Mobile Source Emissions Inventory for Cincinnati Ozone Maintenance Area – MOVES emissions model

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. Emission estimates for the Year 2005, 2008, 2015, 2020, and 2030 developed in support of revision to Ozone State Implementation Plan

April 2012

Prepared for the Indiana Department of Environmental Management, the Kentucky Division for Air Quality and the Ohio Environmental Protection Agency 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 Indiana Department of Environmental Management, the Kentucky Division for Air Quality and the Ohio Environmental Protection Agency. The Cincinnati Ozone Maintenance 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 with emission estimates prepared by the Ohio Department of Transportation. This report includes emission estimates for the years 2005, 2008, 2015, 2020 and 2030 was generated to support a revision to the SIPs for the 8-hour Ozone standard. EPA's Motor Vehicle Emission Simulation (MOVES) 2010 was used to generate the emission rates.
Date	April 2012
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The preparation of this document was financed cooperatively by the Federal Highway Administration, the Federal Transit Administration, the Commonwealth of Kentucky Transportation Cabinet, the Ohio Department of Transportation, and the units of local and county government in the OKI region. The opinions, findings, and conclusions expressed in this document are those of the OKI Regional Council of Governments and are not necessarily those of the U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation.

MOBILE Source Emissions Inventory for the Cincinnati Ozone Maintenance area

This report was prepared for the Indiana Department of Environmental Management, the Kentucky Division for Air Quality and the Ohio Environmental Protection Agency. The Cincinnati Ozone Maintenance 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 Ohio is outside OKI's MPO boundaries. The Ohio Department of Transportation prepares emission estimates for Clinton County. This report includes emission estimates for the years 2005, 2008, 2015, 2020 and 2030 generated to support the SIPs for the 8-hour ozone standard. EPA's Motor Vehicle Emissions Simulator (MOVES) 2010 model was used to generate the vehicle emission rates. In December 2009, MOVES replaced MOBILE6.2 as the EPA's official emission factor model. The OKI travel demand model version 7.6 was used to generate VMT and speed estimates. MOVES emission rates were generated for VOC's, and NO_x.

OKI, as the MPO, is responsible for transportation planning and air quality/transportation conformity. Transportation conformity is a mechanism to ensure that federal funding and approval are given to those transportation activities that are consistent with the air quality goals of the State Implementation Plans (SIPs) for Indiana, Kentucky and Ohio. The SIPs include an inventory of projected emissions from vehicles. One or more of the analysis years in the projected inventory may be designated as the motor vehicle emissions budget (MVEB). This budget establishes a maximum allowable limit on future emissions from vehicles (mobile sources). OKI's transportation plans and programs must be shown to be in conformity with all SIP provisions. The conformity process is a quantitative analysis, using U.S.EPA's vehicle emissions software (currently MOVES), demonstrating that forecasted regional vehicle emissions do not exceed the established budget.

Table 1 shows daily mobile source emissions for the combined Indiana and Ohio portions of the Maintenance area, including Clinton County. Table 2 shows daily mobile source emissions for the Kentucky portion of the Maintenance area. Separate MVEB's are typically designated for these two areas. An additional safety margin should be added to the MVEB's due uncertainty with growth assumptions utilized in the OKI travel demand model and MOVES. Daily mobile source emissions for each county are shown in Table 3.

Table 1

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

	2005	2008	2015	2020	2030
VOC	93.68	95.54	48.75	37.24	31.81
NOx	157.38	131.28	81.95	63.59	56.48

Table 2

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

	2005	2008	2015	2020	2030
VOC	25.20	16.53	9.08	5.89	4.53
NOx	80.14	55.34	31.55	18.75	14.37

Table 3

Mobile Source Emissions by State/County for the Cincinnati Ozone Maintenance Area (tpd)

