

FINAL REPORT

# **Carbon Monoxide Analysis for Highway Projects: Phase II**

**Project IIIA-H1, FY 97**

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# EXECUTIVE SUMMARY

Air quality analyses for highway projects are conducted to determine whether the projects have the potential to cause exceedances of the National Ambient Air Quality Standards (NAAQS). Detailed air quality modeling analyses are often used during the planning stage to estimate a project's impact on the ambient concentration of atmospheric pollutants. One pollutant of concern is carbon monoxide (CO). A detailed CO analysis is performed using computer models that require extensive input data. Performing this type of modeling is time consuming and increases project costs. An alternative to using a detailed model is to use a screening model.

A screening model provides a worst-case analysis of a project and requires relatively little input data, whereas a refined model gives a more accurate prediction of a project's impact and typically requires large amounts of input data. For regulatory purposes, if a screening model shows worst-case impacts from a roadway project will not exceed ambient air quality standards, there is no need to use a more time-intensive refined model, thus reducing the overall number of projects that must be evaluated with refined models.

Because the NAAQS for CO are expressed as maximum concentrations not to be exceeded more than once a year, a screening analysis may be an appropriate tool which can be used to determine whether a detailed analysis is necessary. The screening analysis is used to determine whether a project *may* cause a NAAQS violation. A screening model uses readily available data to make a *conservative* worst-case estimate of a project's impact. Projects that pass a worst-case screening analysis would not require a detailed analysis.

The Illinois Department of Transportation (IDOT) currently uses the computer screening model Illinois CO Screen for Intersection Modeling (COSIM) to estimate worst-case CO concentrations that could result after the construction of proposed roadway projects affecting signalized intersections having total traffic volumes of more than 16,000 average daily traffic (ADT). The model was developed as part of the Illinois Transportation Research Center (ITRC) research project IIIA-H1, FY 97, completed in October 1999. If the results from COSIM are within the NAAQS for CO, no further CO modeling is required for the intersection. If the results from COSIM indicate that the project may cause a NAAQS violation, a detailed analysis is performed to more accurately evaluate potential CO levels.

Modeled results from Version 1.0 and 1.1 of COSIM are based on the U.S. Environmental Protection Agency's (USEPA) mobile source emission model, MOBILE5b, and roadway dispersion model, CAL3QHC v 2.0. In January 2002, the USEPA released an updated version of the MOBILE model called MOBILE6. The main objective of this research was to update COSIM with new vehicle emission factors using MOBILE6. In addition to updating the emission factors used in COSIM, pre-screen criteria for determining when COSIM needs to be used for a roadway project were developed. The new criteria were developed to replace the 16,000 ADT threshold and were incorporated into the new release of COSIM as a Pre-Screen feature. Only three inputs are required to run the Pre-Screen feature: 1) county in which the intersection is located, 2) traffic volume on the busiest leg of the intersection, and 3) closest receptor distance to any one edge of roadway.

The updated version of COSIM, designated as Version 2.0, has been distributed to IDOT personnel in each district for use in project-level CO air quality analysis. An updated COSIM Version 2.0 user's manual was also created and distributed.

# PREFACE

In the first phase of this project, completed in October 1999, researchers developed and tested a Windows-based computer model called Illinois Carbon Monoxide Screen for Intersection Modeling, or Illinois COSIM for short. Illinois COSIM is currently being used in Illinois as a screening model for evaluating worst-case carbon monoxide (CO) air quality impacts from transportation projects. At the completion of Phase I, the Illinois Transportation Research Center (ITRC) Advisory committee recommended two main objectives to be considered in the second phase of the project: 1) to update COSIM to include emission factors from U.S. Environmental Protection Agency's (USEPA) vehicle emission model, MOBILE6, and 2) to investigate replacing the current threshold for determining when a screening level analysis should be performed for an Illinois roadway project.

Due to the delayed release of MOBILE6, Phase II focused on using the draft version of MOBILE6 to determine a preliminary set of emission factors for incorporation into COSIM. Also during Phase II, researchers explored methods to develop "pre-screen" criteria to determine when COSIM should be run. The "pre-screen" criteria were based on emission factors taken from MOBILE5b. This work was completed in September, 2000.

Phase II of the project was extended with the release of MOBILE6 in January, 2002. The main objectives of the extension were: 1) to incorporate emission factors determined using MOBILE6 into an updated version of Illinois COSIM, and 2) to determine the "pre-screen" criteria using the updated version of COSIM with the MOBILE6 emission factors.

This report summarizes the methods used to determine MOBILE6 emission factors and to develop revised pre-screen criteria. The report also documents the creation of a new version of the COSIM model designated as Version 2.0.

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# Chapter 1: Updating Illinois COSIM Emission Factors

Illinois COSIM (Carbon Monoxide Screen for Intersection Modeling) is a Windows-based screening model that is currently being used by the Illinois Department of Transportation (IDOT) staff to estimate worst-case carbon monoxide (CO) concentrations that could result from proposed roadway projects affecting signalized intersections having total traffic volumes of more than 16,000 ADT. If the results from COSIM are within the National Ambient Air Quality Standards (NAAQS) for CO, no further CO modeling is required for the intersection. If the results from COSIM indicate that the project may cause a NAAQS violation, a detailed analysis is performed to more accurately evaluate potential CO levels.

Modeled results from the first version of COSIM are based on the U.S. Environmental Protection Agency's (USEPA) mobile source emission model, MOBILE5b, and roadway dispersion model, CAL3QHC v 2.0.

In January 2002, the USEPA released an updated version of the MOBILE model called MOBILE6. Significant changes to the model include updated basic emission rates, more realistic driving patterns, improved correction factors, changes in fleet composition, and impacts of new regulations promulgated since MOBILE5b (USEPA, 2002a). As COSIM's modeled CO concentrations are determined using emission factors from the MOBILE5 model, it was necessary to update COSIM with new emission factors obtained using MOBILE6. This chapter details the updates made to the "Illinois specific" emission factors used in Version 2.0 of the COSIM model.

## 1.1 Emission Factor Updates

Emission factors in the original COSIM model were based on the results of eight different MOBILE5b input files. Four criteria were used for determining the MOBILE5b input files necessary to cover all areas in Illinois. The original criteria used were as follows:

1. Location north or south in the State for temperature information. The dividing line is roughly the 40° North latitude line.
2. Attainment status in the region – in attainment or non-attainment for ozone.
3. Presence or absence of a vehicle inspection and maintenance (I/M) program in the region.
4. The year for which modeling needs to be performed – before year 2000 or after the year 2000 (applicable only in the non-attainment regions with an I/M program).

Using these four criteria, eight MOBILE5b input files were created to account for all regions on a countywide basis. These files were for:

1. Chicago with Reformulated Gasoline (RFG) and I/M (for the Chicago Non-attainment area (NAA)), using Chicago wintertime temperatures (winter is typically the time of highest CO concentrations), for the years 1999-2000.
2. Chicago with RFG and I/M (for the Chicago NAA), using Chicago wintertime temperatures, for the years 2001-2030.
3. Chicago with RFG but without I/M (for the Chicago NAA), and using Chicago wintertime temperatures.

4. North counties outside Chicago, with no RFG and no I/M, using Chicago wintertime temperatures.
5. South counties outside Metro-East, with no RFG and no I/M, and the same fuel volatility as the North Counties, using St Louis wintertime temperatures.
6. Metro-East with low-volatility gasoline and with I/M, and St Louis wintertime temperatures (with the I/M inputs being the same for Chicago and Metro-East) for the years 1999-2000.
7. Metro-East with low-volatility gasoline and with I/M, and St Louis wintertime temperatures (with the I/M inputs being the same for Chicago and Metro-East) for the years 2001-2030.
8. Metro-East with low-volatility gasoline but no I/M, and St Louis wintertime temperatures.

As Version 2.0 of COSIM will be used to evaluate proposed roadway projects during or after 2003, criterion number 4 (accounting for proposed improvements before 2000) is no longer applicable for determining emission factors. This eliminates the need for input files numbers 1 and 6 listed above. The following sections discuss the methods used to create the six new input files for use in MOBILE6 from the existing MOBILE5b files.

## **1.2 MOBILE6 Input Data Files**

MOBILE6 input files are significantly different from the input files used by MOBILE5b. Not only do the structures of the input files differ, but so do the data requirements. Therefore, a new file format had to be adopted and new input information had to be obtained. Similar to the procedure used to establish the MOBILE5b input files in creation of the first version of COSIM, the MOBILE6 input files were created under guidance from Illinois Environmental Protection Agency (IEPA) using a combination of worst-case values, Illinois State default values, and MOBILE6 default values. A summary of the inputs used for building the MOBILE6 files for COSIM are listed below in the order in which they appear in the files. Copies of the six new input files are provided in Appendix A.

### ***1.2.1 Pollutant Type***

MOBILE6 has the ability to calculate hydrocarbon (HC), oxides of nitrogen (NO<sub>x</sub>), and CO emissions. Input files were set up to only estimate CO emissions.

### ***1.2.2 Emission Types***

MOBILE6 calculates eight different types of emission factors: 1) Exhaust Running; 2) Exhaust Start; 3) Exhaust Hot Soak; 4) Exhaust Diurnal; 5) Evaporative Resting Loss; 6) Evaporative Running Loss; 7) Evaporative Crankcase; and 8) Evaporative Refueling. Exhaust Running and Start Emissions are the only types of emission factors that pertain to CO. To ensure that worst-case conditions were met, all input files were setup to include both exhaust running and start emissions.

### ***1.2.3 Reformulated Gasoline***

MOBILE6 allows for the effects of a reformulated gasoline program to be considered in

determining emissions. The north non-attainment region in Illinois has a reformulated gasoline program, and therefore the two input files for that region include appropriate inputs for reformulated gasoline.

#### ***1.2.4 Oxygenated Fuels***

MOBILE6 allows for the effects of oxygenated fuels to be considered in determining emissions. Oxygenated fuel is used throughout Illinois and thus oxygenated fuel parameters were added to the three southern region input files and the north attainment region input file. The parameters were not included in the two input files representing the north non-attainment region as they already contained parameters for a reformulated gasoline program which account for oxygenated fuel. Approximately 30 percent of the non-Chicago area fuel contains 10 percent ethanol. The oxygenated fuel parameters used in the four input files to reflect this were as follows:

- Ether blend market share - 0.0
- Alcohol blend market share - 0.3
- Average oxygen content of ether blend fuels - 0.0
- Average oxygen content of alcohol blend fuels - 0.35
- A 1-psi Reid Vapor Pressure waiver has been granted

#### ***1.2.5 Daily Temperature Range***

MOBILE6 uses minimum and maximum daily temperatures to apply corrections to exhaust CO emissions. An average daily emission factor is calculated based on a diurnal variation of the minimum and maximum temperatures. As CO concentrations are higher in colder temperatures, daily winter temperatures were used in the input files. January average daily temperatures were considered representative for these purposes. For the three input files representing areas North of 40° latitude maximum and minimum daily temperatures were 29 °F and 13 °F respectively. For the three input files representing areas South of 40° latitude, maximum and minimum daily temperatures were 38 °F and 21 °F respectively. These same values were used in the original MOBILE5b input files.

#### ***1.2.6 Fuel Reid Vapor Pressure (RVP)***

RVP is a measure of gasoline volatility. Both exhaust and evaporative emissions in MOBILE6 can vary with fuel volatility. However, at wintertime temperatures (below 45 °F) RVP has no effect on emissions (USEPA, 2002a). Since the maximum daily temperature for all input files is below 45 °F, RVP does not effect the emissions, but is still a required MOBILE6 input parameter. All input files contain a RVP of 13.5 psi.

#### ***1.2.7 Vehicle Registration Data***

MOBILE6 allows the user to supply vehicle registration distribution by age for the 28 vehicle types included in the model. IEPA provided two external data files that contain vehicle registration data specific to the northern and southern non-attainment areas in Illinois. Contents of the external data files are provided in Appendix B. The two input files representing the northern and southern attainment areas use the default MOBILE6 registration distribution for each vehicle type, which are based on U.S. vehicle fleet data.

### **1.2.8 Inspection/Maintenance (I/M) Programs**

Illinois has implemented I/M programs in the non-attainment areas near Chicago and the Metro-East area to help reduce air pollution from mobile sources. The I/M programs implemented in these two areas are the same. MOBILE6 allows the user to supply up to seven different exhaust and evaporative emission I/M programs and thus take credit for reduced emissions from the programs. IEPA provided an external MOBILE6 I/M data file for calculating emission factors in the Chicago and St. Louis Metro-East areas. The file includes seven I/M programs used in Illinois: 1) idle test for older light-duty vehicles, 2) IM 240 test for newer light-duty vehicles, 3) gas cap check for older light-duty vehicles, 4) evaporative onboard diagnostic and gas cap check for newer light-duty vehicles, 5) idle test for heavy duty vehicles, 6) gas cap check for heavy-duty vehicles, and 7) onboard diagnostic exhaust test for newer light-duty vehicles. Contents of the I/M data file are provided in Appendix B. Contents of the “cutpoint” data file referenced by the IM240 test program are also included in Appendix B. For additional information regarding the interpretation of I/M data inputs, see the *Users Guide to MOBILE6 (Mobile Source Emission Factor Model)*, Chapter 2.8.9.4, available from USEPA’s Office of Mobile Sources ([www.epa.gov/OMSWWW](http://www.epa.gov/OMSWWW)).

### **1.2.9 Calendar Years**

MOBILE6 has the ability to model emission factors for the calendar years 1952 to 2050, inclusive. Each input file contained a separate scenario to model each year from 2002 to 2015. The results from the model years 2002 to 2013 were incorporated into COSIM. Emission factors for model years after 2013 were set equal to the 2013 factors. To ensure that setting model years after 2013 to the 2013 factors would yield worst-case results, emission factors for the North Attainment region were determined for model years 2002 to 2030 as an example case. Results are provided in Appendix C. Results from the example case showed that MOBILE6 emission factors slightly decrease as model year increases, therefore, emission factors for the years 2002 to 2013 are worst-case. This approach was considered conservative and approved by IEPA.

### **1.2.10 Calendar Month**

MOBILE6 can either model emission factors for January 1 or July 1 of the designated model year. Since the average daily temperature range was based on Illinois wintertime temperatures, January 1 was chosen as the calendar month in each input file. Selecting January 1 as the modeled month flags MOBILE6 to use a winter vehicle fleet as well as winter season reformulated gasoline rules when calculating CO emission factors.

### **1.2.11 Altitude**

MOBILE6 can model emission factors for low and high altitude regions. Low regions are based on conditions approximately 500 feet above mean sea level, where as high regions are based on conditions approximately 5,500 feet above mean sea level. The input files were set up to reflect low altitude regions.

### **1.2.12 Roadway Type**

MOBILE6 allows users to calculate facility-specific emissions on four different roadway types: local roadways, arterial/collector roadways, freeways, and freeway ramps. Since COSIM is designed to estimate “worst-case” CO concentrations, emissions from local roadways, arterial/

collector roadways, and freeway ramps were evaluated to determine which type of roadway produces the highest CO emissions. Freeways were not evaluated, as they are not typically controlled with signalized intersections.

CO emission factors for local and freeway ramp roadway types cannot be calculated at idle and specific free flow speeds. Results from both roadway types were compared to emission factors from arterial/collector roadways that were calculated at speeds of 5 to 55 mph in 5 mph increments. The comparison showed that emission factors from local roadways were higher than emission factors from arterial/collector roadways at speeds of 25 to 40 mph and emission factors from freeway ramps were higher than emission factors from arterial/collector roadways at speeds of 10 to 55 mph (see Table 1-1).

Arterial/collector roadway type was used to model the CO emission factors used in COSIM, as idle and free flow speeds cannot be modeled using local roadway and freeway ramp types. However, since it was shown that local and freeway ramp roadway types produce higher emission factors than the arterial/collector roadway type at the speeds listed above, two notes were added to the intersection input dialog box in COSIM asking the user to “Enter an approach speed of 15 mph or less for local roadways” and to “Enter an approach speed of 5 mph for highway ramps.” (This convention is also noted in the COSIM output file report and in the user’s manual.) Following this guidance for local and freeway ramp roadway types slightly overestimates emissions on these roadway types and thus ensures that worst-case conditions are being satisfied in COSIM.

**Table 1-1** Emission factors vs. year for arterial/collector, local, and freeway ramp roadway types in the North Attainment Region.

