Ozone Mobile Source Emissions Inventory for the Cincinnati Ozone Nonattainment Area

Includes the Ohio counties of Butler, Clermont, Clinton, Hamilton, and Warren, the Kentucky counties of Boone, Campbell and Kenton, and Dearborn County Indiana. Emission estimates for the Years 2011, 2014, 2020 and 2030

August 2015

Prepared for the Ohio Environmental Protection Agency, the Kentucky Division for Air Quality and the Indiana Department of Environmental Management by

OKI Regional Council of Governments

Ohio · Kentucky · Indiana
Regional Council of Governments

Acknowledgments

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Abstract	This report was prepared for the Ohio Environmental Protection Agency, the Kentucky Department for Air Quality, and the Indiana Department of Environmental Management. The Cincinnati Ozone Nonattainment Area includes a portion of Dearborn County Indiana, the counties of Boone, Campbell, Kenton in Kentucky, and the counties of Butler, Clermont, Clinton, Hamilton, and Warren in Ohio. Clinton County is outside of OKI's MPO area, however, the Ohio Department of Transportation prepared Clinton emission estimates which are included in this report. This report includes emission estimates for years 2011, 2014, 2020 and 2030. EPA's Motor Vehicle Emission Simulation (MOVES) 2014 was used to generate the emission inventory.
Date	August 2015
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Mobile Source Ozone Emissions Inventory for the Cincinnati Ozone Nonattainment Area

This report was prepared for the Ohio Environmental Protection Agency, the Kentucky Department for Air Quality, and the Indiana Department of Environmental Management. The Cincinnati 2008 Ozone Nonattainment Area includes a portion of Dearborn County Indiana, the counties of Boone, Campbell, Kenton in Kentucky, and the counties of Butler, Clermont, Clinton, Hamilton, and Warren in Ohio. Clinton County is outside of OKI's MPO planning area. The emission estimates for Clinton County were developed by the Ohio Department of Transportation and provided to OKI for inclusion in this report. This report includes emission estimates for years 2011, 2014, 2020 and 2030. The U.S. EPA's Motor Vehicle Emission Simulation (MOVES) 2014 was used to generate the emission inventory. Details on the various county data inputs used to generate the inventory are described in Table 5. Emissions of the ozone precursors, volatile organic compounds (VOC's) and oxides of nitrogen (NO_x), are reported.

Table 1 shows daily mobile source ozone emissions in tons per summer day for the Ohio and Indiana portion of the Cincinnati Ozone Nonattainment Area. The daily mobile source ozone emissions in tons per summer day for the Kentucky portion of the Cincinnati Ozone Nonattainment Area are shown in Table 2. The mobile source ozone emissions for the nonattainment portion only of each county is provided in Table 3. Mobile source emissions for entire counties are shown in Table 4.

Table 1

Mobile Source Emissions Inventory for the Indiana and Ohio Portions of the Cincinnati Ozone Nonattainment Area (tons per day)

	2011	**2014**	**2020**	**2030**
VOC	55.90	41.39	26.10	15.84
NOx	68.85	50.03	26.77	14.10

Table 2

Mobile Source Emissions Inventory for the Kentucky Portion of the Cincinnati Ozone Nonattainment Area (tons per day)

	2011	**2014**	**2020**	**2030**
VOC	8.47	6.50	3.54	1.99
NOx	17.72	14.04	6.20	2.69

Table 3				
Mobile Source Emissions by Nonattainment Portion (tons per summer day)				
State	**2011**	**2014**	**2020**	**2030**
Indiana				
Dearborn NonAttainment				
VOC	0.86	0.64	0.40	0.24
NOx	1.03	0.74	0.40	0.21
Ohio (entire county is NonAttainment)				
Butler				
VOC	10.21	7.59	4.79	2.88
NOx	12.24	8.85	4.74	2.44
Clermont				
VOC	6.27	4.66	2.94	1.77
NOx	7.52	5.44	2.91	1.50
Clinton				
VOC	2.27	1.53	0.93	0.71
NOx	4.53	3.51	1.86	1.28
Hamilton				
VOC	28.09	20.88	13.18	7.92
NOx	33.69	24.37	13.05	6.71
Warren				
VOC	8.21	6.10	3.85	2.32
NOx	9.84	7.12	3.81	1.96
OH/IN NonAttainment VOC Total	55.90	41.39	26.10	15.84
OH/IN NonAttainment NOx Total	68.85	50.03	26.77	14.10
Kentucky	**2011**	**2014**	**2020**	**2030**
Boone NA				
VOC	3.30	2.53	1.38	0.77
NOx	6.90	5.46	2.41	1.05
Campbell NA				
VOC	2.05	1.58	0.86	0.48
NOx	4.30	3.41	1.50	0.65
Kenton NA				
VOC	3.12	2.39	1.30	0.73
NOx	6.53	5.17	2.28	0.99
KY NonAttainment Total				
VOC	8.47	6.50	3.54	1.99
NOx	17.72	14.04	6.20	2.69

