	1.1157	1.2284
08047	Chihuahua	Moris	1.0512	1.0920
08048	Chihuahua	Namiquipa	1.1048	1.1796
08049	Chihuahua	Nonoava	1.0412	1.0645
08050	Chihuahua	Nuevo Casas Grandes	1.0864	1.1695
08051	Chihuahua	Ocampo	1.1401	1.2694
08052	Chihuahua	Ojinaga	1.1619	1.2985
08053	Chihuahua	Praxedis G. Guerrero	0.7294	0.6153
08054	Chihuahua	Riva Palacio	1.0484	1.0881
08055	Chihuahua	Rosales	1.0658	1.1208
08056	Chihuahua	Rosario	1.0787	1.1232
08057	Chihuahua	San Francisco de Borja	1.0502	1.0536
08058	Chihuahua	San Francisco de Conchos	1.1006	1.1640
08059	Chihuahua	San Francisco del Oro	1.0302	1.0512
08060	Chihuahua	Santa Bárbara	1.0569	1.1046
08061	Chihuahua	Satevó	1.0096	1.0006
08062	Chihuahua	Saucillo	1.1090	1.2001
08063	Chihuahua	Temósachic	1.0286	1.0437
08064	Chihuahua	El Tule	1.0507	1.0770
08065	Chihuahua	Urique	1.0524	1.1054
08066	Chihuahua	Uruachi	1.0539	1.1139
08067	Chihuahua	Valle de Zaragoza	1.1309	1.2175
10001	Durango	Canatlán	1.0606	1.1161
10002	Durango	Canelas	1.0251	1.0548
10003	Durango	Coneto de Comonfort	1.0476	1.0920
10004	Durango	Cuencamé	1.0567	1.1060
10005	Durango	Durango	1.0817	1.1677
10006	Durango	General Simón Bolívar	1.0808	1.1482
10007	Durango	Gómez Palacio	1.0652	1.1335
10008	Durango	Guadalupe Victoria	1.0570	1.1139
10009	Durango	Guanaceví	1.0183	1.0390
10010	Durango	Hidalgo	1.0289	1.0500

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
10011	Durango	Indé	1.0703	1.1139
10012	Durango	Lerdo	1.0723	1.1457
10013	Durango	Mapimí	1.0716	1.1356
10014	Durango	Mezquital	1.0729	1.1371
10015	Durango	Nazas	1.0315	1.0579
10016	Durango	Nombre de Dios	1.0566	1.1036
10017	Durango	Ocampo	1.0451	1.0781
10018	Durango	El Oro	1.0635	1.1108
10019	Durango	Otáez	1.0974	1.1851
10020	Durango	Pánuco de Coronado	1.0240	1.0512
10021	Durango	Peñón Blanco	1.0543	1.0985
10022	Durango	Poanas	1.0560	1.1074
10023	Durango	Pueblo Nuevo	1.0440	1.0963
10024	Durango	Rodeo	1.0942	1.1729
10025	Durango	San Bernardo	0.9708	0.9368
10026	Durango	San Dimas	1.0324	1.0752
10027	Durango	San Juan de Guadalupe	1.0297	1.0583
10028	Durango	San Juan del Río	1.0852	1.1573
10029	Durango	San Luis del Cordero	1.0645	1.1136
10030	Durango	San Pedro del Gallo	1.1022	1.1830
10031	Durango	Santa Clara	1.0674	1.1233
10032	Durango	Santiago Papasquiaro	1.0683	1.1385
10033	Durango	Súchil	1.0081	1.0242
10034	Durango	Tamazula	1.0300	1.0659
10035	Durango	Tepehuanes	0.9781	0.9693
10036	Durango	Tlahualilo	1.0840	1.1548
10037	Durango	Topia	1.0633	1.1242
10038	Durango	Vicente Guerrero	1.0371	1.0801
10039	Durango	Nuevo Ideal	1.0614	1.1178
14042	Jalísco	Huejuquilla el Alto	1.0685	1.1386
14061	Jalísco	Mezquitic	1.0821	1.1626
18001	Nayarit	Acaponeta	1.0504	1.1294
18005	Nayarit	Huajicori	1.0601	1.1498
18009	Nayarit	Del Nayar	1.0784	1.1837
19001	Nuevo León	Abasolo	1.0228	1.0686
19002	Nuevo León	Agualeguas	0.9970	0.9972
19003	Nuevo León	Los Aldamas	0.9038	0.8363
19004	Nuevo León	Allende C446	1.0683	1.1502
19005	Nuevo León	Anáhuac	1.0277	1.0714
19006	Nuevo León	Apodaca	1.1383	1.2983
19007	Nuevo León	Aramberri	1.0383	1.0716
19008	Nuevo León	Bustamante	1.0814	1.1605
19009	Nuevo León	Cadereyta Jiménez	1.1037	1.2207

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
19010	Nuevo León	Carmen	1.4178	1.8191
19011	Nuevo León	Cerralvo	1.0017	1.0213
19012	Nuevo León	Ciénega de Flores	1.3136	1.6758
19013	Nuevo León	China	1.0242	1.0614
19014	Nuevo León	Dr. Arroyo	1.0447	1.0888
19015	Nuevo León	Dr. Coss	1.0395	1.0753
19016	Nuevo León	Dr. González	1.0540	1.1154
19017	Nuevo León	Galeana	1.0269	1.0627
19018	Nuevo León	García	1.4686	1.8695
19019	Nuevo León	San Pedro Garza García	1.0255	1.0933
19020	Nuevo León	General Bravo	1.0256	1.0584
19021	Nuevo León	General Escobedo	1.1141	1.2519
19022	Nuevo León	General Terán	1.0278	1.0561
19023	Nuevo León	General Treviño	0.9349	0.8980
19024	Nuevo León	General Zaragoza	1.0312	1.0755
19025	Nuevo León	General Zuazua	1.6976	2.2408
19026	Nuevo León	Guadalupe	1.0054	1.0440
19027	Nuevo León	Los Herreras	1.0562	1.0695
19028	Nuevo León	Higueras	1.0754	1.1561
19029	Nuevo León	Hualahuises	1.0376	1.0814
19030	Nuevo León	Iturbide	1.0147	1.0400
19031	Nuevo León	Juárez	1.3228	1.6760
19032	Nuevo León	Lampazos de Naranjo	1.1222	1.2417
19033	Nuevo León	Linares	1.0715	1.1564
19034	Nuevo León	Marín	1.0216	1.0715
19035	Nuevo León	Melchor Ocampo	0.9059	0.8589
19036	Nuevo León	Mier y Noriega	1.0136	1.0414
19037	Nuevo León	Mina	1.0199	1.0622
19038	Nuevo León	Montemorelos	1.0671	1.1473
19039	Nuevo León	Monterrey	1.0172	1.0616
19040	Nuevo León	Parás	1.0674	1.1240
19041	Nuevo León	Pesquería	1.3138	1.6867
19042	Nuevo León	Los Ramones	0.9303	0.8875
19043	Nuevo León	Rayones	1.0261	1.0575
19044	Nuevo León	Sabinas Hidalgo	1.0586	1.1327
19045	Nuevo León	Salinas Victoria	1.1017	1.2198
19046	Nuevo León	San Nicolás de los Garza	0.9785	0.9981
19047	Nuevo León	Hidalgo	1.0536	1.1282
19048	Nuevo León	Santa Catarina	1.0353	1.1032
19049	Nuevo León	Santiago	1.0520	1.1183
19050	Nuevo León	Vallecillo	1.0482	1.0860
19051	Nuevo León	Villaldama	1.0139	1.0323
23001	Quintana Roo	Cozumel	1.0751	1.2425

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
23002	Quintana Roo	Felipe Carrillo Puerto	1.1025	1.2902
23003	Quintana Roo	Isla Mujeres	1.1393	1.3722
23005	Quintana Roo	Benito Juárez	1.1105	1.3205
23006	Quintana Roo	José María Morelos	1.0811	1.2480
23007	Quintana Roo	Lázaro Cárdenas	1.0951	1.2722
23008	Quintana Roo	Solidaridad	1.2156	1.5593
23009	Quintana Roo	Tulum	1.1939	1.4613
24001	San Luis Potosí	Ahualulco	1.0507	1.1070
24002	San Luis Potosí	Alaquines	1.0353	1.0650
24004	San Luis Potosí	Armadillo de los Infante	1.0022	0.9989
24006	San Luis Potosí	Catorce	1.0412	1.0700
24007	San Luis Potosí	Cedral	1.0610	1.1258
24008	San Luis Potosí	Cerritos	1.0364	1.0652
24010	San Luis Potosí	Ciudad del Maíz	1.0364	1.0704
24013	San Luis Potosí	Ciudad Valles	1.0511	1.1126
24015	San Luis Potosí	Charcas	1.0381	1.0785
24016	San Luis Potosí	Ebano	1.0589	1.1193
24017	San Luis Potosí	Guadalcázar	1.0325	1.0535
24020	San Luis Potosí	Matehuala	1.0703	1.1470
24021	San Luis Potosí	Mexquitic de Carmona	1.0695	1.1503
24022	San Luis Potosí	Moctezuma	1.0425	1.0883
24024	San Luis Potosí	Rioverde	1.0510	1.1059
24025	San Luis Potosí	Salinas	1.0751	1.1525
24028	San Luis Potosí	San Luis Potosí	1.0467	1.1123
24030	San Luis Potosí	San Nicolás Tolentino	1.0019	0.9980
24033	San Luis Potosí	Santo Domingo	1.0442	1.0815
24035	San Luis Potosí	Soledad de Graciano Sánchez	1.1084	1.2287
24036	San Luis Potosí	Tamasopo	1.0500	1.0940
24040	San Luis Potosí	Tamuín	1.0517	1.1086
24044	San Luis Potosí	Vanegas	1.0704	1.1339
24045	San Luis Potosí	Venado	1.0296	1.0566
24047	San Luis Potosí	Villa de Guadalupe	1.0411	1.0661
24048	San Luis Potosí	Villa de la Paz	1.0546	1.1023
24049	San Luis Potosí	Villa de Ramos	1.0646	1.1298
24051	San Luis Potosí	Villa Hidalgo	1.0454	1.0829
24052	San Luis Potosí	Villa Juárez	1.0341	1.0505
24056	San Luis Potosí	Villa de Arista	1.0671	1.1381
24058	San Luis Potosí	El Naranjo	1.0720	1.1382
25001	Sinaloa	Ahome	1.0707	1.1352
25002	Sinaloa	Angostura	1.0608	1.1041
25003	Sinaloa	Badiraguato	0.9875	0.9852
25004	Sinaloa	Concordia	1.0590	1.1019
25005	Sinaloa	Cosalá	0.9905	0.9873

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
25006	Sinaloa	Culiacán	1.0771	1.1500
25007	Sinaloa	Choix	1.0473	1.0792
25008	Sinaloa	Elota	0.9822	0.9748
25009	Sinaloa	Escuinapa	1.0778	1.1411
25010	Sinaloa	El Fuerte	1.0578	1.1022
25011	Sinaloa	Guasave	1.0621	1.1153
25012	Sinaloa	Mazatlán	1.0785	1.1499
25013	Sinaloa	Mocorito	1.0475	1.0727
25014	Sinaloa	Rosario	1.0505	1.0883
25015	Sinaloa	Salvador Alvarado	1.0495	1.0950
25016	Sinaloa	San Ignacio	1.0068	1.0078
25017	Sinaloa	Sinaloa	1.0496	1.0843
25018	Sinaloa	Navolato	1.0290	1.0549
26001	Sonora	Aconchi	1.0609	1.1201
26002	Sonora	Agua Prieta	1.0890	1.1969
26003	Sonora	Alamos	1.0509	1.1040
26004	Sonora	Altar	1.0642	1.1439
26005	Sonora	Arivechi	1.0054	1.0132
26006	Sonora	Arizpe	1.0353	1.0659
26007	Sonora	Atil	0.9290	0.8855
26008	Sonora	Bacadéhuachi	1.0111	1.0076
26009	Sonora	Bacanora	1.0307	1.0325
26010	Sonora	Bacerac	1.0714	1.1500
26011	Sonora	Bacoachi	1.0916	1.1783
26012	Sonora	Bácum	1.0718	1.1489
26013	Sonora	Banámichi	1.0834	1.1438
26014	Sonora	Baviácora	1.0419	1.0701
26015	Sonora	Bavispe	1.0920	1.1639
26016	Sonora	Benjamín Hill	1.0190	1.0470
26017	Sonora	Caborca	1.1066	1.2239
26018	Sonora	Cajeme	1.0724	1.1590
26019	Sonora	Cananea	1.0352	1.0852
26020	Sonora	Carbó	1.1009	1.2100
26021	Sonora	La Colorada	0.9897	0.9712
26022	Sonora	Cucurpe	1.1247	1.2175
26023	Sonora	Cumpas	1.0749	1.1448
26024	Sonora	Divisaderos	1.1284	1.2465
26025	Sonora	Empalme	1.0597	1.1320
26026	Sonora	Etchojoa	1.0696	1.1469
26027	Sonora	Fronteras	1.1038	1.2139
26028	Sonora	Granados	1.1296	1.2310
26029	Sonora	Guaymas	1.0838	1.1781
26030	Sonora	Hermosillo	1.0874	1.1913

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
26031	Sonora	Huachinera	1.0732	1.1433
26032	Sonora	Huásabas	1.0740	1.1247
26033	Sonora	Huatabampo	1.0565	1.1217
26034	Sonora	Huépac	1.0800	1.1299
26035	Sonora	Imuris	1.1089	1.2293
26036	Sonora	Magdalena	1.1087	1.2259
26037	Sonora	Mazatán	1.0151	1.0206
26038	Sonora	Moctezuma	1.0667	1.1429
26039	Sonora	Naco	1.0566	1.1265
26040	Sonora	Nácori Chico	1.1084	1.2030
26041	Sonora	Nacozari de García	1.0594	1.1373
26042	Sonora	Navojoa	1.0716	1.1551
26043	Sonora	Nogales	1.0950	1.2053
26044	Sonora	Onavas	1.0277	1.0486
26045	Sonora	Opodepe	1.0694	1.1224
26046	Sonora	Oquitoa	1.0708	1.1388
26047	Sonora	Pitiquito	1.0445	1.1007
26048	Sonora	Puerto Peñasco	1.1609	1.3297
26049	Sonora	Quiriego	1.0685	1.1250
26050	Sonora	Rayón	1.0371	1.0471
26051	Sonora	Rosario	1.0273	1.0517
26052	Sonora	Sahuaripa	1.0418	1.0784
26053	Sonora	San Felipe de Jesús	1.1649	1.3024
26054	Sonora	San Javier	1.4124	1.8531
26055	Sonora	San Luis Río Colorado	1.0933	1.1965
26056	Sonora	San Miguel de Horcasitas	1.2072	1.4324
26057	Sonora	San Pedro de la Cueva	1.0888	1.1547
26058	Sonora	Santa Ana	1.0727	1.1553
26059	Sonora	Santa Cruz	1.0827	1.1669
26060	Sonora	Sáric	1.0601	1.1181
26061	Sonora	Soyopa	1.0538	1.0762
26062	Sonora	Suaqui Grande	1.0273	1.0361
26063	Sonora	Tepache	1.1020	1.1765
26064	Sonora	Trincheras	1.0377	1.0702
26065	Sonora	Tubutama	1.0121	1.0283
26066	Sonora	Ures	1.0696	1.1300
26067	Sonora	Villa Hidalgo	1.0803	1.1466
26068	Sonora	Villa Pesqueira	0.9682	0.9437
26069	Sonora	Yécora	1.0150	1.0449
26070	Sonora	General Plutarco Elías Calles	1.1494	1.3024
26071	Sonora	Benito Juárez	1.0624	1.1345
26072	Sonora	San Ignacio Río Muerto	1.0572	1.1244
28001	Tamaulipas	Abasolo	1.0293	1.0614

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
28002	Tamaulipas	Aldama	1.0561	1.1172
28003	Tamaulipas	Altamira	1.1708	1.3503
28004	Tamaulipas	Antiguo Morelos	1.0491	1.0980
28005	Tamaulipas	Burgos	0.9982	0.9965
28006	Tamaulipas	Bustamante	1.0419	1.0682
28007	Tamaulipas	Camargo	0.9270	0.8968
28008	Tamaulipas	Casas	1.0524	1.0927
28009	Tamaulipas	Ciudad Madero	1.0366	1.0869
28010	Tamaulipas	Cruillas	0.9526	0.9238
28011	Tamaulipas	Gómez Farías	1.0391	1.0787
28012	Tamaulipas	González	1.0523	1.1089
28013	Tamaulipas	Güémez	1.0658	1.1268
28014	Tamaulipas	Guerrero	1.1087	1.2410
28015	Tamaulipas	Gustavo Díaz Ordaz	1.0480	1.0971
28016	Tamaulipas	Hidalgo	1.0299	1.0564
28017	Tamaulipas	Jaumave	1.0590	1.1149
28018	Tamaulipas	Jiménez	1.0262	1.0581
28019	Tamaulipas	Llera	1.0173	1.0296
28020	Tamaulipas	Mainero	1.0445	1.0643
28021	Tamaulipas	El Mante	1.0399	1.0863
28022	Tamaulipas	Matamoros	1.0521	1.1219
28023	Tamaulipas	Méndez	0.9897	0.9895
28024	Tamaulipas	Mier	0.8484	0.7784
28025	Tamaulipas	Miguel Alemán	1.0887	1.1908
28026	Tamaulipas	Miquihuana	1.0346	1.0552
28027	Tamaulipas	Nuevo Laredo	1.0619	1.1378
28028	Tamaulipas	Nuevo Morelos	1.0761	1.1466
28029	Tamaulipas	Ocampo	1.0409	1.0729
28030	Tamaulipas	Padilla	1.0777	1.1469
28031	Tamaulipas	Palmillas	1.0764	1.1300
28032	Tamaulipas	Reynosa	1.1015	1.2177
28033	Tamaulipas	Río Bravo	1.0752	1.1556
28034	Tamaulipas	San Carlos	1.0218	1.0349
28035	Tamaulipas	San Fernando	1.0135	1.0433
28036	Tamaulipas	San Nicolás	1.0111	1.0363
28037	Tamaulipas	Soto la Marina	1.0662	1.1347
28038	Tamaulipas	Tampico	1.0123	1.0441
28039	Tamaulipas	Tula	1.0574	1.1100
28040	Tamaulipas	Valle Hermoso	1.0278	1.0679
28041	Tamaulipas	Victoria	1.0753	1.1633
28042	Tamaulipas	Villagrán	1.0079	1.0109
28043	Tamaulipas	Xicoténcatl	1.0463	1.0922
30121	Veracruz	Ozuluama de Mascareñas	1.0076	1.0096