Model Year	Arterial/Collector Roadway EFs (g/mi)											Local EFs (g/mi)	Ramp EFs (g/mi)
	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph		
2002	59.98	43.31	38.23	35.58	34.12	33.40	33.41	34.38	35.40	36.46	37.58	33.66	47.93
2003	57.12	41.54	36.79	34.33	32.97	32.33	32.37	33.34	34.35	35.40	36.50	32.30	46.10
2004	51.13	37.68	33.50	31.33	30.13	29.55	29.58	30.39	31.25	32.15	33.08	29.88	40.12
2005	47.70	34.75	30.73	28.64	27.48	26.92	26.93	27.70	28.51	29.35	30.23	27.38	36.10
2006	42.27	30.89	27.30	25.45	24.42	23.90	23.90	24.55	25.23	25.95	26.70	24.62	31.02
2007	40.73	29.84	26.39	24.60	23.60	23.11	23.11	23.75	24.42	25.12	25.85	23.88	29.59
2008	39.03	28.85	25.58	23.89	22.96	22.50	22.51	23.14	23.79	24.48	25.19	23.33	28.35
2009	37.26	27.59	24.50	22.91	22.03	21.61	21.63	22.25	22.89	23.55	24.24	22.40	26.98
2010	35.65	26.41	23.44	21.91	21.07	20.66	20.68	21.28	21.90	22.54	23.21	21.50	25.59
2011	34.29	25.49	22.62	21.14	20.33	19.94	19.96	20.54	21.14	21.77	22.41	20.83	24.50
2012	32.78	24.45	21.71	20.31	19.53	19.17	19.19	19.75	20.33	20.94	21.56	20.06	23.38
2013	31.64	23.61	20.97	19.62	18.88	18.53	18.55	19.09	19.66	20.24	20.84	19.45	22.47
2014	30.67	22.90	20.35	19.04	18.32	17.98	18.00	18.53	19.08	19.64	20.22	18.94	21.71
2015	29.85	22.31	19.83	18.55	17.85	17.52	17.54	18.06	18.59	19.13	19.70	18.51	21.08

### 1.2.13 Speed

MOBILE6 allows users to model a single average speed over the entire day on an arterial/collector type roadway. Allowable values range from 2.5 through 65 miles per hour (mph). Each input file contained separate scenarios to model speeds ranging from 5 to 55 mph in increments of 5 mph. Scenarios for 2.5 mph were also included in the input files to calculate emission factors used in estimating idle speed conditions. Idle emission factors in g/hr were determined by multiplying the emissions calculated at 2.5 mph in g/mi by the modeled speed of 2.5 mi/hr.

#### ***1.2.14 The Remaining MOBILE6 Input Variables***

Default values were assumed for the remaining MOBILE6 input variables and therefore were not explicitly included in the input files.

### **1.3 MOBILE6 Output**

The values in the six lookup tables of emission factors in the original COSIM computer code were replaced with the results from running the new MOBILE6 input files. The new lookup tables are provided in Appendix C. Note that the MOBILE6 emission factors for the six regions are significantly lower than the previously used MOBLIE5b emission factors and the default emission factors found in the MOBILE6 training manual (Sierra Research of Sacramento, 2002). This trend did not surprise IEPA personnel, as an overall comparison of emission factors determined with MOBILE5b and MOBILE6 can vary greatly depending on the pollutant of interest, the calendar year being considered, local fuel parameters, local driving activity and other local user inputs (Long, 2002).

The updated version of COSIM accesses and uses the appropriate emission factors using the same methodology as the original version, as described below.

When a user selects a county in COSIM, a number is assigned to the selected county. Based on the county number, at least one region index is assigned to the current project. The region index references one of the six emission factor tables arranged by model year versus average speed.

The year ranges from 0 to 11, covering the years 2002 to 2013. As previously discussed in section 1.2.9, emission factors for years after 2013 are assumed equal to the 2013 EFs.

The speed ranges from 0 to 11, covering speeds from 0 mph (idle) to 55 mph, in increments of 5 mph. EFs for speeds between the 5 mph intervals are obtained by linear interpolation. The feasibility of linear interpolation was tested in the original COSIM version by comparing the exact emission factors calculated by MOBILE5b to the emission factors interpolated by COSIM (Larson et al., 1999). Results showed that the linear interpolation was acceptable.

In counties where I/M and non I/M regions adjoin, the same methodology is used as in the original COSIM of taking emission factors from both the I/M and non I/M regions, weighting them accordingly, and adding them together to determine an average emission factor for the county is used (Larson et al., 1999).

After the idle and free-flow emission factors are determined, COSIM inserts them into the CAL3QHC input file and runs CAL3QHC to determine the worst-case CO concentrations.

### **1.4 MOBILE6 Updates**

Since the release of MOBILE6 in January 2002, the model has been expanded to include particulates and air toxics. The new model is called MOBILE6.2. MOBILE6.2 model's results for HC, CO, and NO<sub>x</sub> are not changed from the original MOBILE6 (USEPA, 2002b).

## Chapter 2: Developing Revised Pre-screen Criteria

As described in Chapter 1, IDOT currently uses a combination of a pre-screen criterion, a screening model, and a refined analysis for evaluating CO air quality impacts of transportation projects in Illinois. This is outlined in an agreement IDOT has with IEPA titled “Agreement on Microscale Air Quality Assessments for IDOT Sponsored Transportation Projects.” If average daily traffic (ADT) at an intersection is less than 16,000 vehicles per day, CO air quality impacts at the intersection need not be evaluated. If ADT is above this pre-screen criterion, the computer-based screening tool, Illinois COSIM is used to evaluate worst-case CO air quality impacts at the intersection and determine whether a more detailed air quality analysis is required for the project.

With the new version of COSIM, new pre-screen criteria were developed to replace the 16,000 ADT. The new criteria account for the region modeled, the closest receptor distance, and the traffic volume on the heaviest traveled leg of the intersection (both directions, either in vehicles per hour or ADT). Equations representing the new criteria were incorporated into the COSIM program as a new pre-screen feature. This chapter documents the methods used to create the new pre-screen criteria.

### 2.1 Revised Pre-screen Criteria

The goal for developing the new pre-screen was to create conservative yet defensible cut-off criteria (to decide whether or not COSIM was needed) that could be readily used by IDOT personnel. Since the current pre-screen criterion used by IDOT is based on ADT values, the new criteria are also based on ADT values at IDOT’s request. In addition to ADT, the new pre-screen criteria also include the distance to the nearest receptor. Since modeled CO concentrations are higher the closer the receptor is to the roadway, an intersection with receptors located near the intersection should have more stringent ADT limitations than an intersection with receptors located far from the roadways.

The new pre-screen criteria were developed using the new version of COSIM and a “worst-case” input scenario that was created for these COSIM runs to ensure that the new criteria would be conservative.

### 2.2 Creating the COSIM Base Case Scenario

Each COSIM variable that affects modeled CO concentrations was evaluated to ensure that the base case scenario was practical, yet conservative. Model year, background concentration, intersection surroundings, intersection type, and approach speeds used in the base case scenario are summarized in Table 2-1. The variables were determined based on the following evaluations.

**Table 2-1** *COSIM input variables used in the “worst-case” base case scenario.*

COSIM Variable	Value
Model Year	2002
Background Concentration	3.0 ppm
Surroundings	Corn
Intersection Type	3x3 One-way
Approach Speed	10 mph
Total Cycle Time	150 sec

### **2.2.1 Determining Model Year (2002)**

CO emission factors decrease from year to year in the MOBILE model. This is chiefly due to the retirement of older “dirtier” vehicles that occurs each year and their replacement by newer “cleaner” vehicles. Since the older vehicles tend to have greater CO emissions, reducing the number of old vehicles in the fleet reduces overall CO emissions. The earliest model year available in COSIM is 2002, and therefore 2002 was chosen as the base case scenario model year.

### **2.2.2 Determining Background Concentration (3 ppm)**

A CO background concentration of 3.0 ppm was chosen for the base case scenario. Field data show that CO 8-hour average concentrations at air quality sampling sites in Illinois rarely exceed 3 ppm (Illinois EPA, 2002) and therefore a background value of 3 ppm was considered a reasonable and conservative estimate.

### **2.2.3 Determining Intersection Surroundings (Corn)**

There are twelve (12) types of intersection surroundings from which to choose in COSIM. The intersection surroundings determine the surface roughness height and stability class that will be used in the dispersion calculations. In general, the physically shorter surroundings in COSIM are linked to more stable atmospheric conditions and thus produce higher modeled CO concentrations. For example, selecting soy beans will produce more stable atmospheric conditions than selecting fir forest. To provide a more balanced choice between urban and rural surroundings “corn” was chosen for the base case scenario.

### **2.2.4 Determining Intersection Type (3x3 one-way)**

In order to determine which intersection type produced the highest CO concentrations, each intersection type was evaluated with the same set of input variables. The input variables that were held constant during each run (Table 2-2) reflected input variables considered typical to all regions throughout the state.

**Table 2-2** *Input variables held constant to determine worst-case intersection type.*

COSIM Variable	Value
Year	2002
Background Concentration	3.0 ppm
County	McHenry
Surroundings	Corn
Approach Speed	5 mph
Cycle Time	75 sec
Receptor Distance	10 & 30 feet

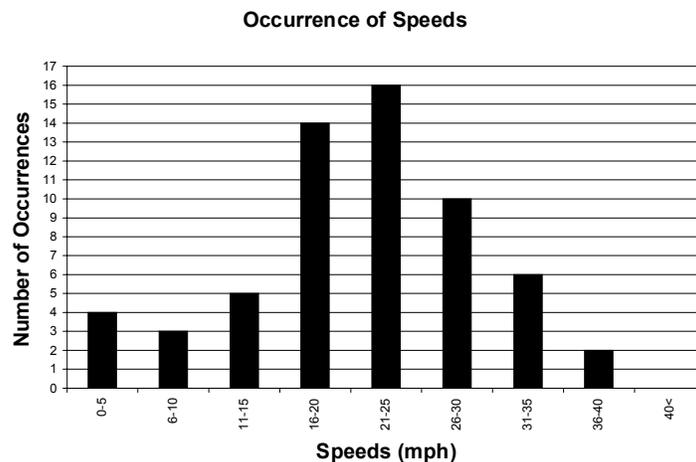
Once the constant variables were entered, the approach traffic volume on each leg of the intersection was assumed to be 50 vehicles per hour (vph). On intersection legs where traffic was traveling in two directions, the approach volumes were set equal for each direction. The approach volumes were then distributed to the various traffic movements on the leg. Designated and non-designated turning volumes were assigned 15% and 10% of the approach volume respectively. The remaining approach volume was assigned to thru traffic. A series of model runs was performed by increasing the approach traffic volumes on each leg by 50 vph until the modeled concentrations exceeded the 8-hour NAAQS of 9 ppm. This procedure was repeated for

each of the fourteen intersection types available in COSIM. The type of intersection that corresponded to the failing model run with the least approach traffic volume per leg was deemed the worst-case intersection. Using this methodology, the worst-case intersection was the 3x3 one-way intersection.

### 2.2.5 Determining Approach Speeds (10 mph)

Approach speeds of 5 mph on each leg of the intersection produce higher modeled CO concentrations than any other combination of approach speeds. This occurs because the CO emission factors used in the dispersion modeling calculations are highest for 5 mph approach speeds. However, variables used for the pre-screen development need to be reasonable as well as conservative. The 5 mph approach speed may be unreasonably low and therefore not representative, i.e., very few intersections would actually be modeled with this low of an approach speed. A frequency plot for approach speed using COSIM runs provided by IDOT District 1 indicates that approach speeds of 5 mph are seldom used (Figure 2-1). (For runs that used different approach speeds on the various legs of the intersection, the lowest speed in the analysis was plotted on the frequency diagram.)

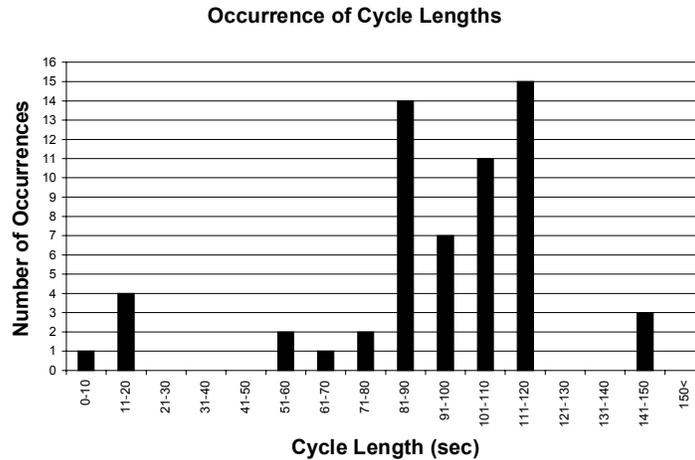
Based on this information, an approach speed of 10 mph was deemed a reasonable value for the approach speed to be used in the base scenario. The frequency plot showed that nearly 90% of the COSIM runs used approach speeds greater than 10 mph. Thus, using a 10 mph approach speed would produce conservative results for the majority of model runs, while still being realistic.



**Figure 2-1** Frequency of approach speeds used in IDOT District 1 COSIM runs.

### 2.2.6 Determining Signal Timing (150 Seconds)

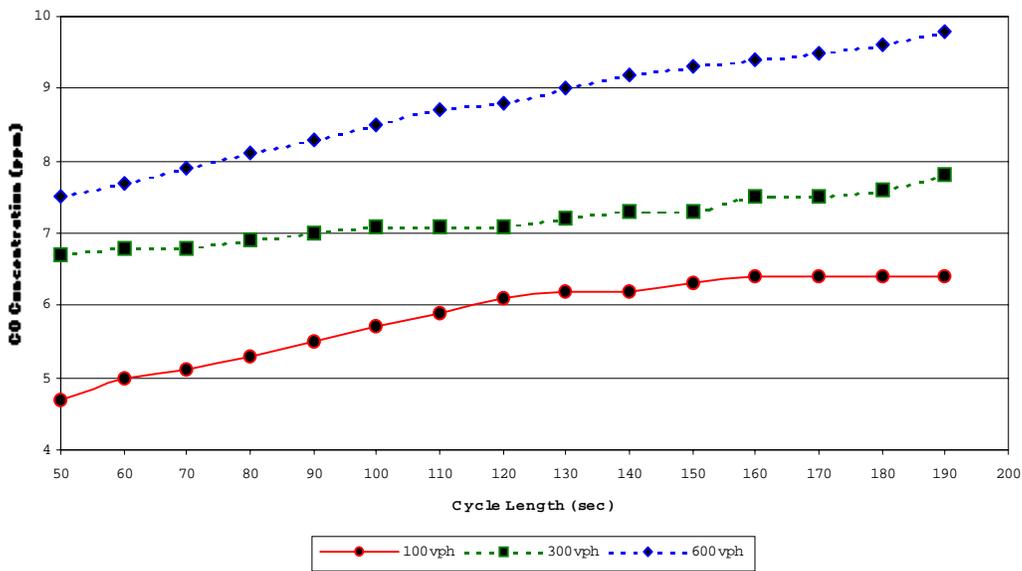
As with the approach speeds, the signal timing variable was chosen to be both conservative and realistic. To determine a base case signal timing typical of actual signal times modeled, a frequency diagram for total cycle time was created using data from COSIM runs provided by IDOT District 1 (Figure 2-2). Figure 2-2 shows that the majority of the COSIM runs used a total cycle time between 80 and 120 seconds.



**Figure 2-2** Frequency of total cycle times used in IDOT District 1 COSIM runs.

In COSIM, modeled CO concentrations generally increase as total cycle time increases. This results because red times assigned to the various traffic movements generally increase in proportion to increases in total cycle time. (This relationship is formally assumed in the "Quick and Easy" signal timing option of COSIM.) Holding all other variables constant, larger red times produce longer queue lengths, and thus create higher modeled CO concentrations. COSIM results, using the "Quick and Easy" feature, showed that modeled CO concentrations increased slightly as the total cycle time increased (Figure 2-3). Based on this information, a total cycle time of 150 seconds (2-1/2 minutes) was chosen as being conservative (a longer cycle time gives higher CO values), yet realistic (most total cycle times used in previous District 1 COSIM runs were between 80 and 120 seconds).

#### Cycle Length Analysis for One-Way 3x3



**Figure 2-3** CO concentrations vs. cycle length for a one-way 3x3 intersection type.

## **2.3 Representative Counties (DeKalb, Marion, Grundy, and Monroe)**

The State of Illinois is divided into 102 counties and these are separated into four regions for the purpose of assigning the emission factors used in COSIM: 1) Counties North of 40° Latitude, 2) Counties South of 40° Latitude, 3) Counties in the Chicago Metro-Area, and 4) Counties in the St. Louis Metro-East Area. COSIM determines the appropriate emission factors based on the region in which the intersection is located.

As emission factors vary significantly by region, four different sets of pre-screen criteria were developed to represent the four regions. Counties needed to be selected to represent each region for the development of the pre-screen criteria. County selection for regions 1 and 2 was arbitrary as the emission factors for each county within the respective region are the same. DeKalb County was chosen to represent region 1 and Marion County was chosen to represent region 2.

Selecting counties to be used for regions 3 and 4 was not as straightforward. The Chicago area and St. Louis Metro-East area are further divided into sub-regions with and without I/M programs. Fleet emission factors in I/M sub-regions are less than the fleet emission factors in non I/M sub-regions. For counties located in the areas where I/M and non I/M sub-regions adjoin, COSIM calculates an average emission factor. Emission factors are taken from both sub-regions (I/M and non I/M), multiplied by the percent of registered vehicles in each sub-region for the specific county, and added together to determine the average county-wide emission factor.

Since non I/M regions produce higher emission factors, the county with the largest fraction of vehicles registered in non I/M regions will have the highest county-wide emission factor and thus will produce the highest modeled CO concentrations (when all other variables are held constant). Grundy county in region 3 and Monroe county in region 4 have the largest fraction of vehicles registered in non I/M regions and therefore were chosen to represent regions 3 and 4 in the respective base scenarios.