Table 4				
Mobile Source Emissions by County (tons per summer day)				
State	**2011**	**2014**	**2020**	**2030**
Indiana				
Dearborn				
VOC	1.33	0.99	0.62	0.38
NOx	1.89	1.37	0.74	0.39
Ohio				
Butler				
VOC	10.21	7.59	4.79	2.88
NOx	12.24	8.85	4.74	2.44
Clermont				
VOC	6.27	4.66	2.94	1.77
NOx	7.52	5.44	2.91	1.50
Clinton				
VOC	2.27	1.53	0.93	0.71
NOx	4.53	3.51	1.86	1.28
Hamilton				
VOC	28.09	20.88	13.18	7.92
NOx	33.69	24.37	13.05	6.71
Warren				
VOC	8.21	6.10	3.85	2.32
NOx	9.84	7.12	3.81	1.96
OH VOC Total	55.04	40.75	25.69	15.59
OH NOx Total	67.82	49.29	26.37	13.89
Kentucky	**2011**	**2014**	**2020**	**2030**
Boone				
VOC	3.68	2.82	1.54	0.86
NOx	7.75	6.14	2.71	1.18
Campbell				
VOC	2.29	1.76	0.96	0.54
NOx	4.83	3.83	1.69	0.74
Kenton				
VOC	3.48	2.67	1.46	0.82
NOx	7.34	5.81	2.57	1.12
KY Total				
VOC	9.46	7.26	3.95	2.22
NOx	19.93	15.78	6.97	3.03

Mobile Source Emission Forecast Process

Emission Factor Model

OKI's inventory assessment utilized U.S.EPA's emissions model MOVES 2014 to generate VOC and NO_X emissions. Table 5 summarizes the settings used in the MOVES run specification file. Table 6 lists the data used in the MOVES County-Data Manager. Further technical details on the use of MOVES are found in the appendix to the OKI report *"Mobile Source Emissions Inventory for Cincinnati PM2.5 Nonattainment Area"*, revised December 2010.

Table 5

MOVES RunSpec Parameter	Settings
MOVES 2014, default database 20141021	
Scale	County, Rates
Time Span	Time aggregation = Hour July weekday, July meteorological data All hours of day selected Weekdays only
Geographic Bounds	Two Custom Domains 1) 4 Ohio counties and Lawrenceburg IN; 2) 3 Kentucky counties
Vehicles/Equipment	All vehicle types. All vehicle/fuel type combos provided by MOVES except electric. Includes gasoline, diesel, ethanol and CNG.
Road Type	All road types including off-network
Pollutants and Processes	Total gaseous hydrocarbons, non-methane hydrocarbons, volatile organic compounds, and oxides of nitrogen
Strategies	none
General Output	Units= U.S. ton, joules and miles
Output Emissions	Time = 24-hour day, Location =county, on-road emission by road type
Advanced Performance	none

Table 6

County Data Manager	Data Source
Source Type Population	Local and default. Custom domain #1, local data from ODOT (2012) and InDOT (2011) motor vehicle registration data. Default data used for source types 41,51,52,53,54,61 and 62. Custom domain #2, local data from KYTC (2014) motor vehicle registration data. Default data used for source types 41,42,43,51,52,53,54,61 and 62. Annual growth rates used to adjust base year.
Vehicle Type VMT	Local and default. HPMSVTypeYear VMT= weekday DVMT from OKI

	travel demand model 8.0 with EPA's daily to annual VMT converter applied. monthVMTFraction = default. dayVMTFraction=default, hourVMTFraction=local.
I/M Programs	No I/M programs
Fuel Formulation	Default
Fuel Supply	Default
Meteorology Data	Default
Ramp Fraction	Local. OKI travel demand model.
Road Type Distribution	Local. OKI travel demand model.
Age Distribution	Local and default. Local data from ODOT (2012), InDOT (2011) and KYTC (2014) motor vehicle registration data. Default data used for source types 41,42,43,51,52,53,54,61 and 62.
Average Speed Distribution	Local. OKI travel demand model V8.0.