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
30123	Veracruz	Pánuco	1.0451	1.0857
30133	Veracruz	Pueblo Viejo	1.0353	1.0717
30152	Veracruz	Tampico Alto	1.0188	1.0243
31001	Yucatán	Abalá	1.0505	1.1240
31002	Yucatán	Acanceh	1.0553	1.1427
31004	Yucatán	Baca	1.0469	1.1114
31005	Yucatán	Bokobá	1.0409	1.1077
31006	Yucatán	Buctzotz	1.0311	1.0838
31007	Yucatán	Cacalchén	1.0524	1.1286
31008	Yucatán	Calotmul	1.0512	1.1178
31009	Yucatán	Cansahcab	1.0107	1.0437
31010	Yucatán	Cantamayec	1.0439	1.1111
31011	Yucatán	Celestún	1.0655	1.1592
31012	Yucatán	Cenotillo	1.0391	1.0875
31013	Yucatán	Conkal	1.0558	1.1401
31014	Yucatán	Cuncunul	1.0440	1.1155
31015	Yucatán	Cuzamá	1.0366	1.1092
31017	Yucatán	Chankom	1.0286	1.0807
31018	Yucatán	Chapab	1.0396	1.1038
31019	Yucatán	Chemax	1.0695	1.1527
31020	Yucatán	Chicxulub Pueblo	1.0537	1.1279
31021	Yucatán	Chichimilá	1.0481	1.1131
31022	Yucatán	Chikindzonot	1.0245	1.0791
31023	Yucatán	Chocholá	1.0373	1.0933
31024	Yucatán	Chumayel	1.0563	1.1326
31025	Yucatán	Dzán	1.0608	1.1477
31026	Yucatán	Dzemul	1.0515	1.1164
31027	Yucatán	Dzidzantún	1.0126	1.0529
31028	Yucatán	Dzilam de Bravo	1.0655	1.1470
31029	Yucatán	Dzilam González	1.0189	1.0597
31030	Yucatán	Dzitás	1.0259	1.0705
31031	Yucatán	Dzoncauich	1.0095	1.0388
31032	Yucatán	Espita	1.0525	1.1251
31033	Yucatán	Halachó	1.0444	1.1189
31034	Yucatán	Hocabá	1.0360	1.0949
31035	Yucatán	Hoctún	1.0289	1.0828
31036	Yucatán	Homún	1.0396	1.1159
31037	Yucatán	Huhí	1.0574	1.1407
31038	Yucatán	Hunucmá	1.0668	1.1647
31039	Yucatán	Ixil	1.0465	1.1233
31040	Yucatán	Izamal	1.0526	1.1256
31041	Yucatán	Kanasín	1.2536	1.5503
31042	Yucatán	Kantunil	1.0287	1.0775

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
31043	Yucatán	Kaua	1.0556	1.1283
31044	Yucatán	Kinchil	1.0719	1.1668
31045	Yucatán	Kopomá	1.0733	1.1626
31046	Yucatán	Mama	1.0580	1.1513
31047	Yucatán	Maní	1.0599	1.1522
31048	Yucatán	Maxcanú	1.0389	1.1100
31049	Yucatán	Mayapán	1.0661	1.1564
31050	Yucatán	Mérida	1.0514	1.1335
31051	Yucatán	Mocochá	1.0447	1.1121
31052	Yucatán	Motul	1.0568	1.1378
31053	Yucatán	Muna	1.0419	1.1147
31054	Yucatán	Muxupip	1.0472	1.1313
31055	Yucatán	Opichén	1.0807	1.1868
31057	Yucatán	Panabá	1.0085	1.0469
31058	Yucatán	Peto	1.0568	1.1342
31059	Yucatán	Progreso	1.0643	1.1527
31060	Yucatán	Quintana Roo	1.0083	1.0513
31061	Yucatán	Río Lagartos	1.0454	1.1123
31062	Yucatán	Sacalum	1.0577	1.1422
31063	Yucatán	Samahil	1.0423	1.1182
31064	Yucatán	Sanahcat	1.0531	1.1251
31065	Yucatán	San Felipe	1.0089	1.0384
31067	Yucatán	Seyé	1.0310	1.0941
31068	Yucatán	Sinanché	1.0394	1.0918
31069	Yucatán	Sotuta	1.0372	1.0929
31070	Yucatán	Sucilá	1.0486	1.1087
31071	Yucatán	Sudzal	1.0573	1.1300
31072	Yucatán	Suma	1.0472	1.0977
31073	Yucatán	Tahdziú	1.0826	1.1718
31074	Yucatán	Tahmek	1.0317	1.0794
31075	Yucatán	Teabo	1.0723	1.1720
31076	Yucatán	Tecoh	1.0438	1.1185
31077	Yucatán	Tekal de Venegas	1.0478	1.1168
31078	Yucatán	Tekantó	0.9993	1.0266
31079	Yucatán	Tekax	1.0606	1.1488
31080	Yucatán	Tekit	1.0613	1.1576
31081	Yucatán	Tekom	1.0419	1.1060
31082	Yucatán	Telchac Pueblo	1.0390	1.0876
31083	Yucatán	Telchac Puerto	1.0512	1.1303
31084	Yucatán	Temax	1.0194	1.0601
31085	Yucatán	Temozón	1.0455	1.1184
31086	Yucatán	Tepakán	1.0478	1.1098
31087	Yucatán	Tetiz	1.0493	1.1377

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
31088	Yucatán	Teya	1.0224	1.0648
31089	Yucatán	Ticul	1.0486	1.1309
31090	Yucatán	Timucuy	1.0554	1.1444
31091	Yucatán	Tinum	1.0909	1.2018
31092	Yucatán	Tixcacalcupul	1.0546	1.1307
31093	Yucatán	Tixkokob	1.0511	1.1290
31094	Yucatán	Tixmehuac	1.0646	1.1362
31095	Yucatán	Tixpéhual	1.0595	1.1416
31096	Yucatán	Tizimín	1.0421	1.1102
31097	Yucatán	Tunkás	1.0196	1.0532
31099	Yucatán	Uayma	1.1438	1.2981
31100	Yucatán	Ucú	1.0875	1.2011
31101	Yucatán	Umán	0.9928	1.0337
31102	Yucatán	Valladolid	1.0569	1.1452
31103	Yucatán	Xocchel	1.0714	1.1656
31104	Yucatán	Yaxcabá	1.0455	1.1072
31105	Yucatán	Yaxkukul	1.0580	1.1391
31106	Yucatán	Yobaín	1.0339	1.0768
32005	Zacatecas	Calera	1.0628	1.1277
32006	Zacatecas	Cañitas de Felipe Pescador	1.0316	1.0585
32007	Zacatecas	Concepción del Oro	1.0482	1.0812
32008	Zacatecas	Cuauhtémoc	1.0386	1.0767
32009	Zacatecas	Chalchihuites	1.0104	1.0199
32010	Zacatecas	Fresnillo	1.0533	1.1073
32012	Zacatecas	Genaro Codina	1.0586	1.1086
32013	Zacatecas	General Enrique Estrada	1.0326	1.0643
32014	Zacatecas	General Francisco R. Murguía	1.0322	1.0594
32016	Zacatecas	General Pánfilo Natera	1.0298	1.0577
32017	Zacatecas	Guadalupe	1.1295	1.2607
32020	Zacatecas	Jerez	1.0593	1.1075
32021	Zacatecas	Jiménez del Teul	0.9721	0.9504
32022	Zacatecas	Juan Aldama	1.0676	1.1297
32025	Zacatecas	Luis Moya	1.0672	1.1249
32026	Zacatecas	Mazapil	1.0805	1.1375
32027	Zacatecas	Melchor Ocampo	1.0442	1.0769
32029	Zacatecas	Miguel Auza	1.0478	1.0941
32031	Zacatecas	Monte Escobedo	1.0108	1.0041
32032	Zacatecas	Morelos	1.0549	1.1119
32035	Zacatecas	Noria de Ángeles	1.1003	1.1862
32036	Zacatecas	Ojocaliente	1.0514	1.1019
32037	Zacatecas	Pánuco	1.0771	1.1470
32038	Zacatecas	Pinos	1.0377	1.0770
32039	Zacatecas	Río Grande	1.0554	1.1093

Municipality Code	State	Municipality	2011 Projection Factor	2017 Projection Factor
32040	Zacatecas	Sain Alto	1.0666	1.1229
32041	Zacatecas	El Salvador	0.9714	0.9387
32042	Zacatecas	Sombrerete	1.0360	1.0698
32043	Zacatecas	Susticacán	1.0621	1.1027
32046	Zacatecas	Tepetongo	1.0087	1.0000
32049	Zacatecas	Valparaíso	1.0193	1.0266
32050	Zacatecas	Vetagrande	1.0721	1.1421
32051	Zacatecas	Villa de Cos	1.0722	1.1333
32053	Zacatecas	Villa González Ortega	1.0541	1.1056
32054	Zacatecas	Villa Hidalgo	1.0477	1.0952
32055	Zacatecas	Villanueva	1.0203	1.0323
32056	Zacatecas	Zacatecas	1.0369	1.0828
32057	Zacatecas	Trancoso	1.0594	1.1195

Appendix F
Mexico Other Area Source Projection Factors

Mexico Other Area Source Projection Factors

Surrogate	Region/State	2011 Projection Factor	2017 Projection Factor
Diesel - Industrial	Noroeste	1.1731	1.3832
Diesel - Industrial	Noreste	1.3046	1.5567
Diesel - Industrial	Centro-Occidente	1.0605	1.3555
Diesel - Industrial	Centro	0.7877	0.6682
Diesel - Industrial	Sur-Sureste	1.0593	1.1525
LPG - Industrial	Noroeste	0.9115	0.8629
LPG - Industrial	Noreste	0.8894	1.0004
LPG - Industrial	Centro-Occidente	1.0910	0.9050
LPG - Industrial	Centro	0.9629	0.9564
LPG - Industrial	Sur-Sureste	1.1144	0.6111
LPG - Commercial	Noroeste	1.0813	1.0032
LPG - Commercial	Noreste	1.2390	1.0524
LPG - Commercial	Centro-Occidente	0.9632	0.9345
LPG - Commercial	Centro	1.0018	0.9610
LPG - Commercial	Sur-Sureste	1.1001	1.1202
LPG - Residential	Noroeste	0.9720	0.8921
LPG - Residential	Noreste	1.0043	0.8322
LPG - Residential	Centro-Occidente	0.9155	0.8019
LPG - Residential	Centro	0.9731	0.9235
LPG - Residential	Sur-Sureste	0.9264	0.8947
LPG - Agricultural	Noroeste	1.2726	1.2925
LPG - Agricultural	Noreste	0.9478	0.8965
LPG - Agricultural	Centro-Occidente	1.0041	0.8839
LPG - Agricultural	Centro	1.1394	0.7507
LPG - Agricultural	Sur-Sureste	1.1257	2.4565
LPG - Overall	Noroeste	0.9681	0.9596
LPG - Overall	Noreste	1.0190	1.0102
LPG - Overall	Centro-Occidente	0.9652	0.9225
LPG - Overall	Centro	0.9754	0.9628
LPG - Overall	Sur-Sureste	0.9749	0.9708
Natural Gas - Commercial	Noroeste	1.2795	1.3597
Natural Gas - Commercial	Noreste	0.9285	1.1272
Natural Gas - Commercial	Centro-Occidente	0.9645	1.6718
Natural Gas - Commercial	Centro	1.2092	1.3746
Natural Gas - Commercial	Sur-Sureste	1.0542	3.4710
Natural Gas - Residential	Noroeste	1.0113	1.2927
Natural Gas - Residential	Noreste	0.8776	1.0025
Natural Gas - Residential	Centro-Occidente	0.9251	1.1775
Natural Gas - Residential	Centro	1.0394	1.2833
Natural Gas - Residential	Sur-Sureste	0.9251	1.1775
Wood - Residential	National	0.9849	0.9567

Surrogate	Region/State	2011 Projection Factor	2017 Projection Factor
Gasoline - Transportation	Aguascalientes	1.0306	1.0920
Gasoline - Transportation	Baja California	0.9774	0.9905
Gasoline - Transportation	Baja California Sur	0.9774	0.9955
Gasoline - Transportation	Campeche	1.0740	1.2158
Gasoline - Transportation	Chihuahua	0.9261	0.9659
Gasoline - Transportation	Coahuila	0.9261	0.9679
Gasoline - Transportation	Durango	0.9261	0.9673
Gasoline - Transportation	Jalisco	1.0306	1.0915
Gasoline - Transportation	Nayarit	1.0306	1.0982
Gasoline - Transportation	Nuevo León	0.9261	0.9152
Gasoline - Transportation	Quintana Roo	1.0740	1.2180
Gasoline - Transportation	San Luis Potosí	1.0306	1.0888
Gasoline - Transportation	Sinaloa	0.9774	0.9908
Gasoline - Transportation	Sonora	0.9774	0.9901
Gasoline - Transportation	Tamaulipas	0.9261	0.9645
Gasoline - Transportation	Veracruz	1.0740	1.2190
Gasoline - Transportation	Yucatán	1.0740	1.2174
Gasoline - Transportation	Zacatecas	1.0306	1.0805
Agricultural Acreage	Aguascalientes	0.7595	0.9322
Agricultural Acreage	Baja California	0.9994	1.0166
Agricultural Acreage	Baja California Sur	1.1060	1.0451
Agricultural Acreage	Campeche	1.0126	1.0082
Agricultural Acreage	Coahuila	1.0285	1.0088
Agricultural Acreage	Chihuahua	0.9972	0.9995
Agricultural Acreage	Durango	0.9709	0.9918
Agricultural Acreage	Jalisco	1.0250	0.9934
Agricultural Acreage	Nayarit	1.0440	0.9746
Agricultural Acreage	Nuevo León	0.8403	1.0186
Agricultural Acreage	Quintana Roo	0.9633	1.0389
Agricultural Acreage	San Luis Potosí	0.8750	0.9992
Agricultural Acreage	Sinaloa	1.1980	0.9559
Agricultural Acreage	Sonora	1.0947	0.9775
Agricultural Acreage	Tamaulipas	1.0417	1.0150
Agricultural Acreage	Veracruz	0.9974	1.0049
Agricultural Acreage	Yucatán	0.9962	0.9834
Agricultural Acreage	Zacatecas	0.8896	0.9846
Sugar Cane Acreage	Aguascalientes	1.0485	0.9869
Sugar Cane Acreage	Baja California	1.0485	0.9869
Sugar Cane Acreage	Baja California Sur	1.0485	0.9869
Sugar Cane Acreage	Campeche	1.0869	0.9432
Sugar Cane Acreage	Coahuila	1.0485	0.9869
Sugar Cane Acreage	Chihuahua	1.0485	0.9869
Sugar Cane Acreage	Durango	1.0485	0.9869

Surrogate	Region/State	2011 Projection Factor	2017 Projection Factor
Sugar Cane Acreage	Jalisco	1.0004	1.0128
Sugar Cane Acreage	Nayarit	0.9753	0.8930
Sugar Cane Acreage	Nuevo León	1.0485	0.9869
Sugar Cane Acreage	Quintana Roo	1.0509	0.9624
Sugar Cane Acreage	San Luis Potosí	1.0254	0.9968
Sugar Cane Acreage	Sinaloa	0.6460	0.8858
Sugar Cane Acreage	Sonora	1.0485	0.9869
Sugar Cane Acreage	Tamaulipas	1.1425	0.9701
Sugar Cane Acreage	Veracruz	1.0462	0.9902
Sugar Cane Acreage	Yucatán	1.0485	0.9869
Sugar Cane Acreage	Zacatecas	1.0485	0.9869
GDP	National	1.0419	1.2386

Appendix G
Mexico Nonroad Mobile Source Surrogate Assignments

Mexico Nonroad Mobile Source Surrogate Assignments

SCC	SCC Description	Surrogate Assignment
2270002000	Construction Equipment	Diesel - Transportation
2270005000	Agricultural Equipment	Agricultural Acreage
2270008000	GSE	Turbosina
2275000000	Aircrafts	Turbosina
2280000000	Commercial Marine Vessels	Diesel - Marine
2285000000	Locomotives	Diesel - Locomotives

Appendix H
Mexico Nonroad Mobile Source Projection Factors

Mexico Nonroad Mobile Source Projection Factors

Surrogate	Region/State	2011 Projection Factor	2017 Projection Factor
Diesel - Transportation	Noroeste	0.9882	1.1695
Diesel - Transportation	Noreste	0.9569	1.0775
Diesel - Transportation	Centro-Occidente	1.0557	1.2836
Diesel - Transportation	Centro	0.9953	1.1407
Diesel - Transportation	Sur-Sureste	0.9467	1.0934
Diesel - Locomotive	Noroeste	1.1040	1.2836
Diesel - Locomotive	Noreste	1.1669	1.1443
Diesel - Locomotive	Centro-Occidente	1.0251	1.0813
Diesel - Locomotive	Centro	1.4398	1.8911
Diesel - Locomotive	Sur-Sureste	1.2948	1.5696
Diesel - Marine	Noroeste	0.8715	0.8256
Diesel - Marine	Noreste	0.9995	0.6016
Diesel - Marine	Centro-Occidente	1.0894	0.5056
Diesel - Marine	Centro	0.9076	0.8722
Diesel - Marine	Sur-Sureste	0.8572	1.1713
Turbosina	Aguascalientes	0.8642	1.1694
Turbosina	Baja California	8.7976	13.5509
Turbosina	Baja California Sur	1.0218	1.4820
Turbosina	Campeche	0.8642	1.1694
Turbosina	Coahuila	0.8642	1.1694
Turbosina	Chihuahua	0.8642	1.1694
Turbosina	Durango	0.8642	1.1694
Turbosina	Jalisco	0.8642	1.1694
Turbosina	Nayarit	0.8642	1.1694
Turbosina	Nuevo León	0.5379	0.6632
Turbosina	Quintana Roo	0.8642	1.1694
Turbosina	San Luis Potosí	0.8642	1.1694
Turbosina	Sinaloa	0.8642	1.1694
Turbosina	Sonora	0.4674	0.6414
Turbosina	Tamaulipas	4.8004	5.7475
Turbosina	Veracruz	0.3251	0.4259
Turbosina	Yucatán	0.5168	0.7542
Turbosina	Zacatecas	0.8642	1.1694
Agricultural Acreage	Aguascalientes	0.7595	0.9322
Agricultural Acreage	Baja California	0.9994	1.0166
Agricultural Acreage	Baja California Sur	1.1060	1.0451
Agricultural Acreage	Campeche	1.0126	1.0082
Agricultural Acreage	Coahuila	1.0285	1.0088
Agricultural Acreage	Chihuahua	0.9972	0.9995
Agricultural Acreage	Durango	0.9709	0.9918
Agricultural Acreage	Jalisco	1.0250	0.9934
Agricultural Acreage	Nayarit	1.0440	0.9746
Agricultural Acreage	Nuevo León	0.8403	1.0186

Surrogate	Region/State	2011 Projection Factor	2017 Projection Factor
Agricultural Acreage	Quintana Roo	0.9633	1.0389
Agricultural Acreage	San Luis Potosí	0.8750	0.9992
Agricultural Acreage	Sinaloa	1.1980	0.9559
Agricultural Acreage	Sonora	1.0947	0.9775
Agricultural Acreage	Tamaulipas	1.0417	1.0150
Agricultural Acreage	Veracruz	0.9974	1.0049
Agricultural Acreage	Yucatán	0.9962	0.9834
Agricultural Acreage	Zacatecas	0.8896	0.9846