## **2.4 Approach Volumes and Receptor Locations**

The only COSIM variables that were not pre-set in the base case scenarios were traffic approach volumes and receptor locations; two of the variables that will be inputs to the pre-screen criteria to determine if COSIM should be run. (The third input parameter is the county, determining which of the four pre-screen criteria will be applied.) A series of COSIM runs for each region was performed to determine the maximum approach volume for given receptor locations.

### ***2.4.1 Approach Volumes***

A series of model runs was set up with approach traffic volumes on each leg equal and ranging from 300 to 1,800 vph. Hourly traffic volumes in COSIM for non-designated turning movements were assigned 10% of the approach volume. Designated turning volumes were 15% of the approach volume. The remaining volume was assigned to thru traffic movements. The approach volume on each leg of the intersection was increased by 300 vph each run until the approach volumes reached 1,800 vph, at which time the intersection experienced oversaturated conditions.

Modeled traffic volumes did not exceed levels which would saturate the intersection. Oversaturation was considered to be an unrealistic case (intersections are designed to avoid overcapacity traffic volumes) that would produce modeled CO concentrations that were unrealistically high. Saturation levels at each modeled traffic volume were obtained from the

volume to capacity ratio, v/c, contained in the CAL3QHC output file produced in each COSIM run. When the v/c ratio exceeds 1.0, the intersection is considered to be over capacity, and large calculated queue lengths result. Since vehicles in a queue are considered to be in idle mode (the mode that produces that highest CO emissions), intersections that are over capacity tend to produce high modeled CO concentrations.

Volumes were set equal on each leg of the intersection. In using the pre-screen, users will enter the highest traffic volume on any one leg (both directions) of the intersection in either peak vehicles per hour or ADT. Since the pre-screen criteria assume the remaining legs have the same traffic volume, the criteria are conservative.

#### **2.4.2 Receptor Locations**

In general, modeled CO concentrations decrease as distance from the intersection increases. Receptor locations were set at equal distances from each leg of the intersection in each quadrant to determine the highest modeled concentrations. Distances ranged from 10 to 100 feet.

### **2.5 Calculating CO Concentrations**

CO concentrations were modeled with COSIM at each receptor distance for approach volumes ranging from 300 to 1,800 vph. The highest modeled 8-hour average concentration was recorded for each run. Note that each “receptor distance” consisted of four receptors located equi-distance from each roadway. Due to the 3x3 one-way street intersection geometry and equally distributed approach volumes, the highest modeled concentration for each run always occurred at the receptors located in quadrants 2 and 4.

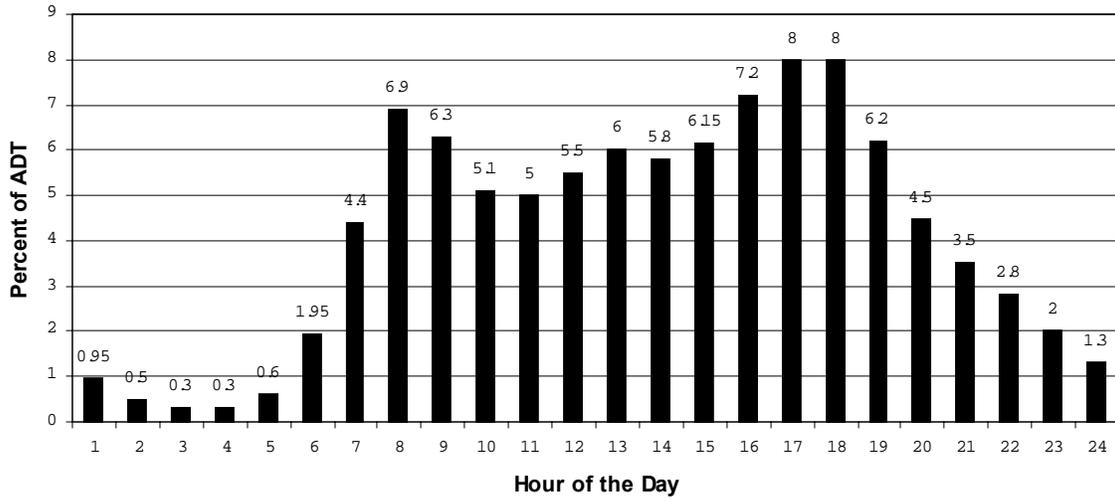
Modeled CO concentrations were plotted against approach volumes for each receptor distance to determine the approach volume that produced modeled 8-hour average concentrations of 8.5 ppm. (The NAAQS for an 8-hour CO average concentration is 9 ppm. The lower 8.5 ppm cut-off was to ensure that the pre-screen criteria were conservative.) Linear interpolation was performed on each data set to estimate the approach volume corresponding to a modeled CO concentration of 8.5 ppm. The “critical approach volume” for each receptor location was then converted into ADT, assuming that peak vph is approximately 8% of ADT.

### **2.6 Modifying the Pre-screen Criteria for ADT**

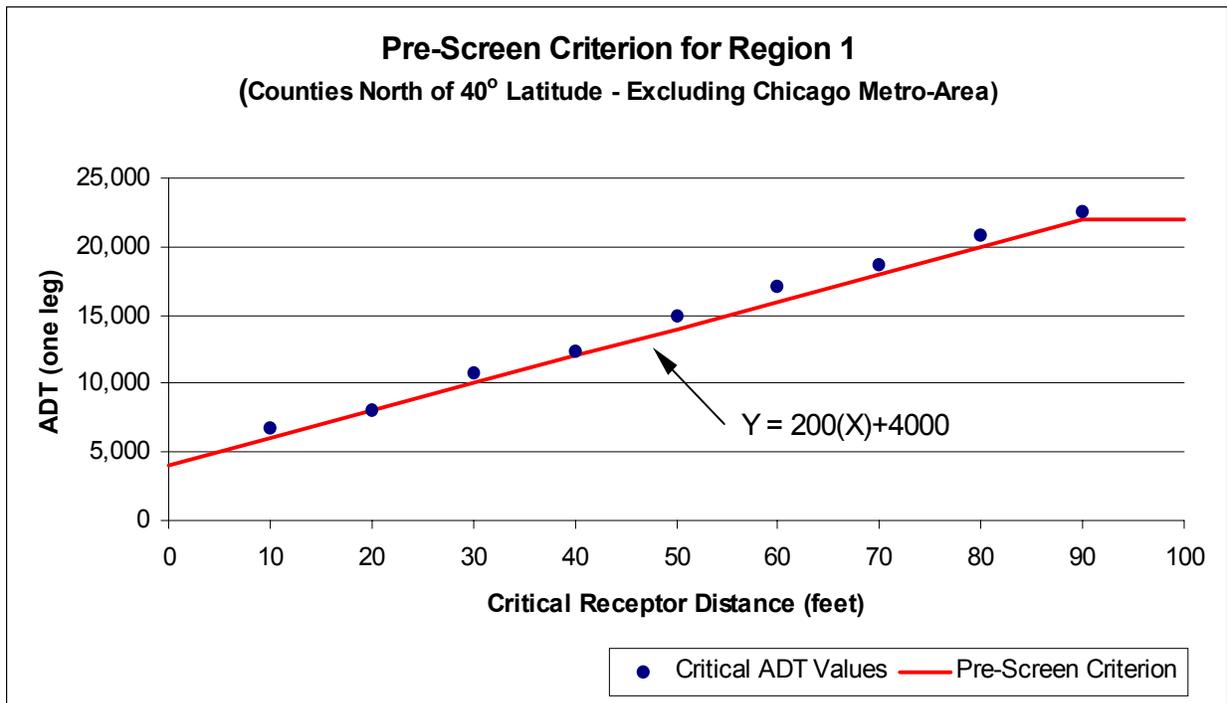
To justify the assumed 8% relationship between vph and ADT, IDOT ADT data were evaluated for each hour of the day for typical urban Illinois non-interstate highways, Monday through Thursday (Figure 2-4). The chart shows that during the peak traffic hour of the day, highway traffic volumes are approximately eight percent of the ADT (IDOT, 2000). Assuming this information applies to highways throughout Illinois, a peak hourly approach volume on a highway can be converted to a highway ADT by dividing the hourly volume by 0.08.

The interpolated “critical approach volumes” discussed in the previous section were divided by 0.08 to obtain “critical ADT values.” The critical ADT values at each receptor location were then plotted against receptor distance. A line was drawn beneath the data points from each modeled region to represent the pre-screen criterion for the region. Points lying below the line meet the pre-screen criterion and do not require additional CO modeling. Points lying above the line fail the pre-screen criterion and require a COSIM analysis to better estimate conditions at the intersection. Results from each of the four regions are provided in Figures 2-5 through 2-8. Figure 2-9 shows the pre-screen criteria for all four regions.

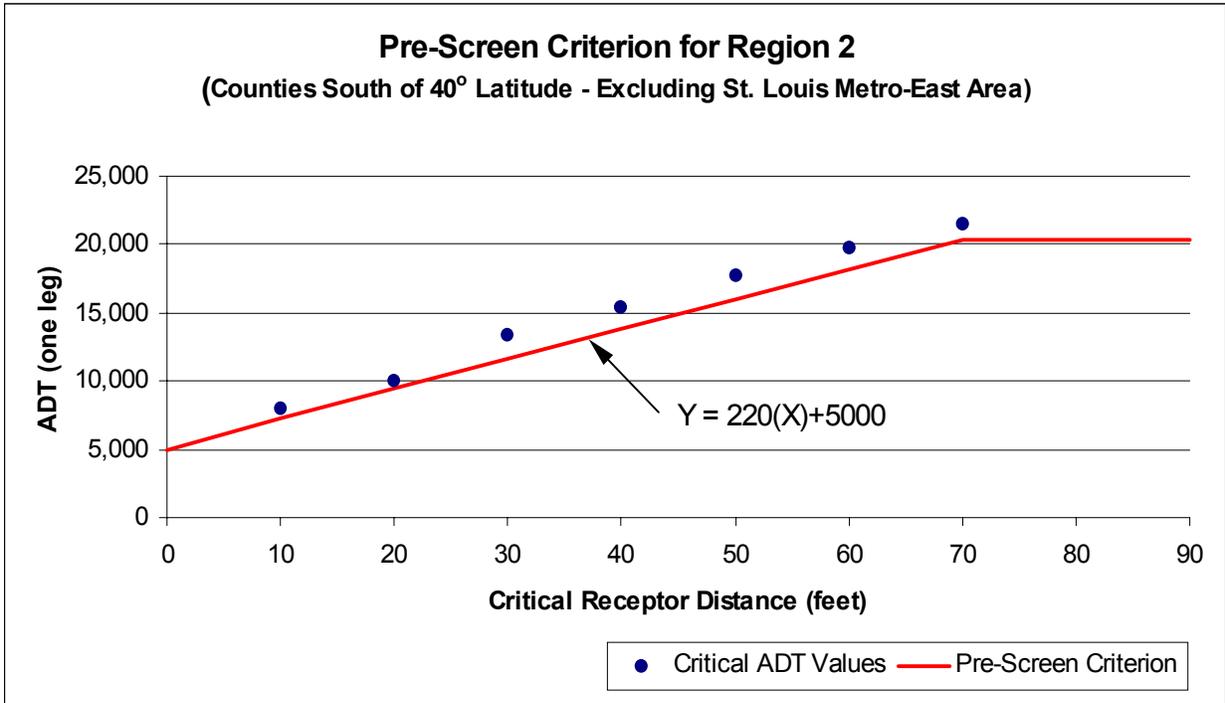
### Traffic by Hour (Mon-Thurs)



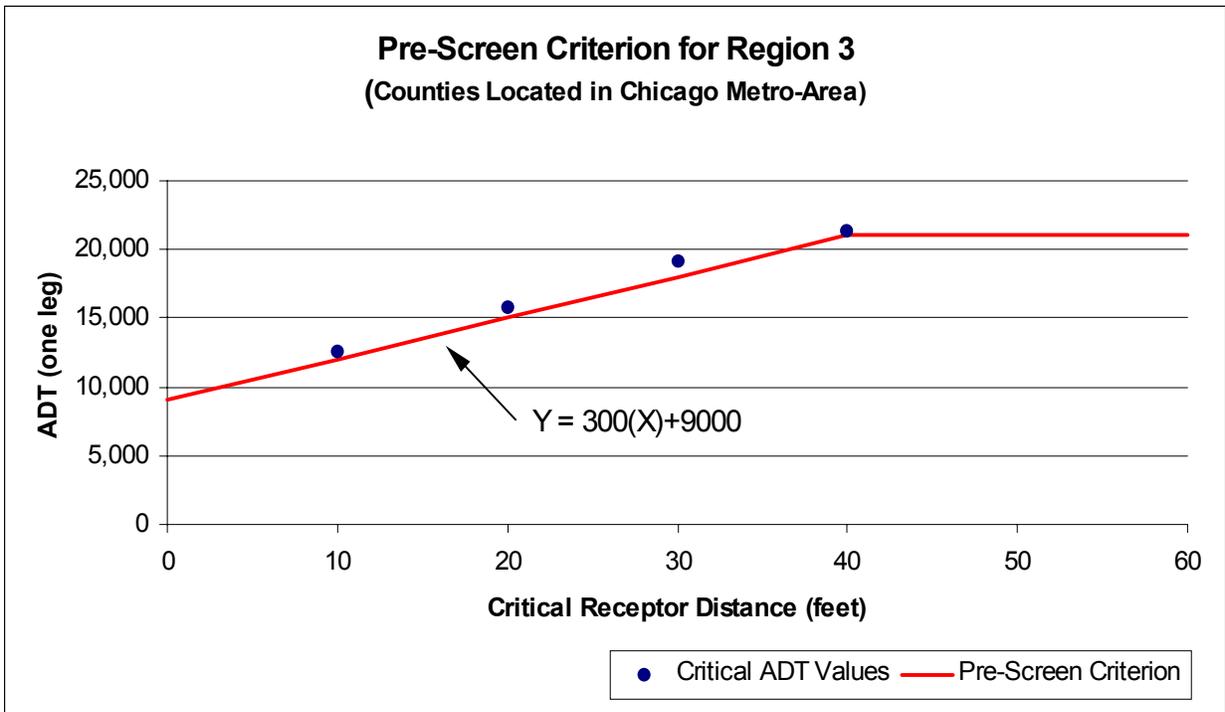
**Figure 2-4** ADT distributions for each hour of the day for typical urban Illinois non-interstate highways, Monday through Thursday (IDOT, 2000).



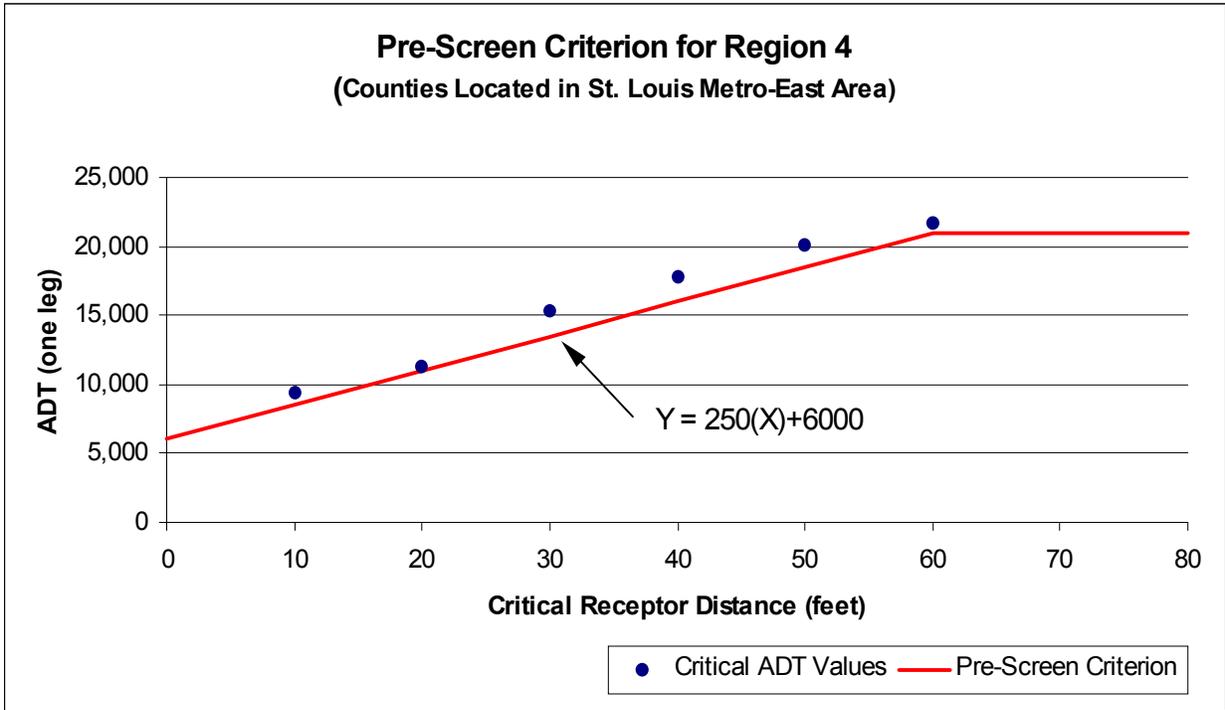
**Figure 2-5** Pre-screen criterion for Region 1 - counties north of 40° Latitude, excluding counties located in the Chicago Metro-Area.