OKI Travel Demand Model

Vehicle miles traveled, vehicle hours and average speeds were estimated using the OKI Travel Demand Model Version 8.0. The OKI Travel Demand Model is composed of a series of CUBE Voyager programs written by Citilabs and OKI. The model covers the combined planning areas of OKI and the Miami Valley Regional Planning Commission. It is a state of the practice model that uses the standard 4 phase sequential modeling approach of trip generation, distribution, modal choice and assignment. The model uses demographic and land use data and capacity and free-flow speed characteristics for each roadway segment in the network to produce a "loaded" highway network with forecasted traffic volumes with revised speeds based on specified speed/capacity relationships.

Travel analysis zones are the basic geographic unit for estimating travel in the OKI model. The region is subdivided into 3312 traffic analysis zones to permit detail as well as manageability. A variety of socioeconomic data items are used in the OKI transportation planning process. These data are used primarily to forecast future travel patterns by serving as independent variables in OKI trip generation equations. The following categories of planning data are utilized:

- Population (household and group quarter)
- Households
- Household vehicles
- Employment (by employment category and zone of work)
- Labor force participation (by zone of residence)
- Area type

The principal data requirements of the OKI travel demand forecasting model are population and employment. From these variables, other characteristics including households, labor force, and personal vehicles may be derived. Chapter 3 of *OKI 2040 Regional Transportation Plan 2012 Update* provides a complete demographic overview of the region.

OKI utilizes both base year (2010) and future year data (2020, 2030 and 2040) in the planning process. Planning data are maintained at the Traffic Analysis Zone (TAZ) level, and originate in the 2010 Census of Population and Housing. Base year 2010 and future year data for each variable are developed through various methods. More detailed explanation of base year and future year data generation for each of the above-mentioned categories of planning data follows. All of the variables represent the latest OKI planning assumptions.

Population

Base and Future Year Data: Population data for base year 2010 and future years 2020, 2030 and 2040 originate with the 2010 US Census of Population. Utilizing the geographic information systems software ArcMap, population data at the zonal level for 2010 was derived from the area proportion allocation of census block level population.

As a tristate regional planning agency, OKI uses county level population projections prepared by the respective state data centers (Ohio Development Services, Kentucky State Data Center and Indiana Business Research Center) as control totals. The most current projections (years 2020 to 2040) were released by Ohio Development Services in 2013, Indiana Business Research Center in 2012 and the Kentucky State Data Center in 2012. Population projections at the zonal level are calculated by multiplying the 2010 household size by the projected zonal households. Then, household size is factored so that, in each county, the sum of the zonal populations equals the control total.

Households

Base Year Data: Household data for base year 2010 originates with the 2010 US Census of Population. Utilizing ArcMap, household data at the zonal level for 2010 was derived from the area proportion allocation of census block level households. Future Year Data: The development of household projections was accomplished by calculating the number of households for a projected county population using 2010 Census ratios of householders to total population by age specific cohorts for each future analysis year. This step results in county-level household control totals for each future analysis year. Disaggregation of households to TAZs was determined by historical trends, existing and future land use, topography, flood plain information, availability of land, local knowledge and other factors.

Household Vehicles

Base and Future Year Data: Base and future year household vehicle data were obtained from 2009-2013 American Community Survey tabulations at the block group level. Average vehicles per household were calculated for block groups and then applied to the TAZs associated with each block group. The 2020, 2030 and 2040 vehicles per household were held at the 2009-2013 level based on the fact that, since 2002, the number of vehicles per household has exceeded the number of drivers per household.

Labor Force

Base and Future Year Data: The OKI labor force is a function of the population as determined by a labor force participation rate (the number of employed persons in the labor force per persons 16 and over).