Appendix I
Canada Point Source Surrogate Assignments

Canada Point Source Surrogate Assignments

NAICS	NAICS Description	SCC	SCC Description	Surrogate Assignment
212114	Coal Mining	2325000000	Mining &Quarrying /All Processes /Total	Coal Production
212116	Coal Mining	2325000000	Mining &Quarrying /All Processes /Total	Coal Production
211113	Oil and Gas Extraction	2102006000	Stationary Fuel Comb /Industrial /Natural Gas /Total: Boilers and IC Engines	Crude Oil Production
211113	Oil and Gas Extraction	2306000000	Petroleum Refining /All Processes /Total	Crude Oil Production
211113	Oil and Gas Extraction	2310000000	Oil & Gas Expl & Prod /All Processes /Total: All Processes	Crude Oil Production
211113	Oil and Gas Extraction	2310020600	Oil & Gas Expl & Prod /Natural Gas /Compressor Engines	Crude Oil Production
211114	Oil and Gas Extraction	2310000000	Oil & Gas Expl & Prod /All Processes /Total: All Processes	Crude Oil Production
221112	Fossil Fuel Electric Power Generation	2101001000	Stationary Fuel Comb /Electric Utility /Anthracite Coal /Total: All Boiler Types	Utility - Coal
221112	Fossil Fuel Electric Power Generation	2101006001	Stationary Fuel Comb /Electric Utility /Natural Gas /All Boiler Types	Utility - Natural Gas
221112	Fossil Fuel Electric Power Generation	2199006001	Stationary Fuel Comb /Total Area Source /Natural Gas /All Boiler Types	Utility - Natural Gas
221119	Other Electric Power Generation	2101006001	Stationary Fuel Comb /Electric Utility /Natural Gas /All Boiler Types	Utility - Natural Gas
486110	Pipeline Transportation of Crude Oil	2310000000	Oil & Gas Expl & Prod /All Processes /Total: All Processes	Crude Oil Production
486110	Pipeline Transportation of Crude Oil	2310020600	Oil & Gas Expl & Prod /Natural Gas /Compressor Engines	Crude Oil Production
486110	Pipeline Transportation of Crude Oil	31000123	Crude Oil Production /Well Casing Vents	Crude Oil Production
486110	Pipeline Transportation of Crude Oil	31000132	Crude Oil Production /Atmospheric Wash Tank (2nd Stage of Gas-Oil Separation): Flashing Loss	Crude Oil Production
486110	Pipeline Transportation of Crude Oil	31000160	Crude Oil Production /Flares	Crude Oil Production

NAICS	NAICS Description	SCC	SCC Description	Surrogate Assignment
486110	Pipeline Transportation of Crude Oil	40600132	Petrol Trans & Marketg /Tank Cars & Trucks /Crude Oil: Submerged Loading (Normal Service)	Crude Oil Production
221210	Natural Gas Distribution	2310020600	Oil & Gas Expl & Prod /Natural Gas /Compressor Engines	Natural Gas Production
486210	Pipeline Transportation of Natural Gas	2310020600	Oil & Gas Expl & Prod /Natural Gas /Compressor Engines	Natural Gas Production
486210	Pipeline Transportation of Natural Gas	31000220	Natural Gas Production /All Equipt Leak Fugitives (Valves, Flanges, Connections, Seals, Drains	Natural Gas Production
486210	Pipeline Transportation of Natural Gas	31000304	Natural Gas Proc Facilities /Glycol Dehydrators: Ethylene Glycol: General	Natural Gas Production
All others		All others		GDP

Appendix J
Canada Point Source Projection Factors

Canada Point Source Projection Factors

Province Code	Province Name	Surrogate	2011 Projection Factor	2017 Projection Factor
59000	British Columbia	Coal Production	0.9489	0.9382
48000	Alberta	Coal Production	0.9489	0.9382
47000	Saskatchewan	Coal Production	0.9489	0.9382
46000	Manitoba	Coal Production	0.9489	0.9382
24000	Québec	Coal Production	0.9489	0.9382
35000	Ontario	Coal Production	0.9489	0.9382
13000	New Brunswick	Coal Production	0.9489	0.9382
59000	British Columbia	Coal Production	0.9489	0.9382
48000	Alberta	Coal Production	0.9489	0.9382
47000	Saskatchewan	Coal Production	0.9489	0.9382
46000	Manitoba	Coal Production	0.9489	0.9382
24000	Québec	Coal Production	0.9489	0.9382
35000	Ontario	Coal Production	0.9489	0.9382
13000	New Brunswick	Coal Production	0.9489	0.9382
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250

Province Code	Province Name	Surrogate	2011 Projection Factor	2017 Projection Factor
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Utility - Coal	1.0000	1.0000
48000	Alberta	Utility - Coal	0.9838	0.8151
47000	Saskatchewan	Utility - Coal	0.9623	1.1225
46000	Manitoba	Utility - Coal	0.8462	5.0000
24000	Québec	Utility - Coal	1.0000	1.0000
35000	Ontario	Utility - Coal	0.3139	0.0000
13000	New Brunswick	Utility - Coal	1.1439	0.5119
59000	British Columbia	Utility - Natural Gas	0.3993	0.8356
48000	Alberta	Utility - Natural Gas	1.1290	1.9680
47000	Saskatchewan	Utility - Natural Gas	1.0763	1.8319
46000	Manitoba	Utility - Natural Gas	1.1042	0.0000
24000	Québec	Utility - Natural Gas	0.8927	15.7897
35000	Ontario	Utility - Natural Gas	1.3182	1.4176
13000	New Brunswick	Utility - Natural Gas	1.0451	0.4632
59000	British Columbia	Utility - Natural Gas	0.3993	0.8356
48000	Alberta	Utility - Natural Gas	1.1290	1.9680
47000	Saskatchewan	Utility - Natural Gas	1.0763	1.8319
46000	Manitoba	Utility - Natural Gas	1.1042	0.0000
24000	Québec	Utility - Natural Gas	0.8927	15.7897
35000	Ontario	Utility - Natural Gas	1.3182	1.4176
13000	New Brunswick	Utility - Natural Gas	1.0451	0.4632
59000	British Columbia	Utility - Natural Gas	0.3993	0.8356
48000	Alberta	Utility - Natural Gas	1.1290	1.9680
47000	Saskatchewan	Utility - Natural Gas	1.0763	1.8319
46000	Manitoba	Utility - Natural Gas	1.1042	0.0000
24000	Québec	Utility - Natural Gas	0.8927	15.7897
35000	Ontario	Utility - Natural Gas	1.3182	1.4176
13000	New Brunswick	Utility - Natural Gas	1.0451	0.4632
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000

Province Code	Province Name	Surrogate	2011 Projection Factor	2017 Projection Factor
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Crude Oil Production	0.9927	0.7938
48000	Alberta	Crude Oil Production	1.0714	1.6220
47000	Saskatchewan	Crude Oil Production	1.0462	1.2430
46000	Manitoba	Crude Oil Production	1.4615	2.4570
24000	Québec	Crude Oil Production	1.0000	1.0000
35000	Ontario	Crude Oil Production	0.9167	0.6250
13000	New Brunswick	Crude Oil Production	1.0000	1.0000
59000	British Columbia	Natural Gas Production	1.1893	1.2662
48000	Alberta	Natural Gas Production	0.9570	0.6437
47000	Saskatchewan	Natural Gas Production	0.9155	0.6338
46000	Manitoba	Natural Gas Production	1.0000	1.0000
24000	Québec	Natural Gas Production	1.0000	1.0000
35000	Ontario	Natural Gas Production	0.8000	0.6000
13000	New Brunswick	Natural Gas Production	1.0000	0.0000
59000	British Columbia	Natural Gas Production	1.1893	1.2662

Province Code	Province Name	Surrogate	2011 Projection Factor	2017 Projection Factor
48000	Alberta	Natural Gas Production	0.9570	0.6437
47000	Saskatchewan	Natural Gas Production	0.9155	0.6338
46000	Manitoba	Natural Gas Production	1.0000	1.0000
24000	Québec	Natural Gas Production	1.0000	1.0000
35000	Ontario	Natural Gas Production	0.8000	0.6000
13000	New Brunswick	Natural Gas Production	1.0000	0.0000
59000	British Columbia	Natural Gas Production	1.1893	1.2662
48000	Alberta	Natural Gas Production	0.9570	0.6437
47000	Saskatchewan	Natural Gas Production	0.9155	0.6338
46000	Manitoba	Natural Gas Production	1.0000	1.0000
24000	Québec	Natural Gas Production	1.0000	1.0000
35000	Ontario	Natural Gas Production	0.8000	0.6000
13000	New Brunswick	Natural Gas Production	1.0000	0.0000
59000	British Columbia	Natural Gas Production	1.1893	1.2662
48000	Alberta	Natural Gas Production	0.9570	0.6437
47000	Saskatchewan	Natural Gas Production	0.9155	0.6338
46000	Manitoba	Natural Gas Production	1.0000	1.0000
24000	Québec	Natural Gas Production	1.0000	1.0000
35000	Ontario	Natural Gas Production	0.8000	0.6000
13000	New Brunswick	Natural Gas Production	1.0000	0.0000
59000	British Columbia	GDP	1.0279	1.2104
48000	Alberta	GDP	1.0572	1.2270
47000	Saskatchewan	GDP	1.0581	1.2256
46000	Manitoba	GDP	1.0212	1.1863
24000	Québec	GDP	1.0200	1.1231
35000	Ontario	GDP	1.0261	1.1843
13000	New Brunswick	GDP	1.0057	1.0458

Appendix K
Canada Area Source Surrogate Assignments

Canada Area Source Surrogate Assignments

SCC	SCC Description	Surrogate Assignment
2101001000	Stationary Fuel Comb /Electric Utility /Anthracite Coal /Total: All Boiler Types	Utility - Coal
2101006001	Stationary Fuel Comb /Electric Utility /Natural Gas /All Boiler Types	Utility - Natural Gas
2101010000	Stationary Fuel Comb /Electric Utility /Process Gas /Total: All Boiler Types	Utility - RPP
2104000000	Stationary Fuel Comb /Residential /Wood /	Residential - Biomass
2104008001	Stationary Fuel Comb /Residential /Wood /Fireplaces: General	Residential - Biomass
2104008030	Stationary Fuel Comb /Residential /Wood /Catalytic Woodstoves: General	Residential - Biomass
2104008051	Stationary Fuel Comb /Residential /Wood /Non-catalytic Woodstoves: Non-EPA certified	Residential - Biomass
2104008060	Stationary Fuel Comb /Residential /Wood /	Residential - Biomass
2104008070	Stationary Fuel Comb /Residential /Wood /Outdoor Wood Burning Equipment	Residential - Biomass
2199006001	Stationary Fuel Comb /Total Area Source /Natural Gas /All Boiler Types	Residential - Natural Gas
2302050000	Food & Kindred Products /Bakery Products /Total	Population
2303020000	Primary Metal Production /Iron & Steel Foundries /Total	GDP
2306010000	Petroleum Refining /Asphalt Paving/Roofing Materials /Total	GDP
2307000000	Wood Products /All Processes /Total	GDP
2311020000	Construction: SIC 15 - 17 /Industrial/Commercial/Institutional /Total	GDP
2325000000	Mining &Quarrying /All Processes /Total	GDP
2401990000	Surface Coating /All Surface Coating Categories /Total: All Solvent Types	GDP
2420000000	Dry Cleaning /All Processes /Total: All Solvent Types	Population
2425000000	Graphic Arts /All Processes /Total: All Solvent Types	Population
2440000000	Misc Industrial /All Processes /Total: All Solvent Types	GDP
2501000000	Petrol & Petrol Product Storage /All Storage Types: Breathing Loss /Total: All Products	Transportation - Gasoline
2501000120	Petrol & Petrol Product Storage /All Storage Types: Breathing Loss /Gasoline	Transportation - Gasoline
2601000000	On-site Incineration /All Categories /Total	Assumed to be 1.0000
2601010000	On-site Incineration /Industrial /Total	Assumed to be 1.0000
2601020000	On-site Incineration /Commercial/Institutional /Total	Assumed to be 1.0000
2610000000	Open Burning /All Categories /Total	Population
2620000000	Landfills /All Categories /Total	Population
2810003000	Cigarette Smoke /Total	Population
2810030000	Structure Fires /Unspecified	Population
2810060100	Cremation /Humans	Population

Appendix L
Canada Area Source Projection Factors

Canada Area Source Projection Factors

Province Code	Province Name	Surrogate Assignment	2011 Projection Factor	2017 Projection Factor
59000	British Columbia	Utility - RPP	0.9846	0.9846
48000	Alberta	Utility - RPP	1.0000	3.1667
47000	Saskatchewan	Utility - RPP	0.5789	0.6316
46000	Manitoba	Utility - RPP	0.9333	1.0952
24000	Quebec	Utility - RPP	0.9501	0.6676
35000	Ontario	Utility - RPP	0.5584	1.7662
13000	New Brunswick	Utility - RPP	0.4588	0.0284
59000	British Columbia	Utility - Natural Gas	0.3993	0.8356
48000	Alberta	Utility - Natural Gas	1.1290	1.9680
47000	Saskatchewan	Utility - Natural Gas	1.0763	1.8319
46000	Manitoba	Utility - Natural Gas	1.1042	0.0000
24000	Quebec	Utility - Natural Gas	0.8927	15.7897
35000	Ontario	Utility - Natural Gas	1.3182	1.4176
13000	New Brunswick	Utility - Natural Gas	1.0451	0.4632
59000	British Columbia	Utility - Coal	1.0000	1.0000
48000	Alberta	Utility - Coal	0.9838	0.8151
47000	Saskatchewan	Utility - Coal	0.9623	1.1225
46000	Manitoba	Utility - Coal	0.8462	5.0000
24000	Quebec	Utility - Coal	1.0000	1.0000
35000	Ontario	Utility - Coal	0.3139	0.0000
13000	New Brunswick	Utility - Coal	1.1439	0.5119
59000	British Columbia	Transportation - Gasoline	1.0304	0.9193
48000	Alberta	Transportation - Gasoline	1.0862	1.1729
47000	Saskatchewan	Transportation - Gasoline	1.0440	0.9327
46000	Manitoba	Transportation - Gasoline	0.9851	0.8763
24000	Quebec	Transportation - Gasoline	1.0112	0.8955
35000	Ontario	Transportation - Gasoline	0.9841	0.9381
13000	New Brunswick	Transportation - Gasoline	1.1926	1.0567

Province Code	Province Name	Surrogate Assignment	2011 Projection Factor	2017 Projection Factor
59000	British Columbia	Residential - Natural Gas	1.2470	1.3199
48000	Alberta	Residential - Natural Gas	1.0606	1.2011
47000	Saskatchewan	Residential - Natural Gas	0.9611	1.0167
46000	Manitoba	Residential - Natural Gas	1.0860	1.1613
24000	Quebec	Residential - Natural Gas	1.1717	1.2273
35000	Ontario	Residential - Natural Gas	1.1193	1.2194
13000	New Brunswick	Residential - Natural Gas	1.2000	1.6000
59000	British Columbia	Residential - Biomass	1.1333	1.2444
48000	Alberta	Residential - Biomass	1.2000	1.2000
47000	Saskatchewan	Residential - Biomass	1.0000	1.0909
46000	Manitoba	Residential - Biomass	1.0500	1.2000
24000	Quebec	Residential - Biomass	1.0472	1.0751
35000	Ontario	Residential - Biomass	1.0711	1.1564
13000	New Brunswick	Residential - Biomass	1.0714	1.0714
59000	British Columbia	Population	1.0159	1.1112
48000	Alberta	Population	1.0137	1.0956
47000	Saskatchewan	Population	1.0059	1.0437
46000	Manitoba	Population	1.0104	1.0747
24000	Quebec	Population	1.0083	1.0558
35000	Ontario	Population	1.0133	1.0929
13000	New Brunswick	Population	1.0044	1.0299
59000	British Columbia	GDP	1.0279	1.2104
48000	Alberta	GDP	1.0572	1.2270
47000	Saskatchewan	GDP	1.0581	1.2256
46000	Manitoba	GDP	1.0212	1.1863
24000	Quebec	GDP	1.0200	1.1231
35000	Ontario	GDP	1.0261	1.1843
13000	New Brunswick	GDP	1.0057	1.0458

Appendix M
Canada Nonroad Mobile Source Surrogate Assignments

Canada Nonroad Mobile Source Surrogate Assignments

SCC	SCC Description	Surrogate Assignment
2260001010	Off-highway Gasoline, 2-Stroke /Recreational Equipt /Motorcycles: Off-road	Transportation - Gasoline
2260001020	Off-highway Gasoline, 2-Stroke /Recreational Equipt /Snowmobiles	Transportation - Gasoline
2260001030	Off-highway Gasoline, 2-Stroke /Recreational Equipt /All Terrain Vehicles	Transportation - Gasoline
2260001060	Off-highway Gasoline, 2-Stroke /Recreational Equipt /Specialty Vehicles/Carts	Transportation - Gasoline
2260001061	Off-highway Gasoline, 2-Stroke /Recreational Equipt /	Transportation - Gasoline
2260001062	Off-highway Gasoline, 2-Stroke /Recreational Equipt /	Transportation - Gasoline
2260002006	Off-highway Gasoline, 2-Stroke /Construction & Mining Equipt /Tampers/Rammers	Transportation - Gasoline
2260002009	Off-highway Gasoline, 2-Stroke /Construction & Mining Equipt /Plate Compactors	Transportation - Gasoline
2260002021	Off-highway Gasoline, 2-Stroke /Construction & Mining Equipt /Paving Equipt	Transportation - Gasoline
2260002033	Off-highway Gasoline, 2-Stroke /Construction & Mining Equipt /Bore/Drill Rigs	Transportation - Gasoline
2260002039	Off-highway Gasoline, 2-Stroke /Construction & Mining Equipt /Concrete/Industrial Saws	Transportation - Gasoline
2260003030	Off-highway Gasoline, 2-Stroke /Industrial Equipt /Sweepers/Scrubbers	Transportation - Gasoline
2260004010	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Lawn Mowers (Residential)	Transportation - Gasoline
2260004011	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Lawn Mowers (Commercial)	Transportation - Gasoline
2260004015	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Rotary Tillers < 6 HP (Residential)	Transportation - Gasoline
2260004016	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Rotary Tillers < 6 HP (Commercial)	Transportation - Gasoline
2260004020	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Chain Saws < 6 HP (Residential)	Transportation - Gasoline
2260004021	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Chain Saws < 6 HP (Commercial)	Transportation - Gasoline
2260004025	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Trimmers/Edgers/Brush Cutters (Residential)	Transportation - Gasoline
2260004026	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Trimmers/Edgers/Brush Cutters (Commercial)	Transportation - Gasoline
2260004030	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Leafblowers/Vacuums (Residential)	Transportation - Gasoline
2260004031	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Leafblowers/Vacuums (Commercial)	Transportation - Gasoline