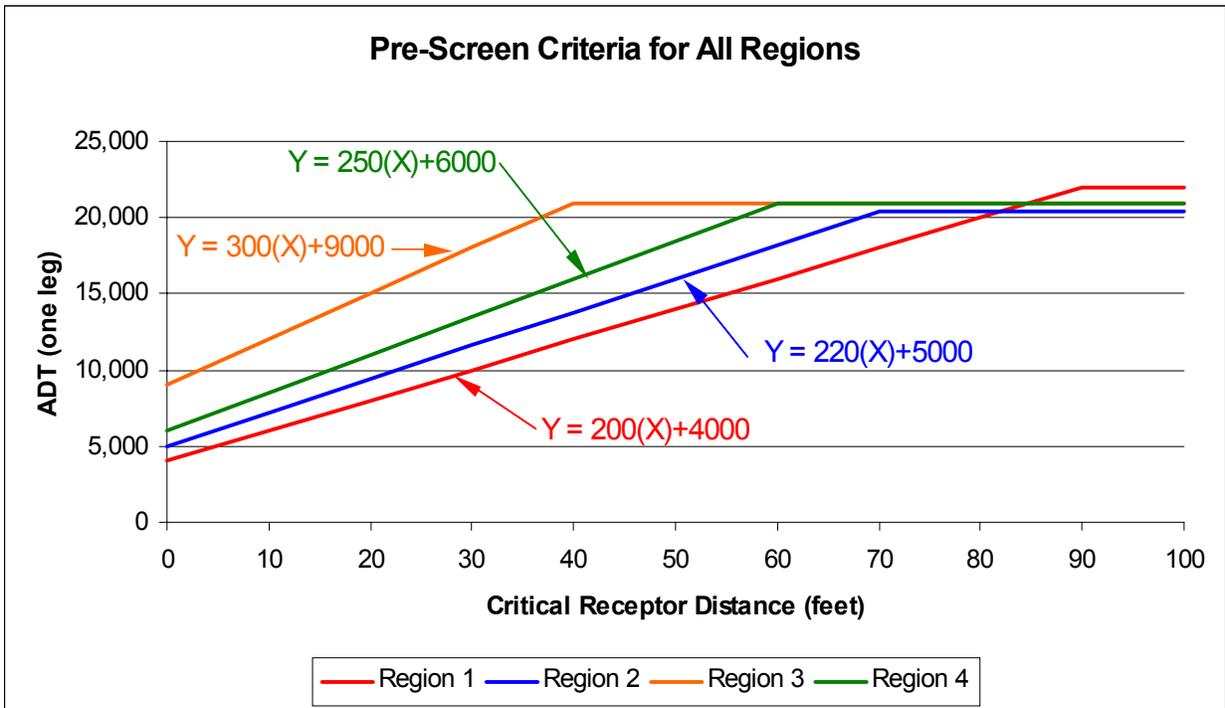
**Figure 2-6** Pre-screen criterion for Region 2 - counties south of 40° Latitude, excluding counties located in the St. Louis Metro-East Area.



**Figure 2-7** Pre-screen criterion for Region 3 - counties located in the Chicago Metro-Area.



**Figure 2-8** Pre-screen criterion for Region 4 - counties located in the St. Louis Metro-East Area.



**Figure 2-9** Pre-screen criteria for the four regions in Illinois.

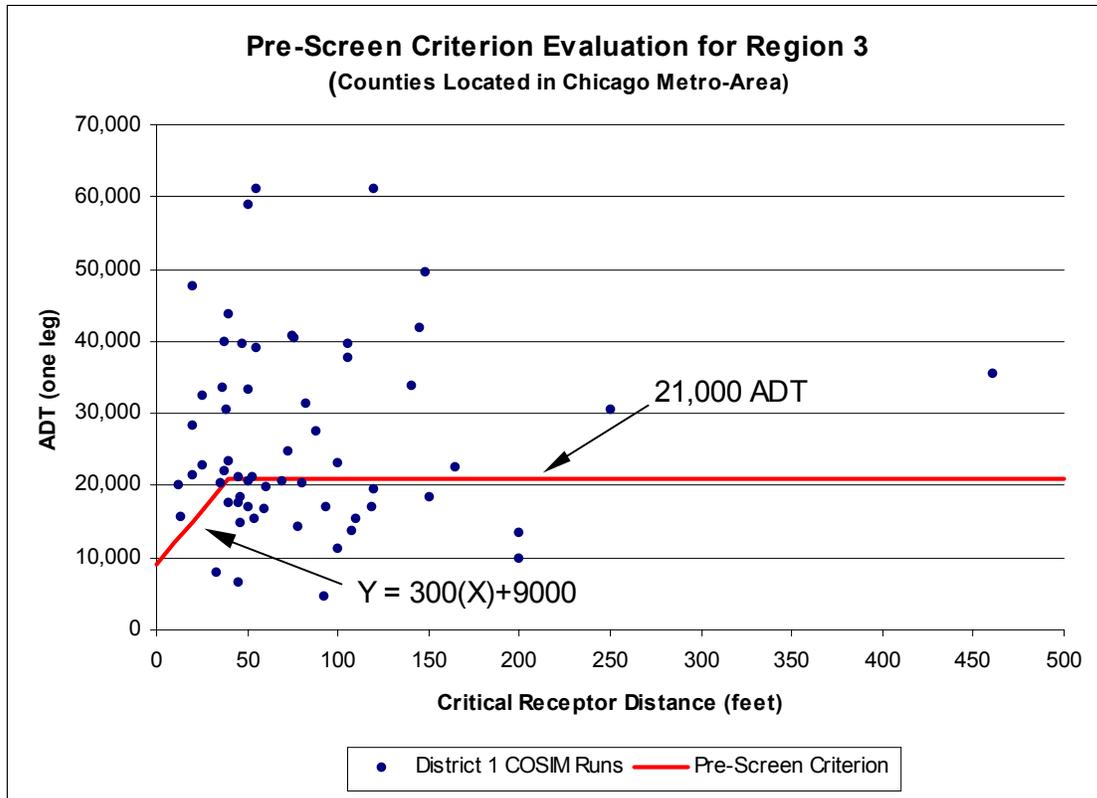
Notice that the pre-screen criteria for all regions flatten out before reaching 22,500 ADT. The flat portion of the graph acts as a ceiling on the pre-screen criteria. This was done because CO concentrations were only calculated at approach volumes between 300 and 1,800 vph. Approach volumes greater than 1,800 produced oversaturated intersection conditions, and the validity of modeled scenario became questionable. The 1,800 vph maximum corresponds to 22,500 ADT ( $1,800 / 0.08 = 22,500$ ). The pre-screen criteria are designed to produce failing results at oversaturated intersection conditions at any receptor distance.

## 2.7 Final Pre-screen Criteria

Equations representing the lines in Figure 2-9 were incorporated into the COSIM program as a new Pre-Screen Feature. Points lying below the line pass the pre-screen criteria and do not require additional CO modeling. Points lying above the line fail the pre-screen criteria and require a complete COSIM analysis to better estimate conditions at the intersection. Information regarding the new COSIM Pre-Screen feature is discussed in Chapter 3 of this report.

## 2.8 Evaluating the Pre-screen Criteria

The pre-screen criterion for counties located in the Chicago area were evaluated using 60 COSIM runs performed by IDOT District 1 (each produced passing COSIM results). For each run, the distance of the receptor located closest to the intersection, and the modeled traffic volume (in vehicles per hour) on the busiest leg of the intersection were used to determine if the run would pass or fail the pre-screen criterion. Approximately 40% of the runs evaluated passed the pre-screen criterion. Results from the evaluation are presented in Figure 2-10.



**Figure 2-10** Pre-screen criterion evaluation for 60 passing COSIM runs in IDOT District 1.

## Chapter 3: Illinois COSIM Version 2.0

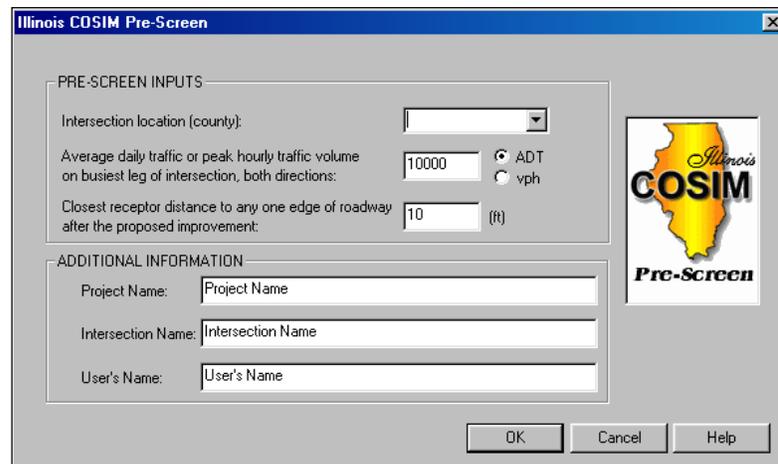
Numerous changes have been made to COSIM Version 1.1 in creating Version 2.0. Aside from replacing the MOBILE5b emission factor lookup tables with the new MOBILE6 emission factors, as discussed in Chapter 1 of this report, the addition of a Pre-Screen feature was the most significant change made to the COSIM program. This chapter documents both revisions and additions made to the COSIM model.

### 3.1 Addition of the Pre-Screen Feature

The revised pre-screen criteria equations shown in Figure 2-9 were incorporated into the COSIM program as a new Pre-Screen feature. The Pre-Screen should be run prior to a COSIM analysis to determine whether a full COSIM analysis should be completed. The new COSIM Pre-Screen feature is intended to replace the 16,000 ADT pre-screen criterion currently used by IDOT.

The Pre-Screen feature is initiated by selecting the *PRE* icon in the tool bar or by selecting *Pre-Screen Input* under the *Input* menu item. Three inputs are required to run the Pre-Screen: 1) county in which the intersection is located, 2) traffic volume on the busiest leg of the intersection, and 3) closest receptor distance to any one edge of roadway. Intersection location is selected using a drop down menu that contains the 102 counties in Illinois. Design year traffic volume may be entered in average daily traffic (ADT) or peak hourly traffic volume (in vph) for the busiest leg of the proposed intersection. The volume should include all traffic traveling on the leg (both directions). The closest receptor distance should be entered for the sensitive receptor located closest to the intersection. IDOT defines a sensitive receptor as a building or location where the general public may be expected to remain for the duration of the period specified by the NAAQS. The distance should be measured from the receptor to the edge of the nearest proposed roadway. In addition to these three required inputs, the user's name, project name, and intersection name should also be entered for documentation purposes. The Pre-Screen input box is shown in Figure 3-1.

When the OK button is selected, the closest receptor distance and one of the four pre-screen criteria equations are used to calculate a maximum ADT value. Selection of the appropriate pre-screen criteria equation is based on the county that was selected for the intersection location. The



The screenshot shows a dialog box titled "Illinois COSIM Pre-Screen". It is divided into two main sections: "PRE-SCREEN INPUTS" and "ADDITIONAL INFORMATION".

**PRE-SCREEN INPUTS:**

- Intersection location (county):** A dropdown menu.
- Average daily traffic or peak hourly traffic volume on busiest leg of intersection, both directions:** A text input field containing "10000". To its right are two radio buttons: "ADT" (selected) and "vph".
- Closest receptor distance to any one edge of roadway after the proposed improvement:** A text input field containing "10" followed by "(ft)".

**ADDITIONAL INFORMATION:**

- Project Name:** A text input field containing "Project Name".
- Intersection Name:** A text input field containing "Intersection Name".
- User's Name:** A text input field containing "User's Name".

At the bottom right of the dialog box, there are three buttons: "OK", "Cancel", and "Help". On the right side of the dialog box, there is a logo for "Illinois COSIM Pre-Screen" featuring a map of Illinois.

Figure 3-1 Input box for Pre-Screen feature .

relationship between pre-screen criteria and counties is presented in Figure 3-2.

If the traffic volume entered by the user exceeds the calculated maximum ADT, the project fails the pre-screen analysis and a complete COSIM analysis is required. If the traffic volume is less than or equal to the maximum ADT, the project passes the pre-screen analysis and a complete COSIM analysis is not required. Note that when traffic volume is entered into the Pre-Screen feature in units of vph, the volume is converted to ADT by dividing by 0.08 before being compared with the maximum ADT. See section 2.6 for additional information regarding vph to ADT conversion.

Once the user has entered the Pre-Screen input variables and pressed the OK button, the Pre-Screen report will appear in the main view. The top of the report displays the date and time the Pre-Screen calculations were made. Below the time is the project name. The next five lines show the inputs used to determine whether the intersection passes or fails the Pre-Screen analysis. Below the input information are the results of the analysis.

<b>Pre-Screen Region 1 - Counties North of 40° Latitude - Excluding Chicago Metro-Area</b>	
<b>Max ADT = 200(Receptor Distance) + 4000</b>	
<b>not to exceed 22,000 ADT</b>	
District 2:	Boone, Bureau, Carroll, DeKalb, Henry, Jo Daviess, Lee, Ogle, Rock Island, Stephenson, Whiteside, & Winnebago.
District 3:	Ford, Grundy, Iroquois, Kankakee, Kendall, La Salle, Livingston, Marshall, McLean, Putnam, & Woodford.
District 4:	Fulton, Henderson, Knox, McDonough, Mercer, Peoria, Stark, Tazewell, & Warren.
District 5:	Champaign, Dewitt, Piatt, & Vermillion.
District 6:	Adams, Brown, Cass, Hancock, Logan, Mason, Menard, & Schuyler.
<b>Pre-Screen Region 2 - Counties South of 40° Latitude - Excluding St. Louis Metro-East Area</b>	
<b>Max ADT = 220(Receptor Distance) + 5000</b>	
<b>not to exceed 20,400 ADT</b>	
District 5:	Clark, Coles, Cumberland, Douglas, Edgar, Macon, Moultrie, & Shelby.
District 6:	Christian, Macoupin, Montgomery, Morgan, Pike, Sangamon, & Scott.
District 7:	Clay, Crawford, Edwards, Effingham, Fayette, Hamilton, Jasper, Jefferson, Lawrence, Marion, Richland, Wabash, Wayne, & White.
District 8:	Bond, Calhoun, Clinton, Greene, Jersey, Randolph, & Washington.
District 9:	Alexander, Franklin, Gallatin, Hardin, Jackson, Johnson, Massac, Perry, Pope, Pulaski, Saline, Union, & Williamson.
<b>Pre-Screen Region 3 - Counties Located in the Chicago Metro-Area</b>	
<b>Max ADT = 300(Receptor Distance) + 9000</b>	
<b>not to exceed 21,000 ADT</b>	
District 1:	Cook, Du Page, Kane, Lake, Mc Henry, & Will.
<b>Pre-Screen Region 4 - Counties Located in the St. Louis Metro-East Area</b>	
<b>Max ADT = 250(Receptor Distance) + 6000</b>	
<b>not to exceed 21,000 ADT</b>	
District 8:	Madison, Monroe, & St. Clair.

**Figure 3-2** Relationship between pre-screen criteria equations and county in which the intersection is located.

A "Pass" result does not require the user to perform a COSIM analysis. A "Fail" result requires the user to run a COSIM analysis to better estimate the intersection's impact on ambient CO concentrations.

### **3.2 Other Additions and Revisions in Version 2.0**

Other minor changes were made to the original COSIM program to create Version 2.0. Some of the additions and revisions are apparent to the user, that is, a user could run Versions 1.1 and 2.0 and see many of the visible differences. Other changes made do not affect the appearance of the program, but rather the program's operating algorithms.

#### ***3.2.1 Visible Revisions***

The following is a list and brief discussion of revisions made to Version 1.1 that are visible to someone using Version 2.0.

- The Welcome to Illinois COSIM title screen - The version number and release date have been updated to Version 2.0 - December 2002.
- COSIM logo in the main view has been updated to Version 2.0.
- Program Title Bar - the program title bar has been updated to display the name of the open COSIM project file followed by COSIM 2.0.
- Getting Started Help File - has been updated to include information on the Pre-Screen feature. A link to Pre-Screen Information has also been added to the help file.
- General Information Help File - has been updated to include information on accessing the Pre-Screen feature. A link to the Pre-Screen help file has also been added.
- Help Index help file - has been updated to include a link to the Pre-Screen help file.
- Page 1 of the final report help file - has been updated to better explain how the 8-hour average concentration is calculated.
- Printing the Final Report help file - has been updated to include the Pre-Screen report.
- Year of Analysis help file - has been updated to include model years 2002 through 2050.
- Peak-Hour Approach Traffic Speeds help file - has been updated to include a statement regarding approach speeds for local roadways and highway ramps.
- Year of Analysis - on page 1 of the General Inputs screens has been updated to include model years 2002 through 2050. Error messages associated with entering a valid model year have also been updated.