State	2005	2008	2015	2020	2030
Indiana					
Dearborn NA					
VMT	599,761	613,027	686,339	730,126	800,277
VOC	1.36	1.38	0.71	0.54	0.46
NOx	2.28	1.90	1.19	0.92	0.82
Ohio					
Butler					
VMT	7,804,476	8,133,554	8,721,511	9,277,916	10,169,344
VOC	17.24	17.58	8.97	6.85	5.85
NOx	28.96	24.16	15.08	11.70	10.39
Clermont					
VMT	5,391,578	5,599,530	5,810,859	6,181,573	6,775,503
VOC	11.49	11.72	5.98	4.57	3.90
NOx	19.30	16.10	10.05	7.80	6.93
Hamilton					
VMT	23,170,766	23,481,421	25,598,858	27,231,982	29,848,450
VOC	50.60	51.61	26.33	20.12	17.18
NOx	85.01	70.92	44.27	34.35	30.51
Warren					
VMT	6,263,010	6,464,217	6,571,210	6,990,432	7,662,077
VOC	12.99	13.25	6.76	5.16	4.41
NOx	21.82	18.20	11.36	8.82	7.83
OKI OH/IN Total					
VMT	43,229,591	44,291,749	47,388,777	50,412,029	55,255,652
VOC	93.68	95.54	48.75	37.24	31.81
NOx	157.38	131.28	81.95	63.59	56.48
Clinton, OH					
VMT	1,956,501	1,939,190	2,215,886	2,349,923	2,736,782
VOC	2.92	2.51	1.37	0.93	0.71
NOx	6.53	5.50	3.01	1.86	1.28
OH/IN VOC Total	96.60	98.05	50.12	38.17	32.52
OH/IN NOx Total	163.90	136.78	84.96	65.45	57.76
Kentucky	**2005**	**2008**	**2015**	**2020**	**2030**
Boone					
VMT	4,186,006	4,355,527	4,712,497	5,129,347	5,802,955
VOC	9.71	6.37	3.50	2.27	1.75
NOx	30.88	21.32	12.16	7.22	5.54
Campbell					
VMT	2,437,698	2,495,174	2,727,746	2,969,033	3,358,939
VOC	5.62	3.69	2.03	1.31	1.01
NOx	17.87	12.34	7.04	4.18	3.20

Kenton					
VMT	4,182,042	4,197,027	4,791,791	5,215,655	5,900,597
VOC	9.87	6.47	3.56	2.31	1.77
NOx	31.40	21.68	12.36	7.34	5.63
OKI KY Total					
VMT	10,805,746	11,047,728	12,232,034	13,314,036	15,062,492
VOC	25.20	16.53	9.08	5.89	4.53
NOx	80.14	55.34	31.55	18.75	14.37
NA Area Total					
VOC	121.80	114.58	59.21	44.06	37.05
NOx	244.05	192.12	116.51	84.20	72.13

Mobile Source Emission Forecast Process

Emission Factor Model

OKI's conformity assessment utilized U.S.EPA's emissions model MOVES 2010 to develop emission factors for VOC and NO_X. Table 4 summarizes the settings used in the MOVES run specification file. Table 5 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 4

MOVES RunSpec Parameter	Settings
MOVES 2010a, default database 20100829	
Scale	County, Emission 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 source types, gasoline and diesel
Road Type	All road types including off-network
Pollutants and Processes	All Ozone categories, Total Energy Consumption
Strategies	Modified AVFT strategy file to reflect 0% CNG buses in the transit fleet
General Output	Units= grams, joules and miles
Output Emissions	Time = hour, Location =county, on-road emission rates by road type and source use type.
Advanced Performance	none

Table 5

County Data Manager	Data Source
Source Type Population	Local and default. Local data from KYTC (2011) and ODOT (2010) from motor vehicle registration data. Default data used for source types 41, 61 and 62.
Vehicle Type VMT	Local and default. HPMSVTypeYear VMT=daily VMT from OKI travel demand model with EPA's daily to annual VMT converter applied. monthVMTFraction = default. dayVMTFraction=default, hourVMTFraction=local.
I/M Programs	Default modified to reflect discontinued I/M program in 2006
Fuel Formulation	Modified to reflect low RVP fuel program in Southwest Ohio
Fuel Supply	Default
Meteorology Data	Local. MOBILE6 converted values for Ohio and Kentucky values from Kentucky Division for Air Quality.
Ramp Fraction	Local. OKI travel demand model.
Road Type Distribution	Local. OKI travel demand model.
Age Distribution	Local and default. Local data from KYTC (2011) and ODOT (2010) from motor vehicle registration data. Default data used for source types 41, 61 and 62.
Average Speed Distribution	Local. OKI travel demand model.