SCC	SCC Description	Surrogate Assignment
2260004035	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Snowblowers (Residential)	Transportation - Gasoline
2260004036	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Snowblowers (Commercial)	Transportation - Gasoline
2260004051	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Shredders < 6 HP (Commercial)	Transportation - Gasoline
2260004075	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Residential)	Transportation - Gasoline
2260004076	Off-highway Gasoline, 2-Stroke /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Commercial)	Transportation - Gasoline
2260005010	Off-highway Gasoline, 2-Stroke /Agricultural Equipt /2-Wheel Tractors	Transportation - Gasoline
2260005030	Off-highway Gasoline, 2-Stroke /Agricultural Equipt /Agricultural Mowers	Transportation - Gasoline
2260005035	Off-highway Gasoline, 2-Stroke /Agricultural Equipt /Sprayers	Transportation - Gasoline
2260005040	Off-highway Gasoline, 2-Stroke /Agricultural Equipt /Tillers : 6 HP	Transportation - Gasoline
2260006005	Off-highway Gasoline, 2-Stroke /Commercial Equipt /Generator Sets	Transportation - Gasoline
2260006010	Off-highway Gasoline, 2-Stroke /Commercial Equipt /Pumps	Transportation - Gasoline
2260006025	Off-highway Gasoline, 2-Stroke /Commercial Equipt /Welders	Transportation - Gasoline
2260006030	Off-highway Gasoline, 2-Stroke /Commercial Equipt /Pressure Washers	Transportation - Gasoline
2260006035	Off-highway Gasoline, 2-Stroke /Commercial Equipt /Hydro-power Units	Transportation - Gasoline
2260007005	Off-highway Gasoline, 2-Stroke /Logging Equipt /Chain Saws : 6 HP	Transportation - Gasoline
2260007010	Off-highway Gasoline, 2-Stroke /Logging Equipt /Shredders : 6 HP	Transportation - Gasoline
2265001010	Off-highway Gasoline, 4-Stroke /Recreational Equipt /Motorcycles: Off-road	Transportation - Gasoline
2265001020	Off-highway Gasoline, 4-Stroke /Recreational Equipt /Snowmobiles	Transportation - Gasoline
2265001030	Off-highway Gasoline, 4-Stroke /Recreational Equipt /All Terrain Vehicles	Transportation - Gasoline
2265001050	Off-highway Gasoline, 4-Stroke /Recreational Equipt /Golf Carts	Transportation - Gasoline
2265001060	Off-highway Gasoline, 4-Stroke /Recreational Equipt /Specialty Vehicles/Carts	Transportation - Gasoline
2265001061	Off-highway Gasoline, 4-Stroke /Recreational Equipt /	Transportation - Gasoline
2265001062	Off-highway Gasoline, 4-Stroke /Recreational Equipt /	Transportation - Gasoline

SCC	SCC Description	Surrogate Assignment
2265002003	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Pavers	Transportation - Gasoline
2265002006	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Tampers/Rammers	Transportation - Gasoline
2265002009	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Plate Compactors	Transportation - Gasoline
2265002012	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Concrete Pavers	Transportation - Gasoline
2265002015	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Rollers	Transportation - Gasoline
2265002021	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Paving Equipt	Transportation - Gasoline
2265002022	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /	Transportation - Gasoline
2265002024	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Surfacing Equipt	Transportation - Gasoline
2265002025	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /	Transportation - Gasoline
2265002030	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Trenchers	Transportation - Gasoline
2265002033	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Bore/Drill Rigs	Transportation - Gasoline
2265002036	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Excavators	Transportation - Gasoline
2265002039	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Concrete/Industrial Saws	Transportation - Gasoline
2265002042	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Cement & Mortar Mixers	Transportation - Gasoline
2265002045	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Cranes	Transportation - Gasoline
2265002046	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /	Transportation - Gasoline
2265002054	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Crushing/Processing Equipt	Transportation - Gasoline
2265002057	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Rough Terrain Forklifts	Transportation - Gasoline
2265002060	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Rubber Tire Loaders	Transportation - Gasoline
2265002066	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Tractors/Loaders/Backhoes	Transportation - Gasoline
2265002069	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Crawler Tractor/Dozers	Transportation - Gasoline
2265002072	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Skid Steer Loaders	Transportation - Gasoline
2265002078	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Dumpers/Tenders	Transportation - Gasoline

SCC	SCC Description	Surrogate Assignment
2265002081	Off-highway Gasoline, 4-Stroke /Construction & Mining Equipt /Other Construction Equipt	Transportation - Gasoline
2265003010	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Aerial Lifts	Transportation - Gasoline
2265003011	Off-highway Gasoline, 4-Stroke /Industrial Equipt /	Transportation - Gasoline
2265003020	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Forklifts	Transportation - Gasoline
2265003021	Off-highway Gasoline, 4-Stroke /Industrial Equipt /	Transportation - Gasoline
2265003030	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Sweepers/Scrubbers	Transportation - Gasoline
2265003031	Off-highway Gasoline, 4-Stroke /Industrial Equipt /	Transportation - Gasoline
2265003040	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Other General Industrial Equipt	Transportation - Gasoline
2265003060	Off-highway Gasoline, 4-Stroke /Industrial Equipt /AC\Refrigeration	Transportation - Gasoline
2265003061	Off-highway Gasoline, 4-Stroke /Industrial Equipt /	Transportation - Gasoline
2265003070	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Terminal Tractors	Transportation - Gasoline
2265003071	Off-highway Gasoline, 4-Stroke /Industrial Equipt /	Transportation - Gasoline
2265004010	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Lawn Mowers (Residential)	Transportation - Gasoline
2265004011	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Lawn Mowers (Commercial)	Transportation - Gasoline
2265004015	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Rotary Tillers < 6 HP (Residential)	Transportation - Gasoline
2265004016	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Rotary Tillers < 6 HP (Commercial)	Transportation - Gasoline
2265004025	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Trimmers/Edgers/Brush Cutters (Residential)	Transportation - Gasoline
2265004026	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Trimmers/Edgers/Brush Cutters (Commercial)	Transportation - Gasoline
2265004031	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Leafblowers/Vacuums (Commercial)	Transportation - Gasoline
2265004035	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Snowblowers (Residential)	Transportation - Gasoline
2265004036	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Snowblowers (Commercial)	Transportation - Gasoline
2265004040	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Rear Engine Riding Mowers (Residential)	Transportation - Gasoline
2265004041	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Rear Engine Riding Mowers (Commercial)	Transportation - Gasoline

SCC	SCC Description	Surrogate Assignment
2265004046	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Front Mowers (Commercial)	Transportation - Gasoline
2265004051	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Shredders < 6 HP (Commercial)	Transportation - Gasoline
2265004055	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Lawn & Garden Tractors (Residential)	Transportation - Gasoline
2265004056	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Lawn & Garden Tractors (Commercial)	Transportation - Gasoline
2265004061	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Wood Splitters (Commercial)	Transportation - Gasoline
2265004066	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Chippers/Stump Grinders (Commercial)	Transportation - Gasoline
2265004071	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Turf Equipt (Commercial)	Transportation - Gasoline
2265004075	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Residential)	Transportation - Gasoline
2265004076	Off-highway Gasoline, 4-Stroke /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Commercial)	Transportation - Gasoline
2265005010	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /2-Wheel Tractors	Transportation - Gasoline
2265005025	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Balers	Transportation - Gasoline
2265005030	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Agricultural Mowers	Transportation - Gasoline
2265005035	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Sprayers	Transportation - Gasoline
2265005040	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Tillers : 6 HP	Transportation - Gasoline
2265005055	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Other Agricultural Equipt	Transportation - Gasoline
2265005060	Off-highway Gasoline, 4-Stroke /Agricultural Equipt /Irrigation Sets	Transportation - Gasoline
2265006005	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Generator Sets	Transportation - Gasoline
2265006010	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Pumps	Transportation - Gasoline
2265006015	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Air Compressors	Transportation - Gasoline
2265006025	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Welders	Transportation - Gasoline
2265006030	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Pressure Washers	Transportation - Gasoline
2265006035	Off-highway Gasoline, 4-Stroke /Commercial Equipt /Hydro-power Units	Transportation - Gasoline
2265007010	Off-highway Gasoline, 4-Stroke /Logging Equipt /Shredders : 6 HP	Transportation - Gasoline

SCC	SCC Description	Surrogate Assignment
2265007015	Off-highway Gasoline, 4-Stroke /Logging Equipt /Forest Equipt - Feller/Bunch/Skidder	Transportation - Gasoline
2265010010	Off-highway Gasoline, 4-Stroke /Industrial Equipt /Other Oil Field Equipt	Transportation - Gasoline
2267001060	Off-highway LPG /Recreational Equipt /Specialty Vehicles/Carts	Transportation - LPG
2267001061	Off-highway LPG /Recreational Equipt /	Transportation - LPG
2267002039	Off-highway LPG /Construction & Mining Equipt /Concrete/Industrial Saws	Transportation - LPG
2267002045	Off-highway LPG /Construction & Mining Equipt /Cranes	Transportation - LPG
2267002057	Off-highway LPG /Construction & Mining Equipt /Rough Terrain Forklifts	Transportation - LPG
2267002060	Off-highway LPG /Construction & Mining Equipt /Rubber Tire Loaders	Transportation - LPG
2267003010	Off-highway LPG /Industrial Equipt /Aerial Lifts	Transportation - LPG
2267003020	Off-highway LPG /Industrial Equipt /Forklifts	Transportation - LPG
2267003030	Off-highway LPG /Industrial Equipt /Sweepers/Scrubbers	Transportation - LPG
2267003070	Off-highway LPG /Industrial Equipt /Terminal Tractors	Transportation - LPG
2267004031	Off-highway LPG /Lawn & Garden Equipt /Leafblowers/Vacuums (Commercial)	Transportation - LPG
2267004040	Off-highway LPG /Lawn & Garden Equipt /Rear Engine Riding Mowers (Residential)	Transportation - LPG
2267006005	Off-highway LPG /Commercial Equipt /Generator Sets	Transportation - LPG
2267006025	Off-highway LPG /Commercial Equipt /Welders	Transportation - LPG
2268003030	Off-highway CNG /Industrial Equipt /Sweepers/Scrubbers	Transportation - Natural Gas
2268003070	Off-highway CNG /Industrial Equipt /Terminal Tractors	Transportation - Natural Gas
2268005060	Off-highway CNG /Agricultural Equipt /Irrigation Sets	Transportation - Natural Gas
2268006005	Off-highway CNG /Commercial Equipt /Generator Sets	Transportation - Natural Gas
2268010010	Off-highway CNG /Industrial Equipt /Other Oil Field Equipt	Transportation - Natural Gas
2270001030	Off-highway Diesel /Recreational Equipt /All Terrain Vehicles	Transportation - Diesel
2270001060	Off-highway Diesel /Recreational Equipt /Specialty Vehicles/Carts	Transportation - Diesel
2270001061	Off-highway Diesel /Recreational Equipt /	Transportation - Diesel
2270001062	Off-highway Diesel /Recreational Equipt /	Transportation - Diesel
2270002003	Off-highway Diesel /Construction & Mining Equipt /Pavers	Transportation - Diesel
2270002006	Off-highway Diesel /Construction & Mining Equipt /Tampers/Rammers	Transportation - Diesel
2270002009	Off-highway Diesel /Construction & Mining Equipt /Plate Compactors	Transportation - Diesel

SCC	SCC Description	Surrogate Assignment
2270002012	Off-highway Diesel /Construction & Mining Equipt /Concrete Pavers	Transportation - Diesel
2270002015	Off-highway Diesel /Construction & Mining Equipt /Rollers	Transportation - Diesel
2270002018	Off-highway Diesel /Construction & Mining Equipt /Scrapers	Transportation - Diesel
2270002021	Off-highway Diesel /Construction & Mining Equipt /Paving Equipt	Transportation - Diesel
2270002022	Off-highway Diesel /Construction & Mining Equipt /	Transportation - Diesel
2270002024	Off-highway Diesel /Construction & Mining Equipt /Surfacing Equipt	Transportation - Diesel
2270002027	Off-highway Diesel /Construction & Mining Equipt /Signal Boards/Light Plants	Transportation - Diesel
2270002030	Off-highway Diesel /Construction & Mining Equipt /Trenchers	Transportation - Diesel
2270002033	Off-highway Diesel /Construction & Mining Equipt /Bore/Drill Rigs	Transportation - Diesel
2270002036	Off-highway Diesel /Construction & Mining Equipt /Excavators	Transportation - Diesel
2270002039	Off-highway Diesel /Construction & Mining Equipt /Concrete/Industrial Saws	Transportation - Diesel
2270002042	Off-highway Diesel /Construction & Mining Equipt /Cement & Mortar Mixers	Transportation - Diesel
2270002045	Off-highway Diesel /Construction & Mining Equipt /Cranes	Transportation - Diesel
2270002048	Off-highway Diesel /Construction & Mining Equipt /Graders	Transportation - Diesel
2270002051	Off-highway Diesel /Construction & Mining Equipt /Off-highway Trucks	Transportation - Diesel
2270002054	Off-highway Diesel /Construction & Mining Equipt /Crushing/Processing Equipt	Transportation - Diesel
2270002057	Off-highway Diesel /Construction & Mining Equipt /Rough Terrain Forklifts	Transportation - Diesel
2270002060	Off-highway Diesel /Construction & Mining Equipt /Rubber Tire Loaders	Transportation - Diesel
2270002066	Off-highway Diesel /Construction & Mining Equipt /Tractors/Loaders/Backhoes	Transportation - Diesel
2270002069	Off-highway Diesel /Construction & Mining Equipt /Crawler Tractor/Dozers	Transportation - Diesel
2270002072	Off-highway Diesel /Construction & Mining Equipt /Skid Steer Loaders	Transportation - Diesel
2270002075	Off-highway Diesel /Construction & Mining Equipt /Off-highway Tractors	Transportation - Diesel
2270002078	Off-highway Diesel /Construction & Mining Equipt /Dumpers/Tenders	Transportation - Diesel
2270002081	Off-highway Diesel /Construction & Mining Equipt /Other Construction Equipt	Transportation - Diesel
2270003010	Off-highway Diesel /Industrial Equipt /Aerial Lifts	Transportation - Diesel
2270003020	Off-highway Diesel /Industrial Equipt /Forklifts	Transportation - Diesel

SCC	SCC Description	Surrogate Assignment
2270003030	Off-highway Diesel /Industrial Equipt /Sweepers/Scrubbers	Transportation - Diesel
2270003040	Off-highway Diesel /Industrial Equipt /Other General Industrial Equipt	Transportation - Diesel
2270003041	Off-highway Diesel /Industrial Equipt /	Transportation - Diesel
2270003042	Off-highway Diesel /Industrial Equipt /	Transportation - Diesel
2270003060	Off-highway Diesel /Industrial Equipt /AC\Refrigeration	Transportation - Diesel
2270003061	Off-highway Diesel /Industrial Equipt /	Transportation - Diesel
2270003070	Off-highway Diesel /Industrial Equipt /Terminal Tractors	Transportation - Diesel
2270004040	Off-highway Diesel /Lawn & Garden Equipt /Rear Engine Riding Mowers (Residential)	Transportation - Diesel
2270004041	Off-highway Diesel /Lawn & Garden Equipt /Rear Engine Riding Mowers (Commercial)	Transportation - Diesel
2270004046	Off-highway Diesel /Lawn & Garden Equipt /Front Mowers (Commercial)	Transportation - Diesel
2270004055	Off-highway Diesel /Lawn & Garden Equipt /Lawn & Garden Tractors (Residential)	Transportation - Diesel
2270004056	Off-highway Diesel /Lawn & Garden Equipt /Lawn & Garden Tractors (Commercial)	Transportation - Diesel
2270004061	Off-highway Diesel /Lawn & Garden Equipt /Wood Splitters (Commercial)	Transportation - Diesel
2270004066	Off-highway Diesel /Lawn & Garden Equipt /Chippers/Stump Grinders (Commercial)	Transportation - Diesel
2270004071	Off-highway Diesel /Lawn & Garden Equipt /Turf Equipt (Commercial)	Transportation - Diesel
2270004075	Off-highway Diesel /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Residential)	Transportation - Diesel
2270004076	Off-highway Diesel /Lawn & Garden Equipt /Other Lawn & Garden Equipt (Commercial)	Transportation - Diesel
2270005010	Off-highway Diesel /Agricultural Equipt /2-Wheel Tractors	Transportation - Diesel
2270005015	Off-highway Diesel /Agricultural Equipt /Agricultural Tractors	Transportation - Diesel
2270005020	Off-highway Diesel /Agricultural Equipt /Combines	Transportation - Diesel
2270005025	Off-highway Diesel /Agricultural Equipt /Balers	Transportation - Diesel
2270005035	Off-highway Diesel /Agricultural Equipt /Sprayers	Transportation - Diesel
2270005040	Off-highway Diesel /Agricultural Equipt /Tillers : 6 HP	Transportation - Diesel
2270005045	Off-highway Diesel /Agricultural Equipt /Swathers	Transportation - Diesel
2270005055	Off-highway Diesel /Agricultural Equipt /Other Agricultural Equipt	Transportation - Diesel
2270005060	Off-highway Diesel /Agricultural Equipt /Irrigation Sets	Transportation - Diesel
2270006005	Off-highway Diesel /Commercial Equipt /Generator Sets	Transportation - Diesel
2270006006	Off-highway Diesel /Commercial Equipt /	Transportation - Diesel
2270006010	Off-highway Diesel /Commercial Equipt /Pumps	Transportation - Diesel
2270006015	Off-highway Diesel /Commercial Equipt /Air Compressors	Transportation - Diesel
2270006025	Off-highway Diesel /Commercial Equipt /Welders	Transportation - Diesel
2270006030	Off-highway Diesel /Commercial Equipt /Pressure Washers	Transportation - Diesel

SCC	SCC Description	Surrogate Assignment
2270006035	Off-highway Diesel /Commercial Equipt /Hydro-power Units	Transportation - Diesel
2270007015	Off-highway Diesel /Logging Equipt /Forest Equipt - Feller/Bunch/Skidder	Transportation - Diesel
2270007020	Off-highway Diesel /Logging Equipt /Fellers/Bunchers	Transportation - Diesel
2270008005	Airport Ground Support Equipment, Diesel	Transportation - Diesel
2270009010	Off-highway Diesel /Underground Mining Equipt /Other Underground Mining Equipt	Transportation - Diesel
2270010010	Off-highway Diesel /Industrial Equipt /Other Oil Field Equipt	Transportation - Diesel
2275001000	Aircraft /Military Aircraft /Total	Transportation - Aviation Fuel
2275020000	Aircraft /Commercial Aircraft /Total: All Types	Transportation - Aviation Fuel
2275050000	Aircraft /General Aviation /Total	Transportation - Aviation Fuel
2275060000	Aircraft /Air Taxi /Total	Transportation - Aviation Fuel
2280002010	Marine Vessels, Commercial /Diesel /Ocean-going Vessels	Transportation - Diesel
2280002020	Marine Vessels, Commercial /Diesel /Harbor Vessels	Transportation - Diesel
2280002030	Marine Vessels, Commercial /Diesel /Fishing Vessels	Transportation - Diesel
2280002100	Marine Vessels, Commercial /Diesel /Port emissions	Transportation - Diesel
2280003010	Marine Vessels, Commercial /Residual /Ocean-going Vessels	Transportation - Diesel
2280003030	Marine Vessels, Commercial /Residual /Fishing Vessels	Transportation - Diesel
2282005010	Pleasure Craft /Gasoline 2-Stroke /Outboard	Transportation - Gasoline
2282005015	Pleasure Craft /Gasoline 2-Stroke /Personal Water Craft	Transportation - Gasoline
2282010005	Pleasure Craft /Gasoline 4-Stroke /Inboard/Sterndrive	Transportation - Gasoline
2282020005	Pleasure Craft /Diesel /Inboard/Sterndrive	Transportation - Diesel
2282020010	Pleasure Craft /Diesel /Outboard	Transportation - Diesel
2282020020	Pleasure Craft /Diesel /Sailboat Auxiliary Inboard	Transportation - Diesel
2285002005	Railroad Equipt /Diesel /Line Haul Locomotives (use subdivisions by class/operation)	Transportation - Diesel
2285002008	Railroad Equipment /Diesel /Line Haul Locomotives: Passenger Trains (Amtrak)	Transportation - Diesel
2285002010	Railroad Equipment /Diesel /Yard Locomotives	Transportation - Diesel
2285002015	Railroad Equipt /Diesel /Railway Maintenance	Transportation - Diesel
2285003015	Railroad Equipt /Gasoline, 2-Stroke /Railway Maintenance	Transportation - Gasoline
2285004015	Railroad Equipt /Gasoline, 4-Stroke /Railway Maintenance	Transportation - Gasoline