- Page 3 of the Intersection Inputs screens has been updated to include statements regarding local roadways and highway ramps. The user is instructed to enter an approach speed of 15 mph or less for local roadways and 5 mph for highway ramps.
- Final Report Heading - has been updated to COSIM 2.0.
- The Date on page 1 of the final report has been corrected to properly display years in 2002 and beyond.
- Notes on the bottom of page 1 of the final report have been revised to better explain how the 8-hour average concentrations are calculated. The problem of the word "background" running off the page in the printed version has also been corrected.
- Emission factor table on page 3 of the final report has been updated to read MOBILE6 Emission Factors. A note has also been added to the bottom of the emission factor table that states local roadways should be modeled with an approach speed of 15 mph or less and highway ramps should be modeled with an approach speed of 5 mph.

### ***3.2.2 Visible Additions***

The following is a list and brief discussion of new additions made to Version 2.0.

- Pre-Screen Feature - has been added to the program. See section 3.1 for additional information regarding the Pre-Screen feature.
- Pre-Screen Help File - has been added to the list of available help files. The help file discusses the inputs required for the Pre-Screen and report page.
- PRE tool bar icon has been added to the tool bar. When the PRE icon is selected the Pre-Screen input box is displayed.
- Pre-Screen Input submenu item has been added under Input in the main menu. When the Pre-Screen Input submenu item is selected the Pre-Screen input box is displayed.

### ***3.2.3 Non-visible Revisions***

In addition to revising the emission factor lookup table with MOBILE6 emission factors as discussed in Chapter 1, the error-checking computer code that ensures valid signal timing inputs are entered (which was not apparent to the user) was revised to correct for problems discovered in the original code. Although the changes affect the operation of the COSIM program they are not visibly apparent to the user.

In COSIM Version 1.1 signal times could be entered on the signal timing input page that created errors in the execution of CAL3QHC. Two types of errors were possible in the original code. The first error occurred when a red time was exactly 5 seconds less than the total signal time.

When a red time was exactly 5 seconds less than the total cycle time, a divide by zero error occurred in the CAL3QHC calculations and the program shut down.

In CAL3QHC, queue length is based on the volume to capacity ratio (V/C) for the queue link. Capacity is calculated using the following equation:

$$C = (\text{Sat. Flow Rate})(\text{Tot. Cycle Time} - \text{Red Time} - \text{Startup Delay} - \text{Clearance Lost}) / \text{Tot. Cycle Time}$$

Where the following variables are set at:

Sat. Flow Rate = 1900 vph

Startup Delay = 2 sec

Clearance Lost = 3 sec

When a red time is 5 seconds less than the total cycle, saturation flow rate is multiplied by zero thus creating a zero capacity value on the queue link. When the V/C ratio is determined for the link, volume is divided by zero and CAL3QHC shuts down and an output file is not created. COSIM did not detect the error and continued to function as if a CAL3QHC output file was created and read the modeled concentrations from the output file in the COSIM program folder. Since CAL3QHC crashed and a new output file was not created, COSIM read concentration values from a previously created output file and erroneously used the values for the current COSIM run.

The second error occurred when a red time was within 4 seconds of the total signal time. When a red time is within 4 seconds of the total signal time, the capacity calculated for the volume to capacity determination is a negative number. This negative value carries through the queue length calculations in CAL3QHC and produces a meaningless output file as concentrations were estimated with negative queue lengths. Again, COSIM did not detect the error and used modeled concentrations from the invalid output file.

To ensure these errors will not occur in the new version of COSIM, the error checking code was updated on the Intersection Signal Timing input page. When the finished button is pressed the inputs are checked to make sure that the total signal time is at least 7 seconds, and that the red times are greater than zero and at least 6 seconds less than the total signal time.

These errors were most likely to occur when COSIM was used to model an intersection governed by stop signs. (It would be unlikely that signalized intersections would have red times that differ from the total cycle time by 5 seconds or less.) These applications are fairly rare and unlikely to fail COSIM, as they are usually accompanied by low traffic volumes. Therefore, it is unlikely that the pass/fail status of any previous COSIM runs were affected by these errors. The small set of COSIM runs provided by District 1 that contained these two types of signal timing errors were re-evaluated to confirm that the errors did not affect the pass/fail outcome of the COSIM runs. The pass/fail status was not affected by the signal timing errors.

### **3.3 Version 1 File Compatibility**

COSIM Version 2.0 has the ability to open project files saved using Version 1 (this includes Versions 1.0 or 1.1). If a Version 1 file is opened, all the saved input variables will appear but the user will have to run through the entire series of input screens before CO concentrations can be calculated. If the previously saved model year was 1999 through 2001, a new valid model year (2002 through 2050) will have to be entered. If a Version 1 file is opened and calculations were made before the file was saved, the final report in Version 1 format (with the exception of the year being shown as 2 digits) will be displayed in the main view. The user is able to print the old

report. However, to rerun the calculations, the user will have to step through all of the input screens. The variables saved to the Version 1 file will appear in the input boxes as the user steps through the screens. When the calculate button is selected, CO concentrations will be recalculated using MOBILE6 emission factors. Once the calculate button is pressed, the previously saved CO concentrations that were calculated using MOBILE5b emission factors will be lost. COSIM Version 2.0 is not able to calculate CO concentrations using MOBILE5b emission factors.

## Chapter 4: Conclusions

This report has summarized Phase II of the ITRC project “Carbon Monoxide Analysis for Highway Projects.” Specific objectives for the last phase were to 1) finalize the MOBILE6 emission factors and incorporate them into a new COSIM version and 2) determine the pre-screen criteria based on MOBILE6 emission factors.

The first step in completing the first objective was to create MOBILE6 input files that were representative of Illinois conditions. Final emission factors for use in the COSIM Version 2.0 were determined by running the input files in the released version of MOBILE6. The emission factor look up tables in the COSIM computer code were updated with the newly calculated MOBILE6 emission factors.

The updated version of COSIM was then used to complete the second project objective of determining pre-screen criteria based on MOBILE6 emission factors. The new pre-screen criteria were developed using a “worst-case” base case scenario in COSIM. The base case scenario was practical yet conservative to ensure that the developed criteria would also be conservative.

In addition to accomplishing the two specific project objectives, the newly developed pre-screen criteria were incorporated into an updated version of COSIM (Version 2.0) as a new Pre-Screen feature. The Pre-Screen should be run prior to a complete COSIM analysis to determine whether a full analysis is required. Three inputs are required to run the Pre-Screen; 1) county in which the intersection is located, 2) traffic volume on the busiest leg of the intersection, and 3) closest receptor distance to any one edge of roadway. In addition to the three required inputs, inputs for the user’s name, the project name, and the intersection name are available for documentation purposes. If the project passes the Pre-Screen, a COSIM analysis is not required. If the project fails the Pre-Screen, a COSIM analysis is required to better evaluate CO impacts from the project.

The updated version of COSIM, designated as Version 2.0, has been distributed to IDOT personnel in each district for use in project-level CO air quality analysis. An updated COSIM Version 2.0 user’s manual was also created and distributed.

## REFERENCES

## References

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U.S. Environmental Protection Agency, User's Guide to MOBILE6.0 (Mobile Source Emissions Factor Model), U.S. EPA, Ann Arbor, Michigan, EPA420-R-02-001, January (2002a).

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**Appendix A**  
**MOBILE6 Input Files**

Note that to conserve space, the Scenario Section in each of the input files presented in this appendix only includes a scenario for an average speed of 2.5 mph for calendar year 2002. The actual MOBILE6 input files used for determining emission factors contained additional Scenario Records for average speeds of 2.5 and 5 to 55 mph in 5 mph increments for calendar years 2002 - 2015 inclusive.

## A.1 Illinois Attainment Areas to the North of 40° N Latitude

```

* Input file for Illinois Attainment areas to the North of 40 deg N. Latitude

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: NONE.
* Oxygenated Fuels - Ether Blend Market Share: 0.000
*                   - Alcohol Blend Market Share: 0.300
*                   - Oxygen Content of Ether Blend: 0.000
*                   - Oxygen Content of Alcohol Blend: 0.350
*                   - RVP Waiver: psi waiver
* Minimum Temperature: 13 oF
* Maximum Temperature: 29 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: NONE.
* I/M Program: NONE.
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Type of Roadway: Arterial only.
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS          : CO

REPORT FILE         : N_ATT.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT    :

* this command will display column names in the output table.
WITH FIELDNAMES   :

* this command will limit the type of emissions included in the output. 1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "N_ATT.TB1"
EMISSIONS TABLE   : N_ATT.TB1

RUN DATA

***** RUN SECTION - For North Attainment Area *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST    :

* five inputs for Ether Blend Market Share, Alcohol Blend Market Share, Oxygen Content of Ether Blend,
* Oxygen Content of Alcohol Blend, and RVP Waiver Switch (2 = 1 psi waiver)
OXYGENATED FUELS  : .000 .300 .000 .035 2

MIN/MAX TEMPERATURE: 13. 29.

FUEL RVP          : 13.5

***** SCENARIO SECTIONS *****
***** Idle Speed Scenarios *****

SCENARIO RECORD   : Scenario Title - North Attainment at Idle Speed for 2002
CALENDAR YEAR     : 2002
EVALUATION MONTH  : 1
ALTITUDE          : 1
AVERAGE SPEED    : 2.5 Arterial

END OF RUN       :

```

## A.2 Illinois Attainment Areas to the South of 40° N Latitude

```
* Input file for Illinois Attainment areas to the South of 40 deg N. Latitude

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of Roadway: Arterial only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: NONE.
* Oxygenated Fuels - Ether Blend Market Share: 0.000
*                   - Alcohol Blend Market Share: 0.300
*                   - Oxygen Content of Ether Blend: 0.000
*                   - Oxygen Content of Alcohol Blend: 0.350
*                   - RVP Waiver: psi waiver
* Minimum Temperature: 21 oF
* Maximum Temperature: 38 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: NONE.
* I/M Program: NONE.
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS       : CO

REPORT FILE      : S_ATT.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT  :

* this command will display column names in the output table.
WITH FIELDNAMES :

* this command will limit the type of emissions included in the output. 1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "S_ATT.TB1"
EMISSIONS TABLE : S_ATT.TB1

RUN DATA

***** RUN SECTION - For South Attainment Area *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST   :

* five inputs for Ether Blend Market Share, Alcohol Blend Market Share, Oxygen Content of Ether Blend,
* Oxygen Content of Alcohol Blend, and RVP Waiver Switch (2 = 1 psi waiver)
OXYGENATED FUELS : .000 .300 .000 .035 2

MIN/MAX TEMPERATURE: 21. 38.

FUEL RVP          : 13.5

***** SCENARIO SECTIONS *****

***** Idle Speed Scenarios *****

SCENARIO RECORD  : Scenario Title - South Attainment at Idle Speed for 2002
CALENDAR YEAR    : 2002
EVALUATION MONTH : 1
ALTITUDE         : 1
AVERAGE SPEED   : 2.5 Arterial

END OF RUN      :
```

### A.3 Illinois Non-Attainment Areas in the Chicago Region with I/M Programs

```
* Input file for Illinois Non-Attainment areas to the North of 40 deg N. Latitude
* In the Chicago Area with I/M Program

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of Roadway: Arterial only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: North Region of the Country
* Oxygenated Fuels: NONE.
* Minimum Temperature: 13 oF
* Maximum Temperature: 29 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: CHIRD01.d Provided by Sam Long of IEPA
* I/M Program: ILLOBDIM.D provided by Sam Long of IEPA
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS       : CO

REPORT FILE      : N_NAT_IM.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT  :

* this command will display column names in the output table.
WITH FIELDNAMES :

* this command will limit the type of emissions included in the output.  1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "N_NAT_IM.TB1"
EMISSIONS TABLE : N_NAT_IM.TB1

RUN DATA

***** RUN SECTION - For North Non-Attainment Area with I/M Program *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST   :

* this indicates a RFG program in the Chicago area using the "North Region" of the country
FUEL PROGRAM     : 2 N

MIN/MAX TEMPERATURE: 13. 29.

* fuel RVP is most likely overridden with the FUEL PROGRAM specifying RFG program.
FUEL RVP        : 13.5

* Call to Vehicle Distribution File (CHIRD01.d Provided by Sam Long of IEPA)
REG DIST        : CHIRD01.d

**** I/M Program Parameters ****

* Call to external data file with I/M parameters
* ILLINOIS ENHANCED I/M DESCRIPTION (ILLOBDIM.D provided by Sam Long of IEPA)
I/M DESC FILE   : ILLOBDIM.D

***** SCENARIO SECTIONS *****

***** Idle Speed Scenarios *****

SCENARIO RECORD : Scenario Title - North Non-Attainment at Idle Speed for 2002
CALENDAR YEAR   : 2002
EVALUATION MONTH : 1
ALTITUDE        : 1
AVERAGE SPEED  : 2.5 Arterial

END OF RUN      :
```

## A.4 Illinois Non-Attainment Areas in the Chicago Region without I/M Programs

```
* Input file for Illinois Non-Attainment areas to the North of 40 deg N. Latitude
* In the Chicago Area without an I/M Program

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of Roadway: Arterial only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: North Region of the Country
* Oxygenated Fuels: NONE.
* Minimum Temperature: 13 oF
* Maximum Temperature: 29 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: CHIRD01.d Provided by Sam Long of IEPA
* I/M Program: NONE.
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS       : CO

REPORT FILE      : N_NAT.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT  :

* this command will display column names in the output table.
WITH FIELDNAMES :

* this command will limit the type of emissions included in the output. 1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "N_NAT.TB1"
EMISSIONS TABLE : N_NAT.TB1

RUN DATA

***** RUN SECTION - For North Non-Attainment Area without an I/M Program *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST   :

* this indicates a RFG program in the Chicago area
FUEL PROGRAM     : 2 N

MIN/MAX TEMPERATURE: 13. 29.

* fuel RVP is most likely overridden with the FUEL PROGRAM specifying RFG program.
FUEL RVP         : 13.5

* Call to Vehicle Distribution File
REG DIST        : CHIRD01.d

***** SCENARIO SECTIONS *****

***** Idle Speed Scenarios *****

SCENARIO RECORD  : Scenario Title - North Non-Attainment at Idle Speed for 2002
CALENDAR YEAR    : 2002
EVALUATION MONTH : 1
ALTITUDE         : 1
AVERAGE SPEED   : 2.5 Arterial

END OF RUN      :
```

## A.5 Illinois Non-Attainment Areas in the Metro-East Region with I/M Programs

```
* Input file for Illinois Non-Attainment areas to the South of 40 deg N. Latitude
* In the Metro-East Area with I/M Program

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of Roadway: Arterial only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: NONE.
* Oxygenated Fuels - Ether Blend Market Share: 0.000
*                   - Alcohol Blend Market Share: 0.300
*                   - Oxygen Content of Ether Blend: 0.000
*                   - Oxygen Content of Alcohol Blend: 0.350
*                   - RVP Waiver: psi waiver
* Minimum Temperature: 21 oF
* Maximum Temperature: 38 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: MERD01.d provided by Sam Long of IEPA
* I/M Program: ILLOBDIM.D provided by Sam Long of IEPA
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS       : CO

REPORT FILE      : S_NAT_IM.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT  :

* this command will display column names in the output table.
WITH FIELDNAMES :

* this command will limit the type of emissions included in the output. 1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "S_NAT_IM.TB1"
EMISSIONS TABLE : S_NAT_IM.TB1

RUN DATA

***** RUN SECTION - For South Non-Attainment Area with I/M Program *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST :

* five inputs for Ether Blend Market Share, Alcohol Blend Market Share, Oxygen Content of Ether Blend,
* Oxygen Content of Alcohol Blend, and RVP Waiver Switch (2 = 1 psi waiver)
OXYGENATED FUELS : .000 .300 .000 .035 2

MIN/MAX TEMPERATURE: 21. 38.

FUEL RVP           : 13.5

* Call to Vehicle Distribution File for Metro-East
REG DIST          : MERD01.d

* Call to external data file with I/M parameters
* ILLINOIS ENHANCED I/M DESCRIPTION (ILLOBDIM.D provided by Sam Long of IEPA)
I/M DESC FILE     : ILLOBDIM.D

***** SCENARIO SECTIONS *****

***** Idle Speed Scenarios *****

SCENARIO RECORD   : Scenario Title - South Non-Attainment at Idle Speed for 2002
CALENDAR YEAR     : 2002
EVALUATION MONTH  : 1
ALTITUDE          : 1
AVERAGE SPEED    : 2.5 Arterial

END OF RUN       :
```