OKI Travel Demand Model

Vehicle miles traveled and vehicle hours were estimated using the OKI Travel Demand Model Version 7.6. The OKI Travel Demand Model is composed of CUBE Voyager programs and a series of FORTRAN programs written by OKI. 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 OKI region is subdivided into 1608 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 5 of *OKI 2030 Regional Transportation Plan 2008 Update* provides a complete demographic overview of the region.

OKI utilizes both base year (2005) and future year data (2010, 2020 and 2030) in the planning process. Planning data are maintained at the Traffic Analysis Zone (TAZ) level, and originate in the 2000 Census of Population and Housing. Base year 2005 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 2005 and future years 2010, 2020 and 2030 originate with the 2000 Census of Population and Housing. Utilizing ArcView GIS, population data at the zonal level for 2000 was derived from the area proportion allocation of block level population.

As a tri-state regional planning agency, OKI uses county level projections as prepared by the respective state data centers (Ohio Department of Development Office of Strategic Research, Kentucky State Data Center and Indiana Business Research Center) as control totals. The most current projections (years 2005 to 2030) were released by the Ohio and Indiana state data centers in 2003 and the Kentucky State Data Center in 2004. Population projections at the zonal level are calculated by multiplying household size by the projected zonal households. 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 2005 originates with the 2000 Census of Population and Housing. Utilizing the geographic information system ArcMap, household data at the zonal level for 2000 was derived from the area proportion allocation of block level households. Year 2000 household data was updated to 2005 with residential building permits issued between January 2000 and December 2004. The residential building locations were geo-coded in ArcMap, then aggregated to the TAZs. The housing unit totals for each TAZ were converted to households by applying a vacancy rate, an adjustment for permitted but unbuilt units, and subtracting demolitions (where data was available). These households were then added to the year Census 2000 zonal household total to arrive at 2005 households for each TAZ.

Future Year Data: The preparation of household projections was accomplished by calculating the number of households for a projected county population using ratios of householders to total population by age specific cohorts derived from the 2000 Census for each analysis year. 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.

Household Vehicles

Base and Future Year Data: Base and future year household vehicle data were obtained from the 2000 Census of Population and Housing. The 2000 Census is the only source of household vehicle data available at the block group level. Average vehicles per household were calculated for block groups then applied to the TAZs associated with each block group. The 2005, 2010, 2020 and 2030 vehicles per household level was held at the 2000 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 ratio (the number of employed persons in the labor force per persons 16 and over). Household data for base year 2005 originates with the 2000 Census of Population and Housing. Utilizing the geographic information system ArcMap, household data at the zonal level for 2000 was derived from the area proportion allocation of block group level employed labor force. The labor force projections for 2005, 2010, 2020 and 2030 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 or ES202) data for 2005 was utilized as the primary tool to calculate employment at the zonal level. Individual business records containing physical location, number of employees and SIC code were geocoded through ArcMap and aggregated to the TAZ level. This data set was supplemented by other sources of data to complete the commuting employment picture in the OKI region. Each zone's employment was divided according to the SIC code into three classes (retail, office, industrial) based upon 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 based on travel time studies performed locally. 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 included as input into MOVES. 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 was the permanent traffic counting stations located throughout the OKI region for the years of 2004-2006. 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 1997 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 1994-1997 utilizing the average daily traffic monthly conversion factors for June, July and August. Further information on OKI's IMPACT program is documented in the report, *"Travel Demand Model*

Summary Reporting and Impact Summary Reporting: OKI/MVRPC Travel Demand Model User's Guide", OKI 2003.