Appendix N
Canada Nonroad Mobile Source Projection Factors

Canada Nonroad Mobile Source Projection Factors

Province Code	Province Name	Surrogate Assignment	2011 Projection Factor	2017 Projection Factor
59000	British Columbia	Transportation - Aviation Fuel	1.1011	1.2055
48000	Alberta	Transportation - Aviation Fuel	1.0692	1.2161
47000	Saskatchewan	Transportation - Aviation Fuel	0.8056	0.8611
46000	Manitoba	Transportation - Aviation Fuel	0.9783	1.0435
24000	Quebec	Transportation - Aviation Fuel	1.0899	1.1561
35000	Ontario	Transportation - Aviation Fuel	1.0861	1.1887
13000	New Brunswick	Transportation - Aviation Fuel	0.9545	1.0000
59000	British Columbia	Transportation - Diesel	0.9592	1.0784
48000	Alberta	Transportation - Diesel	1.0170	1.3645
47000	Saskatchewan	Transportation - Diesel	1.0019	1.0357
46000	Manitoba	Transportation - Diesel	1.0370	1.1481
24000	Quebec	Transportation - Diesel	1.1053	1.1673
35000	Ontario	Transportation - Diesel	0.9978	1.0666
13000	New Brunswick	Transportation - Diesel	1.3308	1.3500
59000	British Columbia	Transportation - Gasoline	1.0304	0.9193
48000	Alberta	Transportation - Gasoline	1.0862	1.1729
47000	Saskatchewan	Transportation - Gasoline	1.0440	0.9327
46000	Manitoba	Transportation - Gasoline	0.9851	0.8763
24000	Quebec	Transportation - Gasoline	1.0112	0.8955
35000	Ontario	Transportation - Gasoline	0.9841	0.9381
13000	New Brunswick	Transportation - Gasoline	1.1926	1.0567
59000	British Columbia	Transportation - LPG	0.9375	0.9063
48000	Alberta	Transportation - LPG	1.0000	0.4615
47000	Saskatchewan	Transportation - LPG	0.5000	0.5000
46000	Manitoba	Transportation - LPG	1.0000	0.5000
24000	Quebec	Transportation - LPG	1.0000	0.8000
35000	Ontario	Transportation - LPG	1.1930	1.0175
13000	New Brunswick	Transportation - LPG	1.0000	1.0000
59000	British Columbia	Transportation - Natural Gas	2.0000	15.0000
48000	Alberta	Transportation - Natural Gas	3.0000	36.0000
47000	Saskatchewan	Transportation - Natural Gas	1.0000	1.0000
46000	Manitoba	Transportation - Natural Gas	1.0000	1.0000
24000	Quebec	Transportation - Natural Gas	1.0000	1.0000
35000	Ontario	Transportation - Natural Gas	0.5000	1.8571
13000	New Brunswick	Transportation - Natural Gas	1.0000	1.0000

Appendix O
Development of On-Road Emission Inventories for Mexico and Canada Portions of MAG Air Quality Modeling Domain

1.0 General MOVES Model Approach

The first step in applying MOVES to Mexico and Canada was to determine the appropriate MOVES run strategy. There are multiple ways to customize MOVES to local conditions. For U.S. use, MOVES provides a default database which enables estimation of on-road emissions to significant detail (i.e., by vehicle class, fuel type, road type and model year) for all 3,222 counties in the U.S., for all calendar years including 1990 and 1999 through 2050. To accomplish this requires a massive underlying database with model inputs for vehicle activity, population, meteorology, fuel properties, road characteristics, projection factors and emission rates. Default results are generated when the National Scale is selected in MOVES, and rely heavily on a "top down" allocation approach, where national totals of vehicle population and activity are allocated to individual U.S. counties based on available county-level surrogates. As an alternative to the default National Scale approach, MOVES also provides the County Scale feature to allow users to improve estimates in a "bottom-up" fashion, allowing customization of many of these elements through data importers. When County Scale is selected, MOVES supplies a template for users to provide data directly at the county level (the County Data Manager). This feature is relied on for development of the U.S. National Emissions Inventory and modeling uses required in the U.S. Clean Air Act, such as State Implementation Plan (SIP) inventories and transportation conformity analyses.

Customizing MOVES to Mexico and Canada could therefore be done following either the National or County Scale approaches. The main consideration was the level of detailed data available for adapting to either country. The MOVES County Scale requires information such as vehicle population, vehicle miles travelled, etc. to be provided at the level of geographic detail being modeled. This approach was developed focused on local inventories, where detailed data is more likely to be available. U.S. EPA does, in fact, use County Scale for the U.S. NEI, but even for this application local data are not available for many U.S. counties, requiring use of national defaults for around half of the counties in the U.S.[1]

An assessment of potential data sources in Mexico and Canada found that detailed information necessary to calculate emission inventories at the County Scale, as done for the U.S., are not available. Several data sources were identified at more aggregate levels of detail, however. ERG decided that developing a national default database for both countries would therefore be preferable, because: a) National Scale is more amenable to the available data in

[1]U.S. EPA 2011 National Emissions Inventory http://www.epa.gov/ttnchie1/net/2011inventory.html

Mexico and Canada; and b) once developed, a national default database provides means to estimate emissions in each Mexican municipality (or state) and Canadian province, for multiple years.

In general, to develop a national default database for Mexico and Canada required:

- domain-wide totals of vehicle fleet and activity inputs such as populations, kilometers travelled, age distribution and speeds;
- factors to allocate vehicle population and activity to the Mexican municipality and Canadian province levels;
- localized data on meteorology, fuels and vehicle inspection/maintenance; and
- for Mexico, updated emission rate database to reflect significant differences between U.S. and Mexican vehicle standards.

Sections 2.0 and 3.0 discuss how ERG developed each input for Mexico and Canada, respectively.

2.0 Development of Inventories for Mexico

ERG worked with consultant Verónica Garibay-Bravo to obtain data for developing Mexico-specific inputs. Ms. Garibay-Bravo worked closely with representatives from INECC to obtain underlying data used in Mexico's most recent National Emissions Inventory, and provide to ERG for use in MOVES. The specific data and sources are discussed in Section 2.1. Section 2.2 then discusses the specific MOVES tables updated to reflect the Mexico data, and any analysis required of the source data to prepare it for MOVES. In some cases, sufficient data for Mexico were not available, so U.S. defaults were used. Note, vehicle miles traveled (VMT) and vehicle kilometers traveled (VKT) are used interchangeably in this section, though MOVES requires VMT as input.

2.1 Data Sources

On-road motor vehicle activity data sources in Mexico are scarce compared to the U.S. Although several data sources are available pertaining to vehicle emissions, vehicle population and VKT, they are frequently inconsistent or based on outdated information. Also, most fuel quality and sales data are not publicly available. Recently, however, several studies have been carried out mostly by the National Institute of Ecology and Climate Change (INECC), the

National Institute of Geography and Statistics (INEGI), the National Population Council and the state-owned fuels company (PEMEX) to overcome these limitations. Although most of the information generated in these studies has not yet been published, we were able to access internal reports and spreadsheets through direct communication with INECC staff, who shared the databases used in their most recent mobile source emission estimates for 2013. Hence, unless otherwise noted, the following information was provided directly by INECC.[2]

2.1.1 Vehicle Population and Age Distribution

In Mexico, vehicle registration is carried out by state authorities, requiring different formats and level of detail, tailored to their particular needs. Usually, local authorities add new vehicles to the registry every year but rarely remove vehicles that are no longer in use. According to Mexican emission inventory experts, this has historically led to an overestimation of the vehicle fleet in emissions inventories. To avoid this, we used INECC estimates of vehicle population and age distribution instead of vehicle registration. These are considered more realistic since INECC derived retirement rates from several field studies carried out between 2007 and 2012 by INECC and the Mexican Petroleum Institute (IMP). INECC applied these retirement rates to historical state-level vehicle sales provided by the automotive industry, resulting in adjusted vehicle population at the state level. Imported used vehicle registries from the Mexican Treasury and Customs Authority (*Secretaría de Hacienda y Crédito Público* - SHCP) were also used to add these vehicles and obtain total population by age and vehicle type. These estimates were used for a recent 2013 emissions estimate developed by INECC.

2.1.2 Vehicle Kilometers Traveled (VKT)

Inventories in Mexico had traditionally used one average VKT number for the whole country based on a limited number of surveys performed in Mexico City, or on a travel demand modeling (TDM) exercise carried out for seven representative cities for the 1999 Mexico NEI. For the MAG inventory, we used data from surveys conducted by INECC between 2007 and 2011 in 20 cities, from which average national-level VKT by vehicle age and vehicle type (light, medium and heavy duty) were derived. These estimates were also used in the most recent 2013 emissions estimates.

[2]Personal Communications with José Andrés Aguilar-Gómez, Deputy Director for Emission Inventories and Air Quality Modeling, INECC (andres.aguilar@inecc.gob.mx).

2.1.3 Road Network

Road type distribution was taken from the National Institute of Geography and Statistics (INEGI) website.[3] GIS-based downloadable files include detailed, city-level data of the road network to 2011. We used these files and a technical report to harmonize INEGI's road types to those used in MOVES.[4] Significant analysis and processing these data were done to produce road type distributions by municipality, as described in Section 2.2.

2.1.4 Fuels

In Mexico, fuels are distributed and sold by a single, state-owned company (PEMEX). Gasoline and diesel sales are publicly available from PEMEX website but only at the state level. However, through INECC, we obtained fuel sales at the municipality level provided by PEMEX, for 2013. Since fuel quality certificates are not publicly available, we used the specifications in the current fuel quality standard as a reference. Actual sulfur concentrations in fuels, however, differ from the standard. We relied on expert opinion from INECC as to which municipalities have access to low-sulfur fuels.

2.1.5 Inspection/Maintenance Programs

Inspection/maintenance (I/M) programs in Mexico are managed by state or even local environmental authorities; however, these are enforced only in a limited number of cities. For example, the I/M program in Mexico City has tighter controls and more stringent conditions than those in other cities, but some cities adjacent to the Mexico City Metropolitan Area have adopted these conditions to avoid transit restrictions. The Federal environmental authority (SEMARNAT) compiles compliance data from all states in Mexico periodically. We used the latest internal status report (2012) provided by INECC, with information gathered by SEMARNAT, focused on this work for I/M areas within the MAG domain.

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[3]Conjunto de Datos Vectoriales de Carreteras y Vialidades Urbanas Edición 1.0 (Distribución por Entidad Federativa). Sistema de consulta. INEGI. http://www.inegi.org.mx/geo/contenidos/topografia/vectoriales_carreteras.aspx, accessed June 12, 2015.

[4]Diccionaro de datos de localidades urbanas. pdf, INEGI. http://www.inegi.org.mx/geo/contenidos/urbana/doc/diccionario_datos_localidades_urbanas_ver_definitiva_septiembre07.pdf, accessed May 26, 2015.

2.1.6 Mexico Emission Standards

INECC provided information on Mexico vehicle standards relative to U.S. standards for light vehicles and heavy-duty trucks, summarized in Table 1. Overall, Mexican vehicle emission standards are outdated compared to U.S. standards. For light duty vehicles, current Mexican specifications (known as NOM42) were partially adapted from a combination of Tier 1 and Tier 2 Bins 5 through 9 EPA limit values, with a 50,000 mile durability. European Euro 4 certificates are also accepted. Emissions from medium duty vehicles are not currently regulated in Mexico. Heavy-duty gas and diesel vehicles are regulated based on NOM 76 and NOM 44, respectively; a primary difference being that Mexico has yet to implement the low NO_x and PM diesel standards implanted in the U.S. beginning in 2007.

According to the International Council on Clean Transportation (ICCT), based on analysis of 2012 model year data, a significant proportion of new cars and light trucks in Mexico comply with more stringent US emission standards.[5] This suggests that light-duty vehicle emissions may be lower than required (i.e., overcompliance). However, data on potential overcompliance were not available for enough years to account for this effect over time. As discussed in Section 2.3., for this work we used the "on-the-book" NOM regulations in Mexico to develop Mexico-specific emission rates, without accounting for overcompliance. This is considered a conservative first step in developing Mexico-specific emission rates.

[5]ICCT & INECC, "Market Analysis of New Light-Duty Vehicles Sales in Mexico and Comparison to U.S. Market" Presentation April 2015

Table 1. Mexico Vehicle Standard Information Provided by INECC

<table>
<tr><th>Cars & Light Trucks (NOM 42)</th><th>Heavy Duty Trucks & Buses (NOM 44 & 76)</th></tr>
<tr>
<td>
MY 1990 and older: No aftertreatment, no fuel injection to carburetor.
MY 1991-1992: 2- and 3-way catalytic converters
MY 1993-2005: U.S. Tier 0 Emission limits at 0 km (no durability requirements).
MY 1999-2005: U.S. Tier 0 Emission limits at 0 km, no OBD required.
MY 2007-2009: Emission limits at 80,000 km and OBD requirements. Phase-in – 2007, 25%; 2008, 50%; 2009, 75%.
MY 2007-2009: U.S. Tier1 emission limits for PM; U.S. Tier 2 Bin 10 limits for NO_x (Euro 3 accepted). Phase-in – 2007, 25%; 2008, 50%; 2009, 75%; 2010, 75%; 2011, 50%; 2012, 30%.
MY 2010 onwards. U.S. Tier 1 emission limits for PM and U.S. Tier 2 Bin 7 limits for NO_x. Euro 4 also accepted. Phase-in –2010, 25%; 2011, 50%; 2012, 70%; 2013, 100%.

Although the regulation does not consider full Tier 2 standards (mainly due to fuel quality), it is reasonable to suppose there Tier 2 vehicles are currently being sold in Mexico, due to the high integration between Mexican manufacturers in the U.S. market.
</td>
<td>
<u>Diesel (NOM 44)</u>
MY 1993 and older: No control
MY 1994-1997: same as U.S.
MY 1998-2008: U.S. 1998 (or similar Euro)
MY 2009 onwards: U.S. 2004 (or similar Euro)

Timeline of Mexico and EPA/Euro standards
<table>
<tr><th></th><th>Standard</th><th>Year</th><th>Required in Mexico</th></tr>
<tr><td rowspan="6">U.S.</td><td>EPA 1991</td><td>1991</td><td>1993</td></tr>
<tr><td>EPA 1994</td><td>1994</td><td>1994</td></tr>
<tr><td>EPA 1998</td><td>1998</td><td>1998</td></tr>
<tr><td>EPA 2004</td><td>2002</td><td>2008</td></tr>
<tr><td>EPA 2007</td><td>2007</td><td>Not considered in Mexican regulations</td></tr>
<tr><td>EPA 2010</td><td>2010</td><td>Proposed phase-in starting 2018.</td></tr>
<tr><td rowspan="6">Europe</td><td>EURO I</td><td>1992</td><td>Not sold in Mexico</td></tr>
<tr><td>EURO II</td><td>1996</td><td>Not sold in Mexico</td></tr>
<tr><td>EURO III</td><td>2000</td><td>2006</td></tr>
<tr><td>EURO IV</td><td>2005</td><td>2008</td></tr>
<tr><td>EURO V</td><td></td><td>Not considered in current Mexican regulations</td></tr>
<tr><td>EURO VI</td><td>2013</td><td>Proposed phase-in starting 2018.</td></tr>
</table>

<u>Gas (NOM 76)</u>
MY 1997 and older: No Control
MY 1998 onwards: NOM 076 “A” (Comparable to U.S. Tier 1 HD Gas Standards)

Emissions from medium duty vehicles are not currently regulated in Mexico. However, since manufacturers have to comply with U.S. and European regulations for these vehicles, it is reasonable to assume that they comply in a similar way as the light duty vehicles.
</td>
</tr>
</table>

2.1.7 Human Population

Current population was taken from 2010 census counts at the municipality level performed by INEGI and available on their website, projected population data were downloaded from the National Population Council (CONAPO) website.[6,7]

2.1.8 Meteorology

Temperature data for 2011 were used for both the 2011 and 2017 runs. State-average maximum and minimum temperatures by year and month are published by the Comisión Nacional Del Agua (CONAGUA) Servicio Meteorológico Nacional (SMN).[8] Hourly temperatures and/or humidity data were not available at this level of coverage; temperature and humidity information is available for individual weather stations across Mexico, but due to concern with coverage and the level of effort necessary to convert these to municipality-specific meteorology, these were not pursued. Instead, as discussed in Section 2.2, an approach developed by EPA to convert min/max temperatures to hourly diurnal profiles was used to generate hour temperatures by state, that were then applied to each municipality in a state. Monthly diurnal profiles of relative humidity were assigned to Mexico using MOVES data from the U.S. border states.

2.2 Updates to MOVES Database Tables

The data sources outlined in Section 2.1 were processed, in some cases with additional analysis, into the format needed by MOVES. The MOVES database is a relational database with dozens of underlying, linked tables providing the model with information on the geography, vehicle fleet, activity, fuels, meteorology and emissions required to produce emission inventories specified in the run specification file, along with necessary information files. Only a subset of 22 tables were updated for Mexico, based on a) Mexico fleet, activity, meteorology and fuel data discussed in Section 2.1; b) informational tables needed to update U.S. counties

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[6]Población total con estimación en 2010 según tamaño localidad 2 tam - total. Sistema de consulta. Sistema Estatal y Municipal de Base de Datos. http://sc.inegi.org.mx/cobdem/resultados.jsp?w=24&Backidhecho=199&Backconstem=198&constembd=199&tm=’Backidhecho:3,Backconstem:3,constembd:3’, accessed May 26, 2015.

[7]Estimaciones y proyecciones de la población por entidad federativa. Archivo. Datos de proyecciones. http://www.conapo.gob.mx/es/CONAPO/Proyecciones_Datos, accessed May 26, 2015.

[8]CONAGUA http://smn.cna.gob.mx/index.php?option=com_content&view=article&id=12&Itemid=77

and states to Mexico municipalities and states; and c) the need to adapt MOVES emission rates to Mexico emission standards. Table 2 provides a list of MOVES tables updated for Mexico. All other MOVES tables were left as in the U.S. default database.