## A.6 Illinois Non-Attainment Areas in the Metro-East Region without I/M Programs

```
* Input file for Illinois Non-Attainment areas to the South of 40 deg N. Latitude
* In the Metro-East Area without I/M Program

* The following is a description of the scenario modeled by this input file:
* Pollutant Modeled: CO only.
* Type of Roadway: Arterial only.
* Type of emissions: Exhaust Running and Start.
* Reformulated Gasoline Program: NONE.
* Oxygenated Fuels - Ether Blend Market Share: 0.000
*                   - Alcohol Blend Market Share: 0.300
*                   - Oxygen Content of Ether Blend: 0.000
*                   - Oxygen Content of Alcohol Blend: 0.350
*                   - RVP Waiver: psi waiver
* Minimum Temperature: 21 oF
* Maximum Temperature: 38 oF
* Fuel RVP: 13.5
* User Supplied Registration Data: MERD01.d provided by Sam Long of IEPA
* I/M Program: NONE.
* Calendar Years: 2002 - 2015
* Calendar Month: January
* Altitude: Low
* Speeds: 2.5 to 55 mph
* All other variables use MOBILE6 Defaults!!!!

***** HEADER SECTION *****
MOBILE6 INPUT FILE :

POLLUTANTS          : CO

REPORT FILE         : S_NAT.out

* this command produces output for all scenarios in each run.
DATABASE OUTPUT    :

* this command will display column names in the output table.
WITH FIELDNAMES   :

* this command will limit the type of emissions included in the output. 1 = do not include, 2 = include.
* emission types in order are Exhaust Running, Exhaust Start, Evaporative Hot Soak, Evaporative Diurnal
* Evaporative Resting Loss, Evaporative Running Loss, Evaporative Crankcase, and Evaporative Refueling.
* The only emission types that pertain to CO are Exhaust Running, Exhaust Start.
* the following line limits emissions to Exhaust Running and Start.
DATABASE EMISSIONS : 2211 1111

* this command will limit output to daily time periods only, and will aggregate output.
AGGREGATED OUTPUT :

* this command will write results table to a file called "S_NAT.TB1"
EMISSIONS TABLE   : S_NAT.TB1

RUN DATA

***** RUN SECTION - For South Non-Attainment Area without I/M Program *****

* this command will display separate start, running, and total exhaust EFs in the descriptive output file.
EXPAND EXHAUST    :

* five inputs for Ether Blend Market Share, Alcohol Blend Market Share, Oxygen Content of Ether Blend,
* Oxygen Content of Alcohol Blend, and RVP Waiver Switch (2 = 1 psi waiver)
OXYGENATED FUELS  : .000 .300 .000 .035 2

MIN/MAX TEMPERATURE: 21. 38.

FUEL RVP          : 13.5

* Call to Vehicle Distribution File for Metro-East
REG DIST         : MERD01.d

***** SCENARIO SECTIONS *****

***** Idle Speed Scenarios *****

SCENARIO RECORD   : Scenario Title - South Non-Attainment at Idle Speed for 2002
CALENDAR YEAR     : 2002
EVALUATION MONTH  : 1
ALTITUDE          : 1
AVERAGE SPEED    : 2.5 Arterial

END OF RUN       :
```

**Appendix B**  
**Additional Files Used for Determining MOBILE6 Emission Factors**

## B.1 Vehicle Registration Data for Chicago Area - CHIRD01.d

```
REG DIST
*
* This file CHIRD01.D is derived from REGDATA.D, the default MOBILE6
* RD file. This file was created 8.v.02 by SSL, and revised by SSL
* on 30.viii.02 to correct the RDs for LDDTs 1 & 2 and 3 & 4, which
* were in error in the May version. Also, the RD for LDGVs was
* recalculated to 4 decimal places. Revisions to the LDGV RD were
* very minor.
*
* It contains Registration Distribution fractions for the 16 vehicle
* classes by age for July of any calendar year for the Chicago NAA,
* based on 2001 gasoline-vehicle age distribution data supplied to
* SL by Jim Matheny of DVIM. (See C:\SSLFILES\INVEN\RDAGE01.XLS.)
* Age distribution fractions have been rounded to 4 decimal places,
* and some of the RDs from for late years (typically in the last
* line-entries 21-25) have at times been modified by +/- 0.0001 as
* necessary to make the RDs add up to 1.0000.
*
* The user is referred to REGDATA.D and to M6 Users Guide Section
* 2.8.7.1 (p. 63 ff) for more detailed information about the nature
* of RD files. See also Section 5.3.2 (p. 169 ff) for information
* on converting M5b RDs to M6 RDs. See also \SOURCE\BD20.FOR
*
* In this file, the first number in each distribution is an integer
* that indicates which of the 16 M6 vehicle classes are represented
* by the RD in question. That number is followed by 25 age fractions
* arranged in two rows of 10 values followed by a row with the last
* 5 values. (This is similar to the format used in M5b for RDs.)
*
* RDs for all vehicle classes are given in this file. This is for
* completeness, even though only those vehicle classes whose RDs
* were changed from the REGDATA defaults need to be included in
* this file. Those that were not changed, are so noted.
*
* LDVs and LDTs were assumed to have the same RDs as LDGVs and LDGTs
* would have in M5b. HDVs were assumed to have the default RDs.
*
* As of 8.v.02, I have assumed Default RDs for the various HDV
* classes, since, although I have information on area-specific HDGV
* age distributions, I do not have such information for HDDVs and
* can only assume the default age distribution for heavy diesels.
* The methodology described in USEPA/OTAQ's publications (including
* the User's Guide and the Technical Guidance) for melding actual
* HDGV and default HDDV age distributions into a single M6 HDV RD,
* is neither clear nor simple, and I have not received a good set
* of HDV RDs from OTAQ—who would presumably know how to do the
* melding. Hence my decision to use this RD file.
*
* -SL
*
* M6 LDV = M5 LDGV (Light-duty Vehicles—passenger cars—from
* RDAGE01.XLS for Chicago
1 0.0548 0.0870 0.0798 0.0735 0.0751 0.0668 0.0775 0.0655 0.0609 0.0565
0.0530 0.0505 0.0472 0.0399 0.0295 0.0241 0.0174 0.0114 0.0062 0.0033
0.0023 0.0024 0.0030 0.0021 0.0103
*
* M6 LDT1 = (M5) LDGT1 as in RDAge01
2 0.0746 0.1128 0.1041 0.1055 0.0886 0.0737 0.0719 0.0694 0.0572 0.0451
0.0437 0.0329 0.0333 0.0289 0.0202 0.0140 0.0092 0.0053 0.0024 0.0015
0.0011 0.0006 0.0008 0.0006 0.0026
*
* M6 LDT2 = (M5) LDGT1 as in RDAge01
3 0.0746 0.1128 0.1041 0.1055 0.0886 0.0737 0.0719 0.0694 0.0572 0.0451
0.0437 0.0329 0.0333 0.0289 0.0202 0.0140 0.0092 0.0053 0.0024 0.0015
0.0011 0.0006 0.0008 0.0006 0.0026
*
* M6 LDT3 = (M5) LDGT2 as in RDAge01
4 0.0629 0.1095 0.1300 0.0889 0.0835 0.0624 0.0725 0.0611 0.0455 0.0388
0.0300 0.0348 0.0387 0.0313 0.0236 0.0225 0.0161 0.0123 0.0076 0.0034
0.0017 0.0032 0.0074 0.0049 0.0074
*
* M6 LDT4 = (M5) LDGT2 as in RDAge01
5 0.0629 0.1095 0.1300 0.0889 0.0835 0.0624 0.0725 0.0611 0.0455 0.0388
0.0300 0.0348 0.0387 0.0313 0.0236 0.0225 0.0161 0.0123 0.0076 0.0034
0.0017 0.0032 0.0074 0.0049 0.0074
*
* HDV2B (Heavy-duty vehicles 2B—M6 Default RDs)
6 0.0503 0.0916 0.0833 0.0758 0.0690 0.0627 0.0571 0.0519 0.0472 0.0430
0.0391 0.0356 0.0324 0.0294 0.0268 0.0244 0.0222 0.0202 0.0184 0.0167
0.0152 0.0138 0.0126 0.0114 0.0499
* HDV3 (Heavy-duty vehicles3, same RD as HDV2B, M6 Default RDs)
7 0.0503 0.0916 0.0833 0.0758 0.0690 0.0627 0.0571 0.0519 0.0472 0.0430
0.0391 0.0356 0.0324 0.0294 0.0268 0.0244 0.0222 0.0202 0.0184 0.0167
0.0152 0.0138 0.0126 0.0114 0.0499
```

```

* HDV4 (Heavy-duty vehicles 4, M6 default RDs)
8 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDV5 (Heavy-duty vehicles 5, same RD as HDV4, M6 Default)
9 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDV6 (Heavy-duty vehicles 6, same RD as HDV4, M6 Default)
10 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDV7 (Heavy-duty vehicles 7, same RD as HDV4, M6 Default)
11 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDV8A (Heavy-duty vehicles 8A same RD as HDV4, M6 Default)
12 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDV8B (Heavy-duty vehicles 8B, same RD as HDV4, M6 Default)
13 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
  0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
  0.0204 0.0191 0.0178 0.0167 0.0797
* HDBS (HDV School buses; this M6 RD default is assumed)
14 0.0393 0.0734 0.0686 0.0641 0.0599 0.0559 0.0522 0.0488 0.0456 0.0426
  0.0398 0.0372 0.0347 0.0324 0.0303 0.0283 0.0264 0.0247 0.0231 0.0216
  0.0201 0.0188 0.0176 0.0165 0.0781
* HDBT (HDV Transit buses; this M6 RD default is assumed)
15 0.0307 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0613
  0.0611 0.0607 0.0595 0.0568 0.0511 0.0406 0.0254 0.0121 0.0099 0.0081
  0.0066 0.0054 0.0044 0.0037 0.0114
* Motorcycles (this M6 default RD is the same as M5a/b's default RD)
16 0.1440 0.1680 0.1350 0.1090 0.0880 0.0700 0.0560 0.0450 0.0360 0.0290
  0.0230 0.0970 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
  0.0000 0.0000 0.0000 0.0000 0.0000
*
*-----
* For reference, here are the original LDGT RDs that were in the file
* from early May '02 to late August '02, being replaced by the revised
* RDs given above. (These are actually representative of Metro-East RDs
* for the vehicle types in question.)
** M6 LDT1 = (M5) LDGT1 as in RDAge01

* 2 0.053 0.081 0.096 0.076 0.071 0.069 0.074 0.064 0.059 0.047
* 0.045 0.045 0.047 0.041 0.027 0.026 0.020 0.013 0.011 0.008
* 0.005 0.002 0.005 0.002 0.013
** M6 LDT2 = (M5) LDGT1 as in RDAge01

* 3 0.053 0.081 0.096 0.076 0.071 0.069 0.074 0.064 0.059 0.047
* 0.045 0.045 0.047 0.041 0.027 0.026 0.020 0.013 0.011 0.008
* 0.005 0.002 0.005 0.002 0.013
** M6 LDT3 = (M5) LDGT2 as in RDAge01

* 4 0.063 0.110 0.130 0.089 0.084 0.062 0.072 0.061 0.045 0.039
* 0.030 0.035 0.039 0.031 0.024 0.023 0.016 0.012 0.008 0.003
* 0.002 0.003 0.007 0.005 0.007
** M6 LDT4 = (M5) LDGT2 as in RDAge01

* 5 0.063 0.110 0.130 0.089 0.084 0.062 0.072 0.061 0.045 0.039
* 0.030 0.035 0.039 0.031 0.024 0.023 0.016 0.012 0.008 0.003
* 0.002 0.003 0.007 0.005 0.007
*
* Here is the unrevised LDGV RD, from the May '02 version of
* this file, to three places instead of four.
* 1 0.055 0.087 0.080 0.074 0.075 0.067 0.077 0.065 0.061 0.056
* 0.053 0.050 0.047 0.040 0.029 0.024 0.017 0.011 0.006 0.004
* 0.003 0.003 0.003 0.003 0.010
* The 4-place and 3-place RDs come from the same data, but
* rounding to 3 places instead of 4 and modifications to make
* the 3-place RDs add to 1.000 mean that rounding the 4-place
* RDs won't necessarily give you exactly the 3-place RDs.
*

```

## B.2 Vehicle Registration Data for Metro-East Area - MERD01.d

```

REG DIST
*
* This file MERD01.D is derived from CHIRD01.D and REGDATA.D, the
* default MOBILE6 RD file. This file was created 29.v.02 by SSL.
*
* It contains Registration Distribution fractions for the 16 vehicle
* classes by age for July of any calendar year for the Metro-East NAA,
* based on 2001 gasoline-vehicle age distribution data supplied to
* SL by Jim Matheny of DVIM.
*
* The user is referred to REGDATA.D and to M6 Users Guide Section
* 2.8.7.1 (p. 63 ff) for more detailed information about the nature
* of RD files. See also Section 5.3.2 (p. 169 ff) for information
* on converting M5b RDs to M6 RDs. See also \SOURCE\BD20.FOR
*

```

```

* In this file, the first number in each distribution is an integer
* that indicates which of the 16 M6 vehicle classes are represented
* by the RD in question. (1=LDV, 2=LDT1, etc) That number is
* followed by 25 age fractions arranged in two rows of 10 values
* and a third row with the last 5 values. The last value on the
* third line is the fraction of vehicles 25 years old or older.
* In this file, the first few values 1 0.045 0.075 ... means that
* 4.5% of LDVs were 1 year old or less, 7.5% were 1-2 years old, etc.
* (This is similar to the format of RDs in M5b.)
*
* RDs for all vehicle classes are given in this file. This is for
* completeness, even though only those vehicle classes whose RDs
* were changed from the REGDATA defaults need to be included in
* this file. Those that were not changed, are so noted.
*
* See SL's file RDAGE01.XLS for original '01 Age Distribution data
* from VIM, and also \AREASPEC\M5RD01.txt, which is a MOBILE5b-type
* RD for the Chicago & Metro-East area for '01 derived from RDAGE01.
*
* LDVs and LDTs were assumed to have the same RDs as LDGVs and LDGTs
* would have in M5b. HDVs were assumed to have the default RDs.
*
* As of 8.v.02, I have assumed Default RDs for the various HDV
* classes, since, although I have information on area-specific HDGV
* age distributions, I do not have such information for HDDVs and
* can only assume the default age distribution for heavy diesels.
* The methodology described in USEPA/OTAQ's publications (including
* the User's Guide and the Technical Guidance) for melding actual
* HDGV and default HDDV age distributions into a single M6 HDV RD,
* is neither clear nor simple, and I have not received a good set
* of HDV RDs from OTAQ-who would presumably know how to do the
* melding. Hence my decision to use this RD file.
*
* -SL
*
* M6 LDV = M5 LDGV (Light-duty Vehicles-passenger cars-from
* RDAGE01.XLS and M5RD01.TXT for Metro-East
1 0.045 0.075 0.081 0.083 0.081 0.070 0.075 0.065 0.058 0.053
0.051 0.042 0.043 0.038 0.029 0.026 0.023 0.014 0.010 0.006
0.004 0.003 0.005 0.004 0.016
* M6 LDT1 = (M5) LDGT1 as in RDAGE01 for Metro-East
2 0.053 0.081 0.096 0.076 0.071 0.069 0.074 0.064 0.059 0.047
0.045 0.045 0.047 0.041 0.027 0.026 0.020 0.013 0.011 0.008
0.005 0.002 0.005 0.002 .013
* M6 LDT2 = (M5) LDGT1 as in RDAGE01
3 0.053 0.081 0.096 0.076 0.071 0.069 0.074 0.064 0.059 0.047
0.045 0.045 0.047 0.041 0.027 0.026 0.020 0.013 0.011 0.008
0.005 0.002 0.005 0.002 0.013
* M6 LDT3 = (M5) LDGT2 as in RDAGE01
4 0.046 0.086 0.065 0.055 0.062 0.075 0.064 0.078 0.059 0.049
0.045 0.047 0.038 0.042 0.027 0.030 0.016 0.017 0.011 0.010
0.004 0.006 0.021 0.021 0.026
* M6 LDT4 = (M5) LDGT2 as in RDAGE01
5 0.046 0.086 0.065 0.055 0.062 0.075 0.064 0.078 0.059 0.049
0.045 0.047 0.038 0.042 0.027 0.030 0.016 0.017 0.011 0.010
0.004 0.006 0.021 0.021 0.026
* HDV2B (Heavy-duty vehicles 2B-M6 Default RDs)
6 0.0503 0.0916 0.0833 0.0758 0.0690 0.0627 0.0571 0.0519 0.0472 0.0430
0.0391 0.0356 0.0324 0.0294 0.0268 0.0244 0.0222 0.0202 0.0184 0.0167
0.0152 0.0138 0.0126 0.0114 0.0499
* HDV3 (Heavy-duty vehicles3, same RD as HDV2B, M6 Default RDs)
7 0.0503 0.0916 0.0833 0.0758 0.0690 0.0627 0.0571 0.0519 0.0472 0.0430
0.0391 0.0356 0.0324 0.0294 0.0268 0.0244 0.0222 0.0202 0.0184 0.0167
0.0152 0.0138 0.0126 0.0114 0.0499
* HDV4 (Heavy-duty vehicles 4, M6 default RDs)
8 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797
* HDV5 (Heavy-duty vehicles 5, same RD as HDV4, M6 Default)
9 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797
* HDV6 (Heavy-duty vehicleless 6, same RD as HDV4, M6 Default)
10 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797
* HDV7 (Heavy-duty vehicles 7, same RD as HDV4, M6 Default)
11 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797
* HDV8A (Heavy-duty vehicles 8A same RD as HDV4, M6 Default)
12 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797
* HDV8B (Heavy-duty vehicles 8B,same RD as HDV4, M6 Default)
13 0.0388 0.0726 0.0679 0.0635 0.0594 0.0556 0.0520 0.0486 0.0455 0.0425
0.0398 0.0372 0.0348 0.0326 0.0304 0.0285 0.0266 0.0249 0.0233 0.0218
0.0204 0.0191 0.0178 0.0167 0.0797