Household data for base year 2010 is derived from 2009-2013 American Community Survey tabulations. Utilizing ArcMap, labor force data at the zonal level for 2009-2013 was derived from the area proportion allocation of block group level. Labor force projections for 2020, 2030 and 2040 were based on the most recent projections of national labor force participation rates by age and sex cohorts from the U.S. Department of Labor, Bureau of Labor Statistics, for each of those years. These rates were then applied to the projected county age/sex cohorts and adjusted to eliminate the unemployed to arrive at a county employed labor force control total. Employed labor force at the zonal level is calculated by multiplying the labor force participation rate by the zonal population. The labor force participation rate is adjusted so that, in each county, the sum of the zonal labor force counts equals the control total.

Employment

Base Year Data: Quarterly Census of Employment and Wages (QCEW) data for 2010 was the primary tool used to calculate employment at the zonal level for the base year. Individual business records containing physical location, number of employees and NAICS code were geocoded in ArcMap and aggregated to the TAZ level. This data set was supplemented by other sources to complete the commuting employment picture in the OKI region. Each zone's employment was divided into 13 classes based on NAICS codes. NAICS codes assignment to a class was based on the potential for generating trips.

Future Year Data: For future year employment projection, calculation was first made of the employment at the regional level. At the regional level, employment is a calculation of the region's employed labor force minus workers who live in the region but commute out to work, plus workers who live outside the region but commute in to work. The regional total was disaggregated first to the county level based on historic trends and expected changes in the county's share of the region's employment and then to the TAZ level. Disaggregation to TAZs was determined by historical trends, existing and future land use, topography, flood plain information, availability of land, local knowledge and other factors.

Area Type

Base and Future Year Data: For each analysis year, each TAZ is assigned an area type designation as CBD, Urban, Suburban or Rural based on population and employment densities.

Model Calibration

OKI's Travel Demand Model has been validated to observed traffic volumes for the model base year 2005. The modeling network encompasses the entire ozone Maintenance area with the exception of Clinton County, Ohio. The modeling network also includes Greene, Miami and Montgomery counties in Ohio and the remainder of Dearborn County Indiana. The difference between estimated vehicle miles traveled (VMT) and 2005 observed VMT is less than 1%. A highway screenline analysis compares the screenline observed and simulated traffic volume discrepancies with the ODOT standard of maximum desirable deviation. The comparison shows that the model performs at a satisfactory level and all the errors were under the ODOT curve. Further information can be found in OKI's 2007 report, "*OKI/MVRPC*

Travel Demand Model Methodology/ Validation Report". For the calibration, OKI used over 3000 traffic counts collected through 2006 by the Ohio Department of Transportation (ODOT), the Kentucky Transportation Cabinet, many county and local governments, transportation engineering consultants, and OKI. These traffic counts cover nearly 50% percent of the links in the OKI portion of the modeling network. The methodology provides consistency with past emission inventory and conformity analysis work performed by OKI.

Local Inputs and Post-Model Processing

OKI incorporates a variety of sources of local data to both improve and confirm the accuracy of VMT, as well as other travel-related parameters. Free flow speeds used on the highway and transit networks are compared to third party data of actual travel speeds gathered by anonymous cell phones, in-vehicle navigation systems and GPS-enabled fleet vehicles. The OKI post-processing program, IMPACT, uses the loaded highway network to generate VMT by hour, VMT by speed distribution and VMT by facility type. These tables are then combined with MOVES emission factors to generate emissions. Two separate sets of VMT tables are generated: one for the four Ohio counties plus Dearborn County Indiana, and a second for the three Kentucky counties. The VMT by hour tables utilize hourly traffic distribution and directional split factors for different roadway types as developed by OKI. The main source of the data is traffic counts from the permanent traffic counting stations located throughout the OKI region for the years of 2008-2012. This data was supplemented with data collected at coverage count stations (locations with counts taken on only one-two days). The stations were classified by area type: urban and rural, and functional classification: freeway, arterial and collector. Speeds representing various "loaded" conditions (with traffic volumes) are estimated using techniques from the 2010 Highway Capacity Manual. This permits the estimation of speeds as conditions vary from hour to hour on the different facility types throughout the region. The IMPACT program performs the appropriate summation by area and roadway type as well as regional totals. OKI has also developed seasonal conversion factors to adjust traffic volumes to summer conditions. The factors were derived from local data collected at permanent traffic counting stations during 2008-2012 utilizing the average daily traffic monthly conversion factors for June, July and August.