Table 2. MOVES Database Tables Updated for MAG Mexico Runs

MOVES-Mexico Database Table Name	Purpose/Description
County	List of municipalities in Mexico.
State	List of states in Mexico.
CountyYear	Stage II refueling program efficiency.
FuelUsageFraction	E85 usage for flex fuel vehicles.
IMCoverage	Inspection and maintenance program description and coverage.
Link	Enables county-specific emissions output in an inventory run.
RegionCounty	Assignment of each county to a fuel region.
Zone	Allocation of the off-network activity from nationwide to municipality.
ZoneMonthHour	Diurnal temperature and relative humidity profiles for each month of year.
ZoneRoadType	Allocation of the on-network activity from nationwide to municipality. On-network activity includes source hours operating, which is how VMT gets allocated to each municipality.
HPMSVTypeYear	Nationwide VMT, annual total, by HPMS vehicle classification.
SourceTypeYear	Nationwide vehicle population by source use type classification.
SourceTypeAgeDistribution	Average fleet age distributions, MAG-domain average. Also two external table versions (1) border and (2) non-border.
AVFT	Gasoline/diesel relative fractions, for each source use type and vehicle model year.
RoadTypeDistribution	Distribution of VMT to road types.
FuelSupply	Assigns specific fuels to each fuel region, by month and calendar year.
FuelFormulation	Parameters for every fuel (e.g., sulfur level and vapor pressure).
MonthVMTFraction	Allocates annual VMT to the twelve months of year.
EmissionRateByAge	Base emission rates by age, model year group, regulatory class, fuel type, pollutant, emission process, and operating mode
CumTVVCoeffs	Coefficients used by MOVES to calculate tank vapor venting

The following sections include a description of how each of these tables were updated.

2.2.1 County

The County table was updated to list all municipalities in Mexico by 4- or 5-digit county code. Although the emission inventories for MAG are limited to municipalities fully or partially in the modeling domain, the database was populated with all municipalities so that the top-down allocation approach used by MOVES national scale worked correctly. The table also

contains a binary altitude description of low or high (L or H), barometric pressure, and geographic phase-in area fractions (GPA does not apply in Mexico). Altitude was set to low (L) everywhere in Mexico, barometric pressure was set to the mean value of the low altitude counties in U.S.

2.2.2 State

The State table was updated to include all states in Mexico, by 1- or 2-digit integer code. The MAG inventories are limited to states covered in the modeling domain, listed in Table 3 below.

Table 3. Mexico States in MAG Domain

stateID	stateName	stateAbbr
1	Aguascalientes	AG
2	Baja California	BC
3	Baja California Sur	BS
4	Campeche	CM
5	Coahuila	CO
8	Chihuahua	CH
10	Durango	DG
14	Jalisco	JA
18	Nayarit	NA
19	Nuevo León	NL
23	Quintana Roo	QR
24	San Luis Potosí	SL
25	Sinaloa	SI
26	Sonora	SO
28	Tamaulipas	TM
30	Veracruz	VE
31	Yucatán	YU
32	Zacatecas	ZA

2.2.3 CountyYear

The CountyYear table contains fractions representing the efficiency of Stage II refueling control programs for each county and year. Stage II refueling emissions are hydrocarbon emissions during gasoline refueling at service stations from either the pump dispenser itself (spillage losses) or the vehicle tank (vapor displacement losses). Control programs reduce these hydrocarbon emissions. However, refueling in the MAG inventories came from area source

emission inventory, and did not come out of MOVES. This table was a structural update only to include all Mexican municipality codes that exist in Mexico.

2.2.4 FuelUsageFraction

The FuelUsageFraction table allows the user to specify relative fractions of gasoline versus E85 use in flex-fuel vehicles by county and calendar year. All E85 was turned off for Mexico. This table also was also updated to include all Mexican municipality codes.

2.2.5 IMCoverage

The IMCoverage table defines specifics of vehicle inspection/maintenance (I/M) programs by municipality. I/M progams in Mexico are mostly idle tests, although some dynamometer testing is done in the state of Baja California. To reflect idle testing, we selected the Two-Speed Idle (TSI) test to represent the IM tests labeled as “static” and the Accelerated Simulation Mode (ASM) to represent those labeled as “dynamometer” in the raw data. The remainder of fields were populated using the local I/M program data discussed in Section 2.1.

Additional analysis was performed to calculate compliance factors for Mexico’s I/M programs. The compliance factor determines the portion of the passenger cars and light truck fleet that actually receive the emissions benefit of a particular I/M test. The compliance factors were calculated as the ratio of the number of vehicles tested to the total light-duty gasoline population. For areas that had I/M, the average compliance was 45%. The minimum compliance factor was only 3% (in Mérida, Yucatán) because only official vehicles are subject to I/M in that city.

There was no Mexico data available on grace period or other exempted model years, so we adopted those particular parameters from the U.S. database.

2.2.6 Link

The Link table is informational to define county and roadtype pairs, and was only updated for the purpose of this work to include all the Mexican municipality codes.

2.2.7 RegionCounty

The RegionCounty table assigns each municipality to a fuel region. Source data on fuel formulations discussed in Section 3.1 specified differences in sulfur, RVP, and oxygenate use by municipality, depending on whether it was located (1) inside or outside a metropolitan area, (2) in a border or non-border state, and (3) RVP regions. This unique combination of metropolitan area, border state, and RVP region resulted in six fuel regions in Mexico, shown in Table 4:

Table 4. Fuel Regions Defined for Mexico

Fuel Region	Metropolitan Area	Border State	Volatility Group
1	No	No	2
2	Yes	Yes	2
3	No	Yes	1
4	No	No	3
5	No	No	1
6	Yes	Yes	1

Diesel sulfur content is 15 ppm in border states and metropolitan areas and is 500 ppm elsewhere. Gasoline sulfur content is 30 ppm in metropolitan areas; and a mix of 30 ppm and 300 ppm sulfur fuel elsewhere. However, due to complication attempting to adjust sulfur effects in MOVES, we ended up running the entire domain at 30ppm sulfur. This was considered a better alternative than applying very high U.S.-specific gasoline sulfur correction factors for advanced technology vehicles to the majority of older technology gasoline vehicles in Mexico that did not merit the adjustment.

Volatility group refers to Reid Vapor Pressure (RVP) of gasoline. RVP requirements vary by month and region in Mexico. From Table 4 above:

- Volatility Group 1 has the least stringent RVP restriction
    - 69 kPa (10 psi) March to October
    - 79 kPa (11.5 psi) January-February and November-December
    - Covers the Monterrey metropolitan area and the states of Nuevo León, Chihuahua, Durango, Coahuila, Tamaulipas, San Luis Potosí
- Volatility Group 2 – moderately stringent RVP restriction
    - 62 kPa (9 psi) June-August
    - 69 kPa (10 psi) Mar-May and Sep-Oct
    - 79 kPa (11.5 psi) Jan-Feb and Nov-Dec

        - Covers the states Aguascalientes, Jalisco, Guanajuato, Michoacán, Zacatecas, Morelos, Tlaxcala, México, Distrito Federal, Hidalgo, Querétaro, Veracruz, Campeche, Puebla, Tabasco, Yucatán, Quintana Roo, Baja California, Baja California Sur, Sonora, Sinaloa, Nayarit, Colima, Guerrero, Oaxaca, and Chiapas.
    - Volatility Group 3 – most stringent RVP restriction
        - 54 kPa (7.8 psi) year-round
        - Mexico City and Guadalajara metropolitan areas

2.2.8 Zone

The Zone table allocates off-network activity (related to the emission processes of start, evaporative and extended idle emissions) from nation to Mexico municipality. The activity allocated for off-network activity includes number of vehicle starts, source hours parked (SHP), and source hours idling (SHI). However, we did not include extended idling emissions in MAG inventories because this activity was deemed significantly smaller in Mexico than in the U.S.

The starts allocation was created using surrogates using surrogates, as follows:

1. National to State based on relative state-level vehicle population data
2. State to County based on relative county-level human population within each state

The SHP allocations were created by calculating SHP at the state level outside of MOVES to force the resulting MOVES-allocated vehicle population to match state totals in the source data discussed in Section 2.1. The equation for this calculation was Target_Population – SHO = SHP. The SHP was then normalized at the state level to create fractions that summed to one (1) over state, which were then subsequently further subdivided into municipalities using relative human population by municipality within each state. Start and Park allocations are shown below in Table 6, along with running allocations discussion in the ZoneRoadType table.

2.2.9 ZoneMonthHour

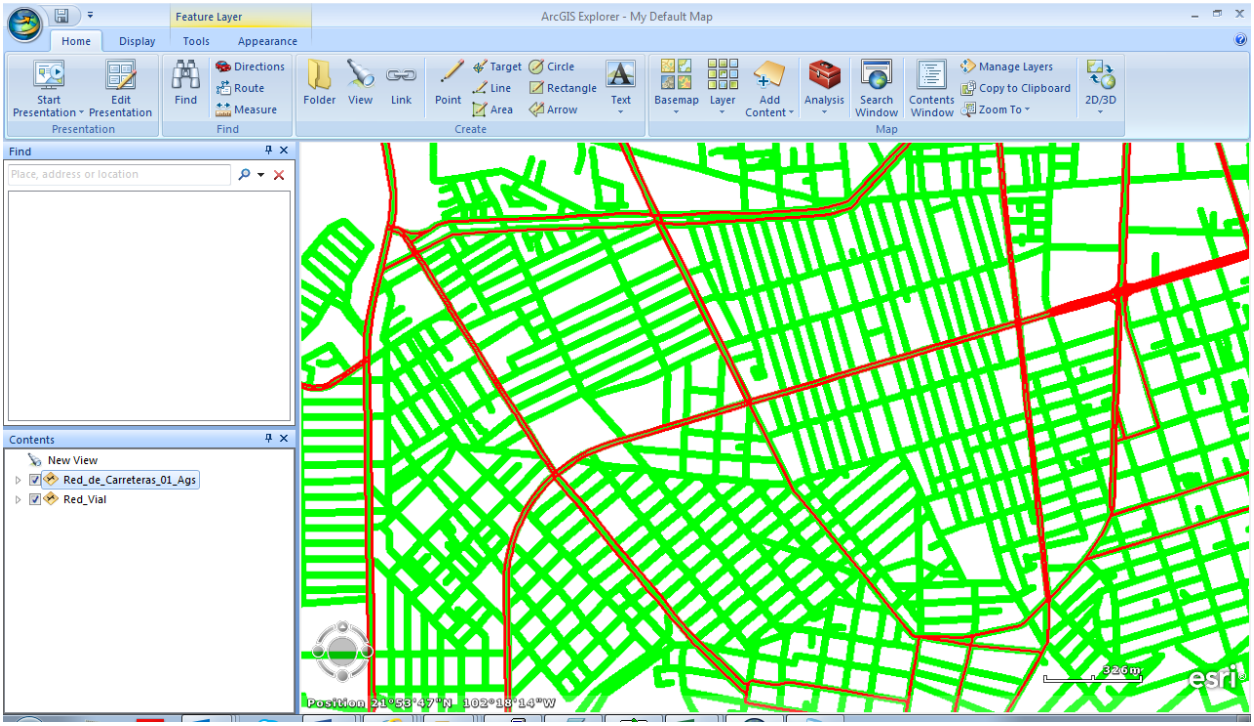
The ZoneMonthHour tables contains temperature and humidity data for each municipality, by month and hour of the the day. For the MAG runs, state-level averages where applied to each municipality in the state. 2011 min/max temperatures for each state and month

from CONAGUA were run through the EPA's temperature profile generator [cite] to estimate hourly temperatures. Since no average humidity data were available for Mexico, 30-year average data contained in the U.S. MOVES default database (calculated an average RH hourly profile over the four U.S. border states of Arizona, New Mexico, Texas, and California) were applied to all of Mexico.

2.2.10 ZoneRoadType

The ZoneRoadType table contains allocations that distribute national total VMT to municipalities, separately by road type. The allocation from nation to state reflect relative VKT at the state level based on 2013 state-level vehicle populations and VKT data discussed in Section 2.1. However, there was no VKT information available at the municipality or state levels, so we used a surrogate of roadway distance from a GIS dataset where the roadway network included distinction by roadway type. The primary data used were state-level GIS shapefiles of lane-meters of roadway by a Mexico road type classification from INEGI, discussed in Section 2.2. The detail of Mexico road type allowed us to determine the mix of Unrestricted Access vs. Restricted. A sample view of GIS shapefile of the roadway network in state of Aguascalientes is shown in Figure 1 below:

Figure 1. Sample Road Network GIS Shapefile from INEGI



Using the GIS roadway data we performed a GIS intersection analysis to determine which links were located in each municipality and totaled their lane-meters (total roadway capacity) accordingly. Road types from the GIS dataset were mapped to either "Restricted Access" or "Unrestricted Access" MOVES definitions, as shown in Table 5, based on road definitions from INEGI.[9,10]

Table 5. Road Type Mapping

GIS Roadtype	MOVES
ANDADOR (PEDESTRIAN)	---
AVENIDA	UNRESTRICTED
BOULEVARD	RESTRICTED
CALZADA	UNRESTRICTED
CALLE	UNRESTRICTED
AMPLIACION	UNRESTRICTED
CALLEJON*	UNRESTRICTED
CERRADA*	UNRESTRICTED
CIRCUITO	RESTRICTED
CIRCUNVALACION	UNRESTRICTED
CONTINUACION	UNRESTRICTED
CORREDOR	UNRESTRICTED
DIAGONAL	UNRESTRICTED
EJE VIAL	UNRESTRICTED
PASAJE (PEDESTRIAN)	---
PEATONAL (PEDESTRIAN)	---
PERIFERICO	RESTRICTED
PRIVADA*	UNRESTRICTED
PROLONGACION	UNRESTRICTED
RETORNO	UNRESTRICTED
VIADUCTO	RESTRICTED
CARRETERA	RESTRICTED

*PRIVADA, CALLEJÓN, CERRADA: These are very narrow roads or backstreets, with fewer, very slow traffic. Mostly destined for limited access to houses.

The INEGI road network did not provide any information on rural vs. urban split. We therefore conducted an analysis to develop a relationship between urban/rural split and

[9]INEGI, 2007. Diccionario de datos de localidades urbanas. Available at: http://www.inegi.org.mx/geo/contenidos/urbana/default.aspx?_file=/geo/contenidos/urbana/doc/diccionario_datos_localidades_urbanas_ver_definitiva_septiembre07.pdf. Downloaded: 06/12/2015

[10]INEGI, 2011. Documento técnico descriptivo – Conjunto de datos vectoriales de carreteras y vialidades. Edición 1.0. Available at: http://www.inegi.org.mx/geo/contenidos/topografia/default.aspx . Downloaded: 06/12/2015

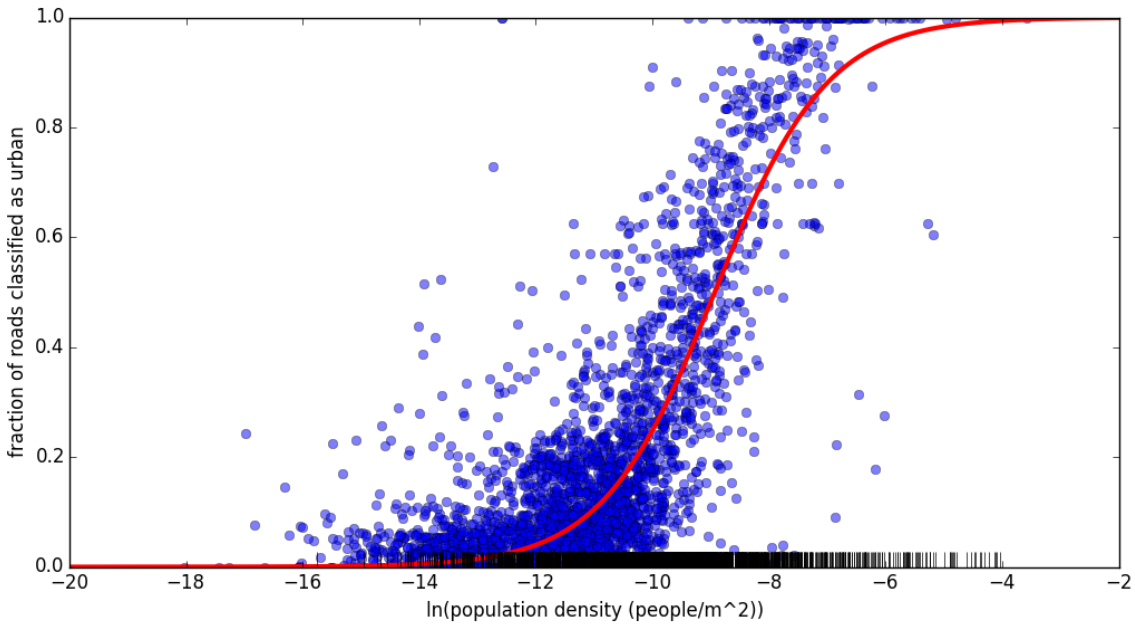
population density, based on MOVES default road distribution by county and U.S. county population density data from the U.S. Census. For this analysis, we obtained U.S. county population and land area data from the U.S. Census Bureau, respectively.[11] We determined the fraction of roads that are urban using data from the default MOVES 2014 database. We obtained population densities and fractions of unrestricted and restricted lane miles for the municipalities.[12]

Generation of the primary categories in the *roadTypeDistribution* table (i.e., fractions of urban restricted, urban unrestricted, rural restricted, and rural unrestricted road types) required an estimate of both the fraction of roads classified as urban and the number of restricted and unrestricted lane miles. Direct information on urban fraction in the Mexican municipalities was unavailable, so we used data from U.S. counties to derive a relationship between population density and urban fraction. Population and land area data were obtained from the U.S. Census Bureau, as described in Data Sources above; from these, population density can be calculated. The urban fractions for U.S. counties were calculated using the *zoneRoadType* and *roadTypeDistribution* tables from MOVES 2014. The relationship between urban fraction and population density was satisfactorily captured by a logistic function (Figure 2). Using this best-fit line, we estimated urban fractions for the municipalities based on their population densities. To determine the fraction of restricted and unrestricted lane miles, we extracted total urban and restricted lane miles from the INEGI GIS dat. Using the product of the urban (rural) fraction and the unrestricted (restricted) lane miles, normalized by total lane miles, we then calculated the *roadTypeVMTFraction* for each road type and applied this to all *sourceTypeIDs*.

[11]U.S. Census Bureau http://www.census.gov/popest/data/counties/totals/2014/CO-EST2014-01.html and http://www.census.gov/geo/maps-data/data/gazetteer2014.html

[12] CENSO NACIONAL DE POBLACIÓN Y VIVIENDA, 2010.INEGI: Sistema Estatal y Municipal de Datos (SIMBAD). http://sc.inegi.org.mx/cobdem/ Downloaded: 5/26/2015 POPULATION FROM NATIONAL CENSUS, by municipality 2010

Figure 2. U.S. Population Density vs. Urban Fraction



After assigning urban road fractions to each municipality, the lane-meters by municipality from the GIS analysis were multiplied by urban fractions and (rural fractions, as 1 – urban) to result in the surrogate of total roadway distance by the four MOVES road types for each municipality. The total roadway distances were normalized by MOVES road type, to fit the format of the ZoneRoadType table. The state level VKT determined part of the allocations from national to state, but the GIS and population density analysis drive the allocation from state to municipality. Shown in Table 6 are the aggregated state-level allocations for roadways (SHO), along with allocations for starts and park discussed in 2.2.8.