```

```

* HDBS (HDV School buses; this M6 RD default is assumed)
14 0.0393 0.0734 0.0686 0.0641 0.0599 0.0559 0.0522 0.0488 0.0456 0.0426
   0.0398 0.0372 0.0347 0.0324 0.0303 0.0283 0.0264 0.0247 0.0231 0.0216
   0.0201 0.0188 0.0176 0.0165 0.0781
* HDBT (HDV Transit buses; this M6 RD default is assumed)
15 0.0307 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0614 0.0613
   0.0611 0.0607 0.0595 0.0568 0.0511 0.0406 0.0254 0.0121 0.0099 0.0081
   0.0066 0.0054 0.0044 0.0037 0.0114
* Motorcycles (this M6 default RD is the same as M5a/b's default RD)
16 0.1440 0.1680 0.1350 0.1090 0.0880 0.0700 0.0560 0.0450 0.0360 0.0290
   0.0230 0.0970 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
   0.0000 0.0000 0.0000 0.0000 0.0000

```

### B.3 Inspection/Maintenance Programs File - ILLOBDIM.d

```

* ILLINOIS ENHANCED I/M DESCRIPTION Filename: ILLOBDIM.D
* OBD EXH AND GAS CAP 1996+ BEGINNING IN 2002
* First I/M program-IDLE test for MY 1968+ LDVs
I/M PROGRAM      : 1 1986 2050 2 T/O IDLE
I/M MODEL YEARS  : 1 1968 1980
I/M VEHICLES     : 1 22222 11111111 1
I/M STRINGENCY   : 1 20.0
I/M COMPLIANCE   : 1 95.0
I/M WAIVER RATES : 1 0.5 2.2      '01 data
I/M GRACE PERIOD : 1 4
* Second I/M program-IM240 for MY 1981 to 1995 LDVs
I/M PROGRAM      : 2 1999 2050 2 T/O IM240
I/M MODEL YEARS  : 2 1981 1995
I/M VEHICLES     : 2 22222 11111111 1
I/M STRINGENCY   : 2 20.0
* The external file Mycuts.d must be placed in the same subdirectory as MOBILE6 (or a path name is required)
I/M CUTPOINTS    : 2 Mycuts.d
I/M COMPLIANCE   : 2 95.0
I/M WAIVER RATES : 2 0.5 2.2      '01 data
I/M GRACE PERIOD : 2 4
* Third I/M program Gas Cap Check for MY 1968 to 1995 LDVs
I/M PROGRAM      : 3 1992 2050 2 T/O GC
I/M MODEL YEARS  : 3 1968 1995
I/M VEHICLES     : 3 22222 11111111 1
I/M COMPLIANCE   : 3 95.0
I/M WAIVER RATES : 3 0.5 2.2      '01 data
I/M GRACE PERIOD : 3 4
* Forth I/M program-EVAP OBD & Gas Cap Check for 1996+ ldv
I/M PROGRAM      : 4 2002 2050 2 T/O EVAP OBD & GC
I/M MODEL YEARS  : 4 1996 2050
I/M VEHICLES     : 4 22222 11111111 1
I/M STRINGENCY   : 4 20.0
I/M COMPLIANCE   : 4 95.0
I/M WAIVER RATES : 4 0.5 2.2      '01 data
I/M GRACE PERIOD : 4 4
* Fifth I/M program-HDV IDLE for MY 1968+ HDVs
I/M PROGRAM      : 5 1986 2050 2 T/O IDLE
I/M MODEL YEARS  : 5 1968 2050
I/M VEHICLES     : 5 11111 22222222 2
I/M STRINGENCY   : 5 20.0
I/M COMPLIANCE   : 5 95.0
I/M WAIVER RATES : 5 1.2 1.5      '01 data
I/M GRACE PERIOD : 5 4
* SIXTH I/M program-Gas Cap Check for MY 1968+ HDVs
I/M PROGRAM      : 6 1992 2050 2 T/O GC
I/M MODEL YEARS  : 6 1968 2050
I/M VEHICLES     : 6 11111 22222222 2
I/M COMPLIANCE   : 6 95.0
I/M WAIVER RATES : 6 1.2 1.5      '01 data
I/M GRACE PERIOD : 6 4
* SEVENTH I/M program-"Exhaust" OBD for MY 1996+ LDVs
I/M PROGRAM      : 7 2002 2050 2 T/O OBD I/M
I/M MODEL YEARS  : 7 1996 2050
I/M VEHICLES     : 7 22222 11111111 1
I/M STRINGENCY   : 7 20.0
I/M COMPLIANCE   : 7 95.0
I/M WAIVER RATES : 7 0.5 2.2      '01 data
I/M GRACE PERIOD : 7 4
*
* -----
*
* NOTES:
* This is the standard I/M input for the OBD
* case, to be used for regular M6 runs for future
* years. (Cf the non-OBD input ILLIM240.D)
*
* Received from Jim Matheny of IEPA/BOA/VIM
* 12.ii.02. This is the OBD I/M program as it
* exists after early March 2002. JM's original
* file is ILLIM3.D. Only comments have been
* edited or added here. The actual inputs
* have not been changed in any way.
*

```

\* All Illinois I/M is Biennial Test Only (2 T/O)  
 \* and applies to LDGVs and LDGTs. Special I/M  
 \* for HDVs in 5th & 6th programs. Note Exhaust &  
 \* Evaporative OBD for MY '96+ vehicles in 4th & 7th  
 \* programs. IM240 remains for pre-'96 LDVs and idle  
 \* test for pre-'81 LDVs and all HDVs.

## B.4 I/M Programs Cutpoints File - Mycuts.d

\* This file was created automatically by a Mobile6 conversion utility.  
 \* The same cutpoints are used for each model year and vehicle type.