Table 6. Allocation Factors by Mexican State

State	Running (SHO)	Start	Park (SHP)
Aguascalientes	0.013	0.013	0.012
Baja California	0.047	0.047	0.042
Baja California Sur	0.012	0.012	0.011
Campeche	0.007	0.007	0.005
Coahuila	0.027	0.027	0.026
Colima	0.008	0.008	0.007
Chiapas	0.016	0.016	0.013
Chihuahua	0.048	0.048	0.045
Distrito Federal	0.133	0.133	0.132

State	Running (SHO)	Start	Park (SHP)
Durango	0.015	0.015	0.014
Guanajuato	0.041	0.041	0.043
Guerrero	0.021	0.021	0.022
Hidalgo	0.024	0.024	0.025
Jalisco	0.088	0.088	0.092
México	0.076	0.076	0.078
Michoacán	0.047	0.047	0.049
Morelos	0.014	0.014	0.015
Nayarit	0.010	0.010	0.010
Nuevo León	0.059	0.059	0.061
Oaxaca	0.019	0.013	0.014
Puebla	0.030	0.036	0.037
Querétaro	0.013	0.013	0.013
Quintana Roo	0.010	0.010	0.010
San Luis Potosí	0.024	0.024	0.024
Sinaloa	0.029	0.029	0.030
Sonora	0.029	0.029	0.030
Tabasco	0.013	0.013	0.013
Tamaulipas	0.041	0.041	0.042
Tlaxcala	0.006	0.006	0.006
Veracruz	0.045	0.045	0.046
Yucatán	0.015	0.015	0.015
Zacatecas	0.018	0.018	0.019

2.2.11 HPMSVTypeYear

This table contains annual, nationwide total vehicle miles traveled (VMT), by calendar year and Highway Performance Monitoring System (HPMS) vehicle groups. Source data included: (1) 2013 state-level vehicle population discussed in Section 2.1, (2) 2013 national VKT per vehicle per year, and (3) fuel projections. National vehicle populations were calculated by using per-vehicle VMT from Section 2.1, converting Mexico vehicle classes to MOVES source use types using methods described for the SourceTypeYear table, then finally aggregated over source types to arrive at HPMS groups. The 2013 VMT was then back-casted to 2011 and projected to 2017 using domestic fuel sales projections. Totals for the MAG domain only are shown in Table 7.

Table 7. Annual Mexico MAG Domain VMT Estimates by Source Type in 2011 and 2017

Source Type	MAG Domain 2011 VMT	MAG Domain 2017 VMT
Motorcycles	8,245,536,150	8,907,361,450
Passenger Cars	48,760,877,060	52,676,132,415
Passenger Trucks	1,020,919,235	1,102,857,355
Light Commercial Trucks	36,777,418,615	39,740,205,010
Transit Buses	1,951,180,135	2,184,297,240
Single Unit Short Haul	4,078,503,795	4,561,602,100
Single Unit Long Haul	242,793,985	271,550,510
Combination Short Haul	1,744,478,445	1,991,890,410
Combination Long Haul	4,114,869,475	4,698,496,810

2.2.12 SourceTypeYear

This table contains National total vehicle population by source use type by calendar year. The source data was 2013 state-level vehicle population by Mexico vehicle type. Data provided were in a different set of Mexico-specific vehicle classes, which needed to be mapped to MOVES source use types to represent the Mexico fleet. The mapping used is shown in Table 8 below. INECC informed us that "Public light transport trucks" include SUVs and vans but not pickups, and "Pickup Trucks" are for transferring a product (both passenger and commercial). Population in the class "Trucks with GVW > 3 ton" was mapped to Single Unit Trucks, and the "Trailer trucks" were mapped to Combination Unit Trucks.

Table 8. Vehicle Classes in Mexico Data Mapped to MOVES Source Types

#	Mexico Vehicle Type	MOVES Source Type	
1	Motorcycles	11	Motorcycle
2	Passenger cars	21	Passenger car
3	Taxi		
4	Public transport light truck	31	Passenger Truck
5	Pickup trucks	32	Light Commercial Truck
6	Trucks with GVW < 3 ton		
7	Buses	42	Transit Bus
8	Microbus/Midibus		
9	Trucks with GVW > 3 ton	52	X% Single Unit Short-haul Truck
		53	100-X% Single Unit Long-haul Truck
10	Trailer trucks	61	Y% Combination Short-haul Truck
		62	100-Y% Combination Long-haul Truck

Because we do not have use type data to distinguish long-haul vs. short-haul activity, U.S. default splits were used. The 2013 population was back-casted to 2011 and projected to 2017 using human population growth trends at the national level.

Population estimates within the MAG domain for 2011 and 2017 by source type (as mapped from Mexico vehicle classes from Table 8 above), are shown in Table 9.

Table 9. Mexico Domain Vehicle Population Estimates by Source Type in 2011 and 2017

Source Type	2011 Population	2017 Population
Motorcycles	454,056	490,500
Passenger Cars	4,808,545	5,194,675
Passenger Trucks	91,965	99,347
Light Commercial Trucks	3,438,594	3,715,625
Transit Buses	66,404	74,117
Single Unit Short Haul	231,665	259,106
Single Unit Long Haul	9,653	10,796
Combination Short Haul	42,323	48,326
Combination Long Haul	44,405	50,703

2.2.13 SourceTypeAgeDistribution

Source data were the 2013 state-level vehicle populations data discussed in Section 2.1, which was provided by individual model year. The Mexico classes were mapped to MOVES source use types, and distributions normalized over the 30 years available so that distributions sum to one (1). Because MOVES uses 31 years (age 0 to 30, inclusive), we divided the age 30 population by two to cover both age bins 30 and 31 year old vehicles. The core database was populated with the MAG domain-average age distributions. In addition to the domain-wide data, two external database tables were created using data specific to the border states and non-border states, separated to account for unique distributions of cars and light trucks in border area, which have a high number of aged vehicles (~ 10 years old) coming over from the U.S. The same age distributions in MOVES-Mexico were applied to all years, including 2011 and 2017. While MOVES has capability to project age distribution dynamically using vehicle growth and scrappage curves, the underlying data do not apply in Mexico so this feature of MOVES was not used for the MAG inventories.

Vehicle age summary charts for border and non-border areas are shown in Figures 3 and 4. Figure 3 shows the age distribution of passenger cars operating in border and non-border portions of the domain, showing the clear bump in ~10 year old vehicles in the border region.

Figure 4 shows the average age of all Mexico vehicle classes for the border and non-border regions.

Figure 3. Age distribution for Passenger Cars, Border vs. Non Border Areas

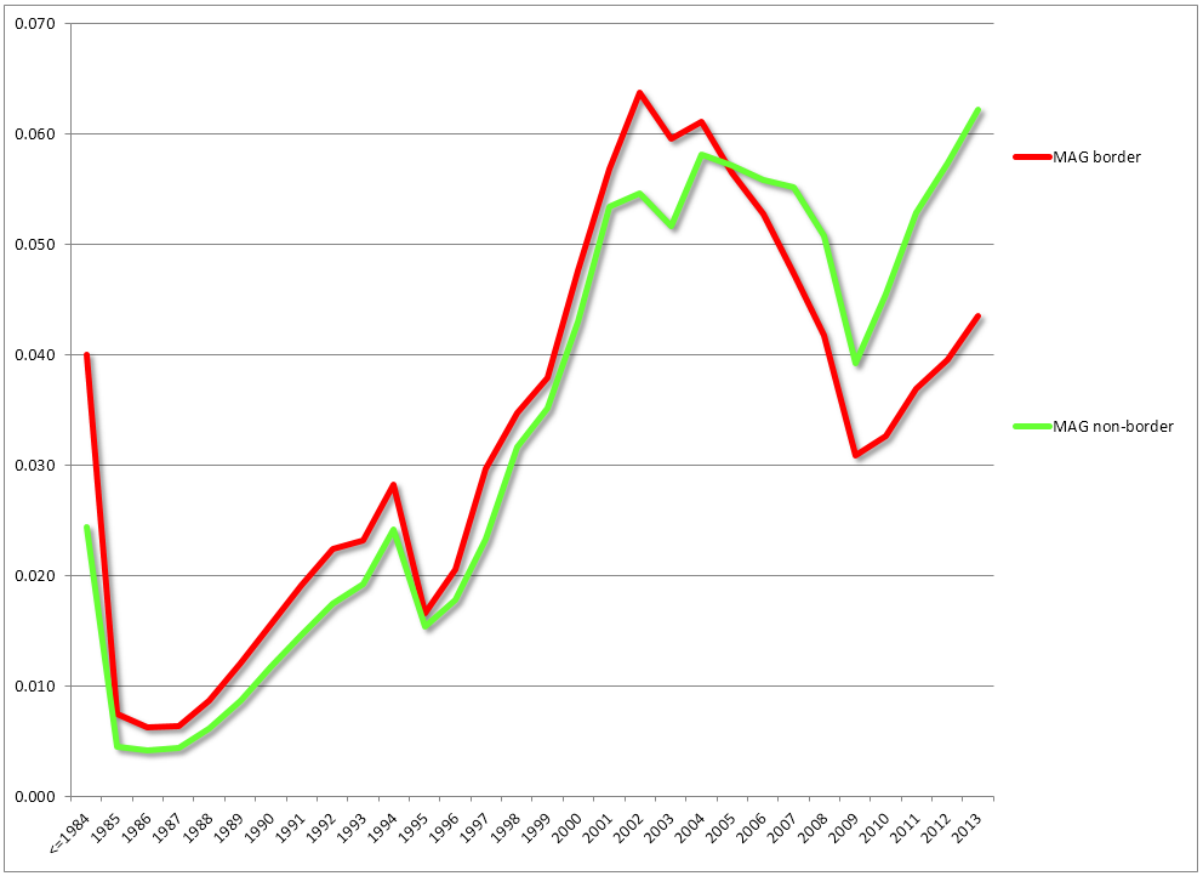
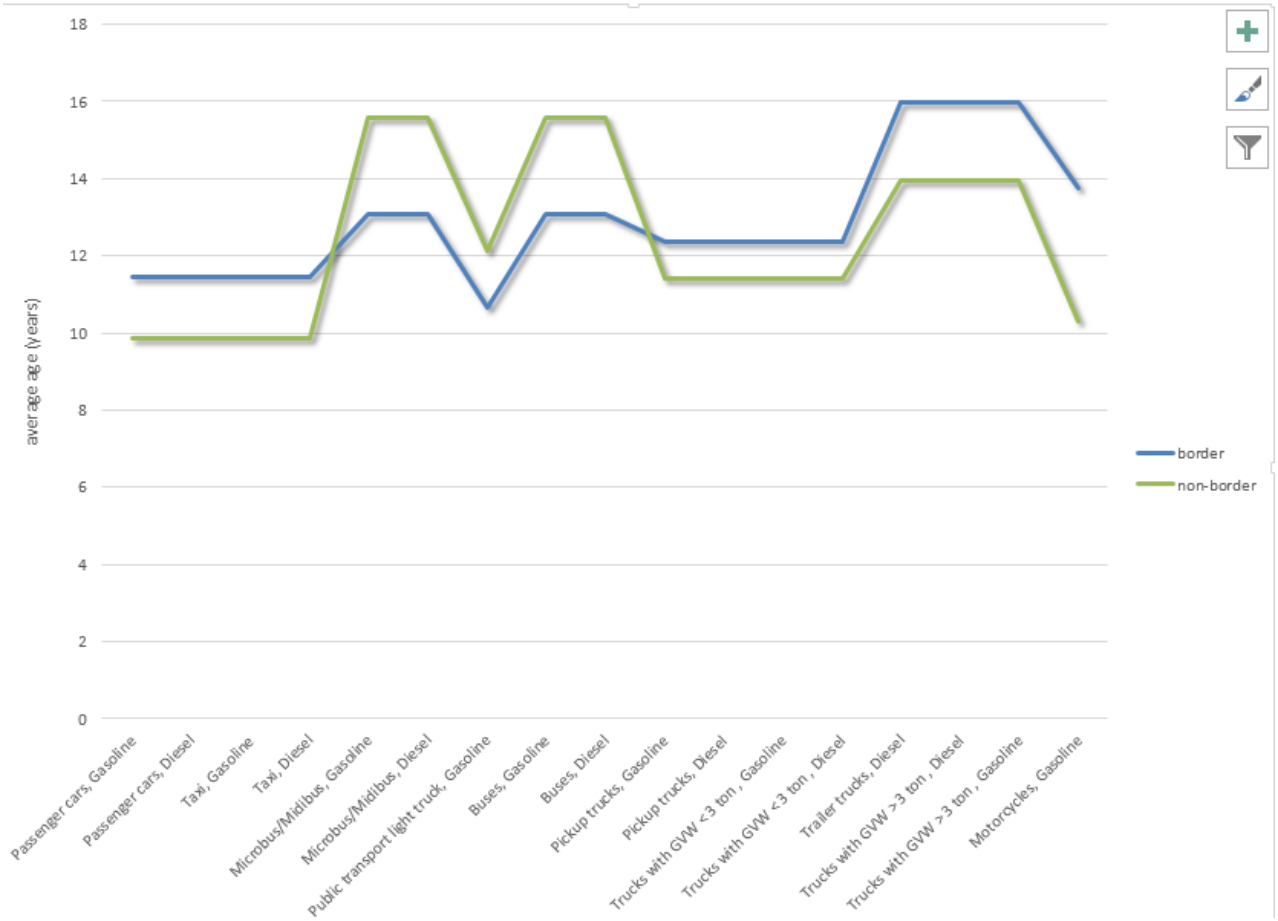


Figure 4. Average Age By Mexico Vehicle Class, Border vs. Non Border Areas



2.2.14 Alternative Vehicle & Fuel Technology (AVFT)

The AVFT table determines the distribution of fuel types, by source type and vehicle model year. The source data were the 2013 state-level vehicle population data discussed in Section 2.1, which included a split of population by gas and diesel. We mapped the Mexico vehicle classes to MOVES source use types using the methods described for the SourceTypeYear table, preserving the details of vehicle model year and fuel type. We then normalized the populations so that for each model year the gas and diesel fractions summed to one (1).

2.2.15 RoadTypeDistribution

The RoadTypeDistribution table contains national fractions of VMT that occur on the four MOVES road types, by source type. This table leveraged off the roadway network analysis described for the ZoneRoadType table. At the stage where total lane-meters are stored by the

four MOVES road types, we summed over the nation, and normalized. The national road type distribution is shown in Table 10 below. The distribution is the same for each source type, since no information was available to allow them to vary by source type, and the U.S. defaults were not considered applicable in this case.

Table 10. Mexico Domain Road Type Fraction by Source Type

Source Type	Rural Restricted	Rural Unrestricted	Urban Restricted	Urban Unrestricted
All Source Types	0.232	0.284	0.107	0.376

2.2.16 FuelSupply & FuelFormulation

These tables provides the market share and properties of individual fuel formulations, broken down for each fuel region, month, and year. Details of these fuels are described in detail in the discussion under RegionCounty table; the same fuels were assumed for 2017 as in 2011.

2.2.17 MonthVMTFraction

This table allocates annual total VMT from HPMSVtypeYear to months. MonthVMTFractions were updated using domestic PEMEX total fuel sales (gasoline + diesel together) relative in each month of the year. The assumption is that VMT will track with fuel sales.

2.3 Emission Rate Updates

2.3.1 Overview of Approach

Emission rates in MOVES were updated to reflect significant differences in vehicle emission controls between Mexico and the U.S. Similar updates were not made for Canada, because Canada emission standards have been harmonized with the U.S. since the late 1980s; for the MAG runs, where the majority of the fleet in 2011 and 2017 will be on post-1990 vehicles, the default U.S.-based emission rates were deemed appropriate. For this project, ERG combined two different methods to estimate emissions rates for the Mexico fleet: one for 2007 and newer light-duty vehicles, based on an adaptation of work ERG previously performed for EPA in developing the beta MOVES International model, and another method for both heavy-duty and older light-duty vehicles, based on fleet technology penetration. These two methods are described below.

2.3.2 Mapping U.S. Rates to Mexico

For Mexico, the approach taken was to adapt the U.S.-based emission rates to Mexico based on differences between the two countries in the level of emission standard and implementation years, summarized earlier in Table 1. For all heavy-duty vehicles, and light-duty prior to 2006 model year, this adaption took for form of simply re-mapping the U.S. emission rates other model years in correspondence with Mexico standards. This approach was taken because for these vehicle classes and model years, there is a direct correspondence between Mexico vehicle standard levels and previous year U.S. standards. Mexico Emission rates for 2006 and later cars and light trucks (reg class 20 and 30) were generated using the method, and a modified version of a script U.S. EPA used to generate U.S. based rates in MOVES, as detailed in the next section.

To facilitate the development of Mexico rates, a mapping between Mexico and U.S. vehicle standards was required. This was developed based on the information provided by INECC from Table 1. Tables 11 through 13 show the mapping of Mexico standards to U.S. standards, and how model years were correlated to enact this mapping.

Table 11. Car and Light-Duty Truck (Regulatory Class 20 and 30) Exhaust Model Year Mappings

Mexico Model Year Range	Correlated U.S. Technology/Standard	U.S. Model Year or Bins Applied
1980-1990	Pre-Catalyst	1970
1991-1992	Catalyst	1980
1993-2006	Tier 0	1990
2007-2009	Tier 2 Bin 10 Phase-In	25/50/75%
2010-2012	Tier 2 Bin 7 Phase-In	25/50/70%
2013 and later	Tier 2 Bin 7	100%

Table 12. Heavy-Duty Diesel Truck (Regulatory Class 40-48) Model Year Mappings

Mexico Model Year Range	Correlated U.S. Technology/Standard	U.S. Model Year or Bins Applied
1980-1992	Pre-Control	1980
1993	"1991"	1992
1994-1997	"1994"	1996
1998-2008	"1998" (Electronic Control)	2000
2009 and later	"2004" (EGR)	2004

Table 13. Heavy-Duty Gas Truck (Regulatory Class 40-48) Model Year Mappings

Mexico Model Year Range	Correlated U.S. Technology/Standard	U.S. Model Year or Bins Applied
1980-1997	Pre-Control	1980
1998 and later	Tier 1	1998

2.3.3 Adjustment Scripts

In the case of fleet technology penetration, ERG created a spreadsheet tool that allows users to select technology penetration by both type and calendar year, and use that information to reweight the existing FTP phase in fractions developed by EPA. Technology penetration fractions sum to 1.0, and vary from pre-Tier 1 technologies all the way through LEV2 (with Euro technologies integrated). Technology fractions can be provided for each model year to be analyzed, and users may alter or delay introduction of certain technologies as appropriate for their fleet. These inputs produced reweighted technology fractions by model year and technology type, which were also subsequently converted to CSV format and input to the modified SAS program.

For heavy duty vehicles and older light duty vehicles (2006 and older), the approach presented above did not apply. Instead, ERG developed a series of MySQL scripts to shift the default emission rates by model year in the MOVES Emission Rate By Age table (ERBAT) consistent with mappings shown in the tables above. These rates were then combined with the 2006 and later LD rates described above to arrive at a single ERBAT that could be used for all MOVES runs performed in Mexico.

2.3.4 Evaporative Emissions

According to INECC, evaporative emissions are not explicitly regulated in Mexico. However, for the purpose of this work, it was assumed that the level of evaporative control that corresponds with exhaust control in the U.S. would be in place in Mexico. An updated Cumulative Tank Vapor Venting Coefficient (CumTVVCoeff) table was prepared based on the mappings show in Tables 14 and 15, for cars/light trucks and heavy gas trucks.

Table 14. Car and Light-Duty Truck Evaporative Model Year Mappings

Mexico Model Year Range	Correlated U.S. Technology/Standard	U.S. Model Year or Bins Applied
1980-1992	Uncontrolled	1971-1977
1993-2007	Pre-Enhanced Control	1978-1995
2008-2050	Tier 2 Enhanced	2008-2016

Table 15. Heavy-Duty Gas Truck Evaporative Model Year Mappings

Mexico Model Year Range	Correlated U.S. Technology/Standard	U.S. Model Year or Bins Applied
1980-1997	Pre-Enhanced Control	1978-1995
1998 and later	Enhanced Control	1998

2.4 Inventory Runs

2.4.1 Configuration

Multiple runs of MOVES were needed to produce the emissions output needed for the onroad portion of the inventory. In order to efficiently generate the MOVES run input files (runspecs) for the 2011 and 2017 MOVES runs, ERG developed a Perl pre-processing script to build the input files based on a template input file and arrays containing the required parameters of municipalities, months, years, fuel types, and emission processes that needed to be included in each unique run.

Such a large number of MOVES runs would have been a large computational burden for a standalone desktop machine. After initial runtime tests, ERG decided to setup the MOVES runs to execute in an Amazon cloud computing environment using methods adapted from ERG's support of EPA's Office of Air Quality Planning and Standards (OAQPS) & Office of Transportation and Air Quality (OTAQ) for the National Emissions Inventory (NEI).

The cloud MOVES runs were grouped in units of two runs together (to separate fuels and emission processes for efficiency). There were 1,054 instances of this set of two runs. Each instance corresponds to two Amazon central processing unit (CPUs) with 4 GB of RAM, and ERG was permitted the use of 500 instances at a time. Therefore, the 1,054 instances were run in batches of three groups. The total runtime was approximately 1000 hours of processing time, which is about 1.3 months. The expense of using Amazon computing was a minimal cost to the project, roughly equivalent to two staff hours. ERG developed a Perl post-processing script that converts the raw MOVES output of emissions and VMT activity contained in the 2,108 MOVES output databases into a single on-road emissions by municipality, SCC, pollutant, and source type. The post-processing script executes a number of MySQL queries that (1) add labels to the database results and (2) perform basic addition and division calculations. The addition of labels was necessary to differentiate fuel processed from the MOVES outputs, as well as to make the results more easily understandable and readable.

National Scale runs covering the 527 municipalities in the MAG domain were executed for 2011 and 2017 ozone season day. Output was provided by Weekday and Weekend (Post-Processed to Average Day outside MOVES). Two run specification files were developed for each municipality/year: 1) Exhaust VOC, CO and NO_x in a runspec run with Day pre-aggregation, and 2) Evaporative VOC in a runspec with Hour pre-aggregation (required, but slows runtime) outputs by Day. Municipalities in states along the U.S. border called an external database with the border age distribution data. Likewise, other municipalities not in these states received the non-border age distribution.

All runs reference the external databases EmissionRateByAge and CumTVVCoeffs, and all runs produced outputs by SCC, municipality, year, day type. This resulted in 2,108 MOVES runs in total (527 counties × 2 runspecs × 2 years =2,108) run in parallel on Amazon Cloud, with an elapsed runtime of about one hour.

2.4.2 Mexico MAG Domain Results

Results were provided to MAG by municipality, year and Source Classification Code (SCC), for ozone season weekday and weekend. State level results are summarized for an average day in Tables 16 and 17 below.

Table 16. 2011 Emissions in Mexico MAG Domain, by State (Average Tons/Day)

State	NO_x	VOC	CO
Aguascalientes	1.2	0.3	5.6
Baja California	167.5	72.3	1,053.2
Baja California Sur	42.1	18.2	288.2
Campeche	1.7	0.7	10.9
Coahuila	97.1	46.5	699.8
Chihuahua	175.6	77.9	1,164.5
Durango	53.2	21.4	320.2
Jalisco	1.8	0.5	9.1
Nayarit	1.7	0.8	12.4
Nuevo León	213.9	105.1	1,451.3
Quintana Roo	28.1	11.3	179.5
San Luis Potosí	64.2	25.9	399.4
Sinaloa	98.4	44.3	689.7
Sonora	101.2	52.3	774.2
Tamaulipas	146.6	69.3	1,059.4
Veracruz	5.2	1.6	26.7
Yucatán	48.8	20.8	322.4
Zacatecas	53.9	21.0	300.9

Table 17. 2017 Emissions in Mexico MAG Domain, by State (Average Tons/Day)

State	NO_x	VOC	CO
Aguascalientes	1.0	0.2	4.3
Baja California	144.6	49.7	775.3
Baja California Sur	35.5	12.1	211.2
Campeche	1.4	0.4	8.0
Coahuila	84.3	31.9	522.0
Chihuahua	152.2	53.5	862.2
Durango	44.7	14.3	232.2
Jalisco	1.5	0.3	6.9
Nayarit	1.4	0.6	8.8
Nuevo León	184.4	71.8	1,099.9
Quintana Roo	23.7	7.6	130.9
San Luis Potosí	54.0	17.3	291.5
Sinaloa	83.0	29.6	506.4
Sonora	87.8	35.9	580.0
Tamaulipas	127.0	47.6	789.9
Veracruz	4.4	1.1	19.8
Yucatán	41.1	13.9	235.3
Zacatecas	45.3	14.1	216.0

3.0 Adapting MOVES to Canada

3.1 Data Sources

A Canada-specific MOVES input database was developed for Canada runs within the MAG domain. The extent of updates the database were more limited than for Mexico, because a) less data were available to make updates with, b) emissions were generated at the province level, requiring less data to allocate to finer geographic detail, and c) U.S. defaults were considered to be more representative of Canada vs. Mexico. With the exception of the table updates described below, the adaptation of MOVES for Canada used the default MOVES 2014 database for the U.S. This means several key inputs were based on U.S. defaults, such as emission rates, speeds and vehicle age distribution. The U.S. default were judged reasonable for Canada in these cases because of the close alignment between U.S. and Canadian vehicle fleet, emission standards, and transportation infrastructure.

Data for table updates were primarily drawn from a combination of the default MOVES 2014 database and several additional sources that provided national level estimates on which to base MOVES updates:

- The 2009 Canadian Vehicle Survey (CVS) report;[13]
- Updates to the SMOKE modeling framework for Canada that included vehicle activity estimates at the province level;[14] and
- Projections of future gasoline and diesel use for each province.

Other data were developed based on existing MOVES2014 defaults, as noted in the following sections.

3.2 Table Updates

3.2.1 fuelSupply

The *fuelSupply* table, containing fuel formulations for 2011 and 2017 applied to all provinces in the MAG study area, was generated by averaging the fuel supply mix across the

[13]Statistic Canada, Canadian Vehicle Survey: Annual 2009 http://www.statcan.gc.ca/pub/53-223-x/53-223-x2009000-eng.htm

[14]Zhang et al. "Improvements to SMOKE processing of Canadian on-road mobile emissions" presented at the 2012 International Emission Inventory Conference (http://www.epa.gov/ttn/chief/conference/ei20/)

U.S. states bordering Canada, weighted by the relative VMT of each state. The surrogate border states included were Idaho, Maine, Michigan, Minnesota, Montana, New York, Ohio, Pennsylvania, South Dakota, Vermont, Washington, and Wisconsin.

3.2.2 HPMSVtypeYear

The *HPMSVtypeYear* table contains VMT by year and *HPMSVtype*. Obtaining these data required the combination of multiple tables from the CVS to correctly map VMT onto the appropriate MOVES source type and fuel type (gasoline or diesel) so VMT could be projected to 2011 and 2017 using the fuel projections described above. VKT by province and weight class were obtained from Table 4.1 of the CVS. We apportioned this into VKT by vehicle type using Table 3.3 of the CVS, which provided vehicle population by vehicle type and weight class. We then translated the CVS vehicle types and weight classes to MOVES *sourceTypeIDs* using the mapping shown in Table 18. Some vehicle type/weight combinations mapped to multiple sourceTypeIDs, in which case we used the population splits contained in the 2009 sourceTypeYear table in MOVES 2014 to apportion the VKT to the two *sourceTypeIDs*. These VKTs by *sourceTypeID* were then split by fuel type using the gasoline and diesel splits found in Table 3.4 of the CVS. Bus and motorcycle populations were obtained from the raw CSV table 405-0004 found online.

Table 18. Mapping of Canadian Vehicle Survey Classes to MOVES Source Types

CVS Vehicle Type	CVS Vehicle Body	MOVES Source Type
Vehicles up to 4.5 tonnes	Car	21
Vehicles up to 4.5 tonnes	Station wagon	21
Vehicles up to 4.5 tonnes	Van	3132
Trucks 4.5 tonnes to 14.9 tonnes	Van	5253
Vehicles up to 4.5 tonnes	Sport utility vehicle	31
Vehicles up to 4.5 tonnes	Pickup	3132
Trucks 4.5 tonnes to 14.9 tonnes	Pickup	5253
Trucks 15 tonnes and over	Pickup	5253
Vehicles up to 4.5 tonnes	Straight truck	5253
Trucks 4.5 tonnes to 14.9 tonnes	Straight truck	5253
Trucks 15 tonnes and over	Straight truck	5253
Trucks 4.5 tonnes to 14.9 tonnes	Tractor trailer	6162
Trucks 15 tonnes and over	Tractor trailer	6162
Buses	Bus	42

Combining all of these data and converting to miles, for MOVES, yielded VMT for all *sourceTypeIDs* for 2009, which were then projected forward to 2011 and 2017 using the gasoline and diesel growth projections (Table 19). The gasoline and diesel data were then recombined. The final step was to map the *sourceTypeIDs* onto *HPMSVtype* using the *sourceUseType* table in MOVES 2014.

Table 19. Annual Canada MAG Domain VMT by Source Type in 2011 and 2017

Source Type	MAG Domain VMT 2011	MAG Domain VMT 2017
Motorcycles	1,436,914,173	1,521,575,562
Passenger Cars	109,847,953,341	116,320,072,857
Passenger Trucks	65,370,091,014	69,221,624,238
Light Commercial Trucks	10,713,859,840	11,345,108,573
Transit Buses	1,057,516,079	1,230,394,915
Single Unit Short Haul	10,132,582,064	12,401,354,254
Single Unit Long Haul	455,288,944	557,232,051
Combination Short Haul	4,757,838,928	5,433,208,033
Combination Long Haul	4,706,597,399	5,374,692,836

3.2.3 sourceTypeYear

The *sourceTypeYear* table, which contains vehicle population by *yearID* and *sourceTypeID*, was also generated using a combination of tables from the CVS. Vehicle counts by vehicle type, weight class, and province were obtained by combining the information in Tables 3.3 and 3.1 with the vehicle type and weight class to *sourceTypeID* mapping in to the CVS was again used to obtain gasoline/diesel splits, and then these population by *sourceTypeID* and fuel type data were projected forward to 2011 and 2017 using the fuel use projections and recombined (Table 20).

Table 20. Population Estimates by Source Type in 2011 and 2017

Source Type	2011 Population	2017 Population
Motorcycles	412,511	431,279
Passenger Cars	11,472,549	11,965,665
Passenger Trucks	6,827,269	7,075,809
Light Commercial Trucks	1,118,958	1,200,626
Transit Buses	63,211	79,547
Single Unit Short Haul	569,972	731,294
Single Unit Long Haul	25,610	33,165
Combination Short Haul	119,728	137,879
Combination Long Haul	118,439	146,690

3.2.4 roadTypeDistribution

We created a national average *roadTypeDistribution* table (the fractions of VMT allocated to different *roadTypeIDs* for each *sourceTypeID*) for the Canadian provinces included in the MAG study area by using *roadTypeDistributions* generated by MOVES 2014 for proxy U.S. states. The proxy states were based on the analysis contained in Zhang et al., as follows: Minnesota-Saskatchewan; Colorado-Alberta; Minnesota-Manitoba; Pennsylvania-Quebec; New York-Ontario; Washington-British Columbia; and Maine-New Brunswick. We ran MOVES 2014 for 2009 to match the CVS survey year, and then created the national average by calculating a VKT-weighted average across all of the MAG provinces, using VKT by province obtained from the CVS (Table 21).

Table 21. Domain Road Type Fraction by Source Type

Source Type	Rural Restricted	Rural Unrestricted	Urban Restricted	Urban Unrestricted
Motorcycles	0.075	0.215	0.257	0.453
Passenger Cars	0.075	0.215	0.257	0.453
Passenger Trucks	0.077	0.252	0.238	0.434
Light Commercial Trucks	0.077	0.252	0.238	0.433
Transit Buses	0.149	0.263	0.263	0.325
Single Unit Short Haul	0.149	0.263	0.263	0.325
Single Unit Long Haul	0.150	0.263	0.264	0.324
Combination Short Haul	0.204	0.260	0.285	0.251
Combination Long Haul	0.213	0.257	0.289	0.241

3.2.5 zoneRoadType

For *zoneRoadType,* which contains *SHOAllocFactor* by province and *roadTypeID*, we also used MOVES 2014 output for the proxy states identified in the Zhang et al. report. To back out the effect of the proxy states' VMTs on the hours allocated to each state, we divided the *SHOAllocFactor* for each state by its VMT. These normalized *SHOAllocFactors* were then scaled up in proportion to the provinces' VMT, i.e., the *SHOAllocFactor* for a specific province and road type was calculated as: $\text{SHOAllocFactor}_{\text{province}} = \text{SHOAllocFactor}_{\text{proxy state}} \times (\text{VMT}_{\text{province}}/\text{VMT}_{\text{all MAG provinces}})/(\text{VMT}_{\text{proxy state}}/\text{VMT}_{\text{all proxy states}})$. Table 22 shows the resulting SHO allocation factors by roadtype and province.

Table 22. Running (SHO) Allocation Factors by Province

Province	Rural Restricted	Rural Unrestricted	Urban Restricted	Urban Unrestricted
Alberta	0.185	0.148	0.163	0.153
British Columbia	0.150	0.091	0.128	0.109
Manitoba	0.032	0.058	0.031	0.030
New Brunswick	0.051	0.061	0.006	0.012
Ontario	0.248	0.343	0.451	0.426
Quebec	0.299	0.236	0.188	0.237
Saskatchewan	0.035	0.063	0.033	0.033

3.2.6 zone

The *zone* table contains three allocation factors for each province: *startAllocFactor, SHPAllocFactor*, and *idleAllocFactor.* The first two are simply the fraction of the population in the MAG study area contained in each province. *idleAllocFactor* is equal to the SHOAllocFactor for roadTypeID=2 in each province, calculated above for the *zoneRoadType* table. The resulting allocation factors are shown in Table 23, including Source Hours Idle, since Extended Idle was included for the Canadian runs.

Table 23. Start, Extended Idle, Park Allocation Factors by Province

Province	Rural Restricted	Rural Unrestricted	Urban Restricted
Alberta	0.143	0.185	0.143
British Columbia	0.138	0.150	0.138
Manitoba	0.036	0.032	0.036
New Brunswick	0.025	0.051	0.025
Ontario	0.377	0.248	0.377
Quebec	0.240	0.299	0.240
Saskatchewan	0.040	0.035	0.040

3.2.7 zoneMonthHour

To generate a *zoneMonthHour* table for the MAG provinces, we ran MOVES 2014 for proxy U.S. states located in close proximity to the provinces, as follows: Montana-Alberta; Washington-British Columbia; North Dakota-Manitoba; Maine-New Brunswick; Wisconsin-Ontario; Vermont-Quebec; and Montana-Saskatchewan.

3.3 Inventory runs

3.3.1 Configuration

We generated Canada emissions at the province using a National Scale MOVES 2014 run. To speed the runs, we arbitrarily chose seven counties to represent the seven MAG provinces (for simplicity, we chose the first county of the first seven states in MOVES), and specified the appropriate *zoneIDs* and *countyIDs* to map the data for each province to its respective county. We then ran MOVES for July 2011 and July 2017; all hours; all roadTypes; and both weekdays and weekends.

3.3.2 Results

Emissions were provided to MAG by province and SCC for both year. A summary by province is shown in Tables 24 and 25.

Table 24. 2011 Emissions by Province (Average Tons/Day)

Province	NO_x	VOC	CO
Alberta	229.6	90.5	890.0
British Columbia	165.1	72.3	706.2
Manitoba	47.0	20.8	216.8
New Brunswick	36.9	14.4	139.6
Ontario	446.4	193.5	1,888.9
Quebec	276.0	116.6	1,102.8
Saskatchewan	53.6	20.7	192.8

Table 25. 2017 Emissions by Province (Average Tons/Day)

Province	NO_x	VOC	CO
Alberta	119.4	49.4	568.5
British Columbia	89.0	41.6	439.8
Manitoba	24.8	11.7	134.7
New Brunswick	20.3	8.1	88.5
Ontario	247.1	112.4	1,240.0
Quebec	150.7	67.2	724.2
Saskatchewan	27.9	11.3	123.3

APPENDIX F

DRAFT EIGHT-HOUR OZONE NONATTAINMENT AREA EMISSIONS

Draft daily emissions for the period of May 1 through September 30 in 2011 and 2017 are developed for the 4 km domain. Daily emissions for the Maricopa eight-hour ozone nonattainment area are extracted from gridded daily emissions for the 4 km domain. Table F-1 presents 2011 and 2017 draft average daily emissions for May 1 through September 30 for the Maricopa eight-hour ozone nonattainment area, which will be used to meet the 15% VOC reduction requirement of the Reasonable Further Progress (RFP) for Marginal area under the CAA.

Table F-1 Draft average daily emissions for the eight-hour ozone nonattainment area (unit: metric tons/day)

	VOC			NOx			CO		
Source	2011	2017	Difference	2011	2017	Difference	2011	2017	Difference
Point	2.47	3.11	0.64	5.63	4.67	-0.96	4.05	5.33	1.28
Area	95.22	96.76	1.54	11.10	12.75	1.65	7.75	8.55	0.80
Onroad*	70.80	46.67	-24.13	117.53	63.51	-54.02	681.40	504.60	-176.80
Nonroad**	33.05	24.60	-8.45	54.09	36.76	-17.33	362.96	336.11	-26.85
Total	201.54	171.14	-30.40	188.35	117.69	-70.66	1,056.17	854.59	-201.57

* Draft onroad emissions are estimated with the MOVES2014, being revised with the MOVES2014a.

** Draft nonroad emissions are estimated with the NONROAD2008a, being revised with the MOVES2014a nonroad model.