I/M CUTPOINTS : CUTP015.D

```

*
*
* Block 1 (LDGV, LDGT1)
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000
*
* Block 2 (LDGT2, LDGT3)
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000
*
* Block 3 (LDGT4)
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800 0.800
0.800 0.800 0.800 0.800 0.800
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000 15.000
15.000 15.000 15.000 15.000 15.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000 999.000
999.000 999.000 999.000 999.000 999.000
*
* Block 4 (HDGV)
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**Appendix C**  
**MOBILE6 Emission Factor Lookup Tables Used in COSIM**

### C.1 Emission Factor Table - Region 0 - North Attainment Region

Note that COSIM only uses emission factors for the years 2002-2013. Emission factors for years after 2013 in COSIM are held constant at 2013. The additional years in this chart are presented to document the slight decline in emission factor values as model year increases.

Year	Index	Idle (2.5 mph)	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
		<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
2002	<b>0</b>	236.542	59.977	43.310	38.228	35.582	34.116	33.404	33.411	34.377	35.396	36.462	37.580
2003	<b>1</b>	224.464	57.120	41.542	36.791	34.326	32.969	32.326	32.370	33.337	34.350	35.403	36.501
2004	<b>2</b>	197.542	51.134	37.679	33.501	31.330	30.132	29.555	29.576	30.393	31.250	32.146	33.082
2005	<b>3</b>	186.305	47.702	34.752	30.727	28.639	27.485	26.923	26.932	27.702	28.509	29.352	30.231
2006	<b>4</b>	164.157	42.273	30.887	27.305	25.446	24.417	23.905	23.896	24.546	25.231	25.947	26.696
2007	<b>5</b>	157.440	40.734	29.844	26.388	24.595	23.604	23.114	23.111	23.749	24.419	25.120	25.853
2008	<b>6</b>	149.217	39.029	28.846	25.583	23.890	22.957	22.502	22.512	23.137	23.793	24.478	25.193
2009	<b>7</b>	142.312	37.260	27.593	24.504	22.909	22.032	21.610	21.631	22.246	22.886	23.550	24.239
2010	<b>8</b>	135.911	35.650	26.411	23.440	21.908	21.066	20.662	20.684	21.280	21.900	22.543	23.209
2011	<b>9</b>	129.933	34.292	25.485	22.616	21.139	20.326	19.939	19.960	20.541	21.143	21.766	22.411
2012	<b>10</b>	123.604	32.784	24.447	21.712	20.305	19.531	19.165	19.189	19.751	20.334	20.937	21.559
2013	<b>11</b>	119.247	31.644	23.610	20.974	19.621	18.876	18.525	18.549	19.094	19.658	20.241	20.843
2014		115.490	30.673	22.900	20.349	19.040	18.318	17.979	18.002	18.530	19.076	19.641	20.223
2015		112.267	29.853	22.307	19.827	18.554	17.852	17.522	17.543	18.055	18.586	19.134	19.700
2016		108.917	28.978	21.656	19.247	18.010	17.328	17.007	17.027	17.523	18.038	18.569	19.118
2017		106.180	28.274	21.141	18.791	17.585	16.919	16.606	16.624	17.107	17.609	18.126	18.661
2018		103.425	27.535	20.579	18.284	17.107	16.456	16.151	16.168	16.639	17.128	17.633	18.156
2019		101.300	26.971	20.152	17.901	16.746	16.107	15.808	15.824	16.285	16.765	17.260	17.772
2020		99.659	26.547	19.839	17.622	16.484	15.855	15.560	15.575	16.029	16.501	16.988	17.492
2021		98.396	26.229	19.612	17.425	16.302	15.681	15.390	15.404	15.852	16.317	16.798	17.295
2022		97.402	25.978	19.434	17.270	16.159	15.544	15.256	15.270	15.713	16.173	16.649	17.141
2023		96.590	25.772	19.286	17.140	16.039	15.430	15.145	15.158	15.598	16.054	16.525	17.013
2024		95.927	25.602	19.163	17.032	15.939	15.334	15.051	15.064	15.501	15.953	16.422	16.906
2025		95.348	25.452	19.054	16.937	15.850	15.249	14.968	14.981	15.415	15.865	16.331	16.812
2026		94.830	25.318	18.956	16.851	15.771	15.172	14.893	14.906	15.337	15.785	16.248	16.727
2027		94.403	25.206	18.873	16.777	15.702	15.107	14.828	14.841	15.271	15.717	16.178	16.655
2028		93.711	24.997	18.698	16.613	15.544	14.952	14.675	14.688	15.115	15.559	16.018	16.493
2029		93.500	24.944	18.660	16.580	15.513	14.922	14.646	14.659	15.086	15.529	15.987	16.461
2030		93.216	24.869	18.604	16.530	15.466	14.877	14.602	14.614	15.040	15.481	15.938	16.411

\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.

**C.2 Emission Factor Table - Region 1 - North Non-Attainment Region with I/M**

Year	Index	Idle (2.5 mph)	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
		<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
2002	<b>0</b>	143.641	38.358	28.845	25.769	24.144	23.243	22.838	22.888	23.559	24.274	25.028	25.823
2003	<b>1</b>	134.610	36.254	27.542	24.743	23.270	22.456	22.106	22.177	22.837	23.534	24.265	25.032
2004	<b>2</b>	131.969	35.680	27.201	24.471	23.039	22.249	21.915	21.995	22.660	23.359	24.090	24.853
2005	<b>3</b>	123.650	33.495	25.571	23.015	21.674	20.936	20.622	20.696	21.317	21.969	22.651	23.362
2006	<b>4</b>	103.899	28.307	21.657	19.482	18.337	17.705	17.425	17.472	17.966	18.488	19.037	19.613
2007	<b>5</b>	99.969	27.208	20.788	18.685	17.580	16.968	16.700	16.745	17.227	17.735	18.269	18.829
2008	<b>6</b>	96.296	26.201	20.005	17.972	16.905	16.314	16.056	16.100	16.568	17.063	17.581	18.125
2009	<b>7</b>	91.600	24.893	19.033	17.132	16.139	15.590	15.356	15.406	15.864	16.344	16.844	17.365
2010	<b>8</b>	87.609	23.838	18.244	16.427	15.480	14.956	14.736	14.784	15.227	15.690	16.172	16.673
2011	<b>9</b>	83.903	22.878	17.540	15.804	14.900	14.400	14.191	14.238	14.666	15.112	15.576	16.058
2012	<b>10</b>	80.532	22.004	16.900	15.239	14.375	13.897	13.698	13.743	14.155	14.585	15.031	15.495
2013	<b>11</b>	77.438	21.202	16.318	14.730	13.906	13.449	13.261	13.305	13.702	14.116	14.545	14.990

*\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.*

**C.3 Emission Factor Table - Region 2 - North Non-Attainment Region without I/M**

Year	Index	Idle (2.5 mph) <b>0</b>	5 mph <b>1</b>	10 mph <b>2</b>	15 mph <b>3</b>	20 mph <b>4</b>	25 mph <b>5</b>	30 mph <b>6</b>	35 mph <b>7</b>	40 mph <b>8</b>	45 mph <b>9</b>	50 mph <b>10</b>	55 mph <b>11</b>
2002	<b>0</b>	172.708	44.960	33.011	29.165	27.150	26.031	25.496	25.508	26.254	27.046	27.880	28.758
2003	<b>1</b>	165.283	43.276	31.987	28.354	26.460	25.412	24.921	24.954	25.701	26.486	27.307	28.165
2004	<b>2</b>	160.250	42.193	31.331	27.818	25.989	24.980	24.514	24.560	25.306	26.089	26.905	27.756
2005	<b>3</b>	150.963	39.737	29.488	26.168	24.441	23.488	23.047	23.087	23.788	24.522	25.287	26.083
2006	<b>4</b>	130.413	34.368	25.471	22.562	21.047	20.210	19.809	19.826	20.402	21.008	21.642	22.304
2007	<b>5</b>	124.991	32.973	24.440	21.638	20.181	19.374	18.991	19.010	19.571	20.161	20.777	21.421
2008	<b>6</b>	120.288	31.750	23.531	20.825	19.418	18.640	18.272	18.291	18.837	19.411	20.010	20.635
2009	<b>7</b>	114.747	30.253	22.443	19.892	18.573	17.844	17.505	17.532	18.066	18.623	19.201	19.800
2010	<b>8</b>	110.035	29.046	21.564	19.116	17.851	17.152	16.828	16.854	17.372	17.910	18.468	19.046
2011	<b>9</b>	105.653	27.947	20.780	18.427	17.214	16.544	16.235	16.260	16.761	17.281	17.820	18.377
2012	<b>10</b>	101.614	26.922	20.044	17.785	16.621	15.976	15.681	15.706	16.190	16.692	17.211	17.749
2013	<b>11</b>	98.084	26.019	19.398	17.225	16.107	15.488	15.205	15.230	15.698	16.183	16.684	17.202

*\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.*

**C.4 Emission Factor Table - Region 3 - South Attainment Region**

Year	Index	Idle (2.5 mph)	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
		<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
2002	<b>0</b>	212.877	53.802	38.648	34.001	31.576	30.228	29.569	29.563	30.424	31.336	32.295	33.303
2003	<b>1</b>	201.665	51.139	37.000	32.664	30.409	29.164	28.570	28.598	29.462	30.369	31.317	32.306
2004	<b>2</b>	177.387	45.764	33.554	29.741	27.754	26.655	26.121	26.131	26.860	27.628	28.433	29.277
2005	<b>3</b>	167.395	42.757	31.019	27.348	25.440	24.382	23.864	23.864	24.550	25.274	26.031	26.823
2006	<b>4</b>	147.554	37.909	27.585	24.317	22.617	21.674	21.202	21.187	21.766	22.379	23.023	23.699
2007	<b>5</b>	141.550	36.536	26.659	23.507	21.867	20.959	20.507	20.497	21.066	21.667	22.298	22.959
2008	<b>6</b>	133.869	34.925	25.707	22.737	21.193	20.339	19.921	19.925	20.483	21.072	21.688	22.333
2009	<b>7</b>	127.682	33.339	24.587	21.776	20.323	19.522	19.134	19.148	19.698	20.273	20.870	21.492
2010	<b>8</b>	122.030	31.916	23.544	20.840	19.444	18.674	18.304	18.318	18.853	19.410	19.989	20.590
2011	<b>9</b>	116.640	30.693	22.714	20.103	18.757	18.015	17.660	17.675	18.195	18.737	19.299	19.881
2012	<b>10</b>	110.964	29.341	21.786	19.297	18.015	17.308	16.973	16.991	17.495	18.019	18.562	19.124
2013	<b>11</b>	107.092	28.328	21.043	18.645	17.411	16.731	16.410	16.428	16.917	17.425	17.951	18.495

\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.

**C.5 Emission Factor Table - Region 4 - South Non-Attainment Region with I/M**

Year	Index	Idle (2.5 mph)	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
		<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
2002	<b>0</b>	165.264	42.809	31.454	27.907	26.039	25.007	24.543	24.606	25.386	26.213	27.083	27.998
2003	<b>1</b>	155.211	40.622	30.216	26.977	25.276	24.341	23.937	24.027	24.798	25.609	26.458	27.345
2004	<b>2</b>	133.446	35.709	26.999	24.223	22.761	21.956	21.599	21.663	22.296	22.965	23.669	24.409
2005	<b>3</b>	124.996	33.482	25.321	22.711	21.338	20.582	20.247	20.307	20.901	21.531	22.191	22.885
2006	<b>4</b>	106.887	28.884	21.954	19.705	18.519	17.863	17.564	17.601	18.083	18.596	19.138	19.709
2007	<b>5</b>	103.288	27.924	21.222	19.041	17.892	17.257	16.969	17.007	17.481	17.985	18.515	19.074
2008	<b>6</b>	98.787	26.746	20.344	18.257	17.158	16.551	16.277	16.314	16.772	17.257	17.768	18.306
2009	<b>7</b>	93.959	25.415	19.358	17.401	16.377	15.813	15.565	15.609	16.059	16.532	17.027	17.544
2010	<b>8</b>	89.644	24.285	18.511	16.639	15.661	15.123	14.888	14.932	15.368	15.826	16.304	16.802
2011	<b>9</b>	85.613	23.263	17.765	15.973	15.040	14.525	14.302	14.346	14.769	15.211	15.672	16.153
2012	<b>10</b>	82.006	22.328	17.076	15.362	14.469	13.977	13.766	13.808	14.216	14.643	15.088	15.550
2013	<b>11</b>	78.856	21.496	16.462	14.821	13.968	13.498	13.298	13.340	13.733	14.145	14.573	15.018

\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.

**C.6 Emission Factor Table - Region 5 - South Non-Attainment Region without I/M**

Year	Index	Idle (2.5 mph)	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
		<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>
2002	<b>0</b>	201.692	51.028	36.654	32.188	29.855	28.561	27.937	27.949	28.808	29.716	30.670	31.674
2003	<b>1</b>	192.169	49.007	35.520	31.313	29.124	27.916	27.347	27.386	28.246	29.149	30.092	31.076
2004	<b>2</b>	168.094	43.627	32.032	28.339	26.415	25.350	24.839	24.858	25.581	26.344	27.143	27.979
2005	<b>3</b>	158.871	41.090	30.044	26.516	24.681	23.665	23.175	23.187	23.871	24.590	25.342	26.129
2006	<b>4</b>	139.450	36.223	26.535	23.410	21.783	20.882	20.437	20.434	21.008	21.615	22.252	22.921
2007	<b>5</b>	133.512	34.821	25.571	22.567	21.003	20.138	19.714	19.717	20.281	20.876	21.500	22.154
2008	<b>6</b>	127.272	33.305	24.513	21.644	20.152	19.327	18.925	18.933	19.480	20.057	20.660	21.292
2009	<b>7</b>	121.467	31.771	23.410	20.695	19.291	18.516	18.145	18.161	18.699	19.261	19.846	20.455
2010	<b>8</b>	116.195	30.455	22.459	19.849	18.501	17.757	17.402	17.420	17.943	18.489	19.055	19.644
2011	<b>9</b>	111.249	29.266	21.626	19.114	17.819	17.105	16.765	16.784	17.292	17.821	18.369	18.938
2012	<b>10</b>	106.629	28.108	20.800	18.391	17.150	16.466	16.142	16.162	16.653	17.165	17.695	18.244
2013	<b>11</b>	103.054	27.178	20.125	17.803	16.608	15.949	15.639	15.658	16.135	16.631	17.143	17.674

\* Emission Factors in g/mi except for Idle Speed. Idle speed EFs in g/hr.

**Appendix D**  
**COSIM Version 2.0 User's Manual**



CARBON MONOXIDE SCREEN FOR INTERSECTION MODELING

## **USER'S MANUAL**

Version 2.0 - May 2003

Written by: Scott Peters  
University of Illinois  
Prepared for:



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## Preface

Illinois COSIM is a Windows-based screening model used for determining worst-case carbon monoxide (CO) concentrations at signalized intersections throughout Illinois. COSIM uses readily available data in a user-friendly application to make a conservative estimate of project CO levels. This is done by using a combination of worst-case conditions that when occurring simultaneously produce the highest levels of CO. If the results from COSIM do not violate National Ambient Air Quality Standards (NAAQS) for CO, the impact from any other combination of conditions will also be below the standards and no further modeling is required. If the results from COSIM indicate that the project may cause a NAAQS violation, a detailed analysis should be performed to better evaluate project CO levels.

COSIM was developed by researchers at the University of Illinois, Urbana-Champaign (UIUC). The model is the product of research sponsored by the Illinois Transportation Research Center (ITRC) and UIUC. Principal researchers on the project were Scott Peters, Padmini K. Gollapalli, Angela Schnapp, and Lee Melcher under the academic guidance of Dr. Susan M. Larson and Dr. Fred Coleman III. Illinois COSIM was designed and written by Scott Peters, Jung-Suk Lee, and Padmini K. Gollapalli. Program documentation and user's manual were written and created by Scott Peters. Project guidance was given from a committee consisting of members from UIUC, ITRC, Illinois Department of Transportation (IDOT), Illinois Environmental Protection Agency (IEPA), and Federal Highway Administration (FHWA). We would like to extend special thanks to committee chairman Walt Zyznieuski (IDOT) and committee members Dr. Steven J. Hanna (ITRC), Dianne Kay (ITRC), Mitch Rogers (IDOT), Patricia Broers (IDOT), Mike Rogers (IEPA), Rob Kaleel (IEPA), Michael Claggett (FHWA), and Kevin Ward (FHWA). Additionally, we would like to thank Sam Long (IEPA) for his help with the MOBILE6 input files used in creating and updating COSIM.



## Definitions and Acronyms

**Actuated intersection** - An intersection with signal timing and phasing controlled by an actuated controller. The controller is dependent on traffic volumes and the presence of pedestrians.

**ADT** - Average Daily Traffic.

**Ambient air** - That portion of the atmosphere external to buildings and to which the general public has access (IDOT, 1982).

**Attainment area** - Area that has met National Ambient Air Quality Standards.

**Background concentration** - In this manual, the concentration of CO in the ambient air that is not attributed to the intersection.

**CAL3QHC** - The latest model recommended by the USEPA for modeling inert airborne pollutants, more specifically, carbon monoxide at signalized roadway intersections (USEPA, 1995). CAL3QHC is used to calculate the CO concentrations in COSIM, based on the intersection geometry, user inputs, and worst-case assumptions.

**Clearance lost time** - Portion of the yellow phase of a traffic signal that is not used by the motorist (USEPA, 1995).

**CO** - Carbon Monoxide.

**COSIM** - Carbon Monoxide Screen for Intersection Modeling.

**Detailed CO analysis** - A rigorous method used to determine if a project may cause a violation of the National Ambient Air Quality Standards. USEPA models MOBILE6 and CAL3QHC are typically used for a detailed analysis.

**Edge of roadway** - The edge of the outermost lane of vehicle travel.

**EF** - Emission Factor. The amount or mass of contaminant that is emitted per rate of activity.

**Existing year** - The year in which the NEPA document or project report is performed.

**FHWA** - Federal Highway Administration.



**GPE** - Gaussian Plume Equation. An equation depicting pollution as dispersing horizontally and vertically in a Gaussian or normal distribution.

**IDOT** - Illinois Department of Transportation.

**IEPA** - Illinois Environmental Protection Agency.

**I/M** - Inspection and Maintenance program.

**LOS** - Level of Service.

**MOBILE6** - The most current in a series of mobile source emission models released by the USEPA. The model may be used to estimate the emission factors for hydrocarbons, nitrogen oxides, and carbon monoxide from 28 different vehicle classifications.

**MPH** - Miles per hour.

**NAAQS** - National Ambient Air Quality Standards.

**NEPA** - National Environmental Policy Act.

**Nonattainment area** - Area that has failed to meet National Ambient Air Quality Standards.

**Pretimed intersection** - An intersection with signal timing and phasing controlled by a pretimed controller. The controller has a fixed cycle length and preset phase intervals.

**Queue** - A platoon of vehicles stopped or in idle mode.

**Screening CO analysis** - A quick and simplified method used to indicate if a project should receive a detailed analysis.

**Semi-actuated intersection** - An intersection with signal timing and phasing controlled by an actuated controller operating in semi-actuated mode. The major phase receives green until interrupted by a signal from detectors on the minor phase.

**Sensitive receptor** - A building or location where the general public may be expected to remain for the duration of the period specified by the National Ambient Air Quality Standards (IDOT, 1982).



**TOC** - Project time of completion.

**TOC + 10** - The proposed time of project completion plus an additional ten years.

**Total Cycle Length** - The time required to complete one full traffic signal cycle for an entire intersection.

**USEPA** - United States Environmental Protection Agency.

**VPH** - Vehicles per hour.



## Background Information

### Carbon Monoxide Air Quality

Air pollution, stemming from industrialization and the extensive burning of fossil fuels, is a problem in today's global ecosystem which can cause human health problems and adverse effects on the environment. The specific effects of an air contaminant are dependent on the pollutant's chemical composition (and size, for particulate pollutants), the pollutant's concentration in the atmosphere, and the exposure time to the pollutants. Air quality regulations have been established to monitor sources and to control their emissions. In order to develop source control regulations, source emissions must be related to the pollutant concentrations found in the atmosphere, i.e., to the pollutant's ambient concentrations. One way of accomplishing this task is through the use of numerical models.

Today, models combining physical, statistical, and analytical processes are commonly used to estimate pollutant source strengths and to predict how the pollutant will be transported and dispersed once released into the atmosphere. Using these models, we can estimate the concentrations of pollutants at a given location. The modeled concentrations can then be compared to standards designed to protect human health and welfare. The necessary control strategies can then be developed to help insure that the standards are not exceeded.

The major source of transportation-related pollutants is the internal combustion engine. The main airborne pollutants produced, volatile organic compounds (or hydrocarbons, HCs), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), sulfur oxides (e.g., SO<sub>2</sub>), and particulate matter, are the result of both evaporative losses and the combustion of carbonaceous fuels. Vehicle emission limits have been established to help reduce the amount of these pollutants entering the atmosphere each year. Meeting state and federal regulatory standards is an important consideration in the design of transportation projects. Modeling is an integral part of these design and regulatory issues.

CO is a colorless, odorless gas that is found naturally in the atmosphere at very low concentrations, approximately 50 to 120 parts per billion. At these low concentrations, CO is not detrimental to human health. At higher concentrations, however, CO can impair psychomotor skills and even cause death. At an average exposure time of 8 hours, CO



concentrations between 10 and 15 ppm can cause impaired time interval discrimination, and concentrations above 30 ppm can adversely effect psychomotor skills (Seinfeld, H.J., 1986). Concentrations in these ranges can be measured at traffic-congested intersections.

To protect human health, national standards have been set for ambient levels of CO. Violations are determined by comparing measurements made from stationary monitors to the National Ambient Air Quality Standards (NAAQS); the 1-hour average standard for CO is 35 ppm, the 8-hour average standard is 9 ppm. The 8-hour standard is more frequently violated and is thus usually the standard of concern.

In general, due to improvements in automobile technology, CO emissions have been decreasing over the past 15 years. One of the most successful steps in reducing emissions from automobiles was the addition of the catalytic converter. Other common emission reduction measures currently used around the country include the use of oxygenated fuels, carpool programs, and vehicle I/M programs. Another method to reduce vehicle emissions is through the proper design of roadways, freeways, and intersections so that they minimize traffic congestion, and thus also minimize the environmental impacts of the vehicular emissions. Estimating a project's likely impact on the ambient air before the project is built is most commonly done using simulation models.

### **Modeling Discussion**

A simulation model is a representation of an object or process. It can be used to predict or describe how a system will react to a given set of conditions. A good predictive model should be able to estimate current conditions and accurately predict future conditions. In intersection air quality modeling, we are interested in mathematically representing a roadway intersection to estimate and predict the current and future air quality resulting from the combined traffic geometry, traffic volumes and speeds, fleet characteristics, and weather conditions at the intersection. The two types of models frequently used together in an air quality analysis are mobile emission models and dispersion models.



## Vehicle Emission Factor Models

Knowledge of vehicle emissions from a roadway is necessary for any intersection air quality analysis. Unfortunately, exact emissions are never known. It would be next to impossible to monitor the emissions of every vehicle that passed by the intersection of concern. Even if it were possible, one would be hard pressed to determine what emission rates would be at that intersection in an hour, a year or even 10 years after these hypothetical measurements were taken. Emission models are therefore used to help estimate current and projected emissions from vehicles passing through an intersection.

A transportation emission model estimates the amount of vehicle emissions in terms of average emission factors (EFs) for different vehicle classifications in a given fleet for a given year. A composite emission factor is also computed to represent the entire fleet. An emission factor quantifies the amount or mass of emissions that is emitted per rate of activity. Typical emission factor units for moving vehicles are mass of CO per miles traveled and, for stationary vehicles, mass of CO per idle time. The emission factors are then used in a separate dispersion model to predict the pollutant transport and dispersion in the ambient air. The most current vehicle-fleet emission model recommended by the United States Environmental Protection Agency (USEPA) and the one used in developing this screening model is MOBILE6.

## MOBILE6

MOBILE6 is the most current in a series of mobile source emission models released by the USEPA. The model is used to estimate the emissions of hydrocarbons, nitrogen oxides, and carbon monoxide from 28 different vehicle classifications. The model is routinely used on projects ranging in size from the microscale (e.g., local hot-spot analysis) to the macroscale (e.g., developing regional emission inventories) to fulfill the conformity requirements of the 1990 Clean Air Act Amendments. Note there are currently no CO nonattainment or maintenance areas in Illinois. The COSIM model is concerned specifically with **microscale** intersection analysis and only utilizes MOBILE6's ability to predict CO emissions.



## Dispersion Models

Atmospheric dispersion modeling is used to determine how a pollutant will be transported, dispersed, and transformed once it is introduced into the atmosphere. Given emission source strengths, a dispersion model predicts ambient pollutant concentrations at various locations or receptors. Several methods are used to model atmospheric dispersion ranging from actual physical wind tunnel models to complex mathematical models capturing physical and chemical mechanisms through numerical representations. Many of the mathematical models, including COSIM, are based on dispersion characteristics captured in what is known as the Gaussian plume equation (GPE). The original form of the GPE is used to describe how a non-reactive pollutant originating from a point source moves in a uniform wind field with respect to time. The equation describes the concentration of pollution as the pollutant disperses horizontally and vertically in a Gaussian or normal distribution. The point source GPE has been modified to the line source GPE for use in modeling roadway mobile source emissions. This line source GPE is derived by integrating the point source equation over a continuous line or line segment.

## CAL3QHC v 2.0

CAL3QHC v 2.0 is the latest model recommended by the USEPA for use in modeling inert airborne pollutants, for example, carbon monoxide at signalized roadway intersections (USEPA, 1995). The model combines traffic queuing algorithms, based on techniques presented in the 1985 Highway Capacity Manual and the Deterministic Queuing Theory (USEPA, 1995) and newly created delay algorithms with the dispersion methods created for California line source model, CALINE3.

## Illinois Specifics

The new COSIM Pre-Screen feature replaces the pre-screen criterion formerly used by IDOT of 16,000 ADT. The Pre-Screen feature should be run prior to performing a complete COSIM analysis to determine if a complete COSIM run is necessary. If the project *passes* the pre-screen, a complete COSIM analysis is not required, and the passing pre-screen result should be reported in the National Environmental Policy Act (NEPA) document or project report. If the project *fails* the pre-screen, a complete COSIM analysis should be performed to better estimate the intersection's impact on ambient CO concentrations.



If the results of a complete COSIM analysis indicate that all receptors *pass* the screening test, there is no need for a detailed analysis. Results from the 8-hr screening analysis should be reported in the NEPA document or project report. The COSIM final report should be added to the project files. If any of the COSIM receptors indicate a *fail* result (NAAQS CO exceedance) a detailed analysis should be performed on the intersection to better evaluate CO levels. Contact IDOT Air Quality Specialist Walt Zyznieuski at (217) 785-4181 with any comments or questions pertaining to COSIM or on conducting a detailed CO analysis.

### Screening vs. Detailed Modeling

If required, the detailed air quality analysis is performed using the two previously discussed USEPA models, MOBILE6 and CAL3QHC, to predict whether CO concentrations arising from the project, when added to the background concentrations, will cause a violation of the NAAQS. The detailed analysis requires input data that often times may be difficult and time consuming to obtain. The detailed analysis also requires the expertise of a user who is familiar with the models. This can prolong the start date of the project and increase project expenditures.

Because the NAAQS for CO are expressed as maximum concentrations not to be exceeded more than once a year, a screening analysis may be used to determine if a detailed analysis is necessary. A screening analysis is used to determine if a project *may* cause a NAAQS violation. The goal of a CO screening analysis is to use readily available data in a user-friendly application to make a *conservative* estimation of a project's contribution to the ambient CO concentrations. This is done by evaluating a project using a combination of conditions that when occurring simultaneously produce the highest ambient CO concentrations. The background concentration is then added to the estimates and the totals are compared to the NAAQS. This type of evaluation is termed a worst-case analysis.

If the results from the worst-case analysis do not indicate a NAAQS violation, the impact from any other combinations of conditions should also be below the standards, and no further modeling is required. On the other hand, if the screening model indicates that the project *may* cause a NAAQS violation, a detailed analysis is required to better estimate the project's impacts.



## Getting Started

### System Requirements

COSIM will run on Windows 95, Windows 98, Windows 2000, Windows Me, Windows XP, or Windows NT operating systems. The program was designed to run from the hard drive of an individual PC. If COSIM is run off a system server, only one person should run the program at a time. Minimum memory requirements are 16 MB RAM and 9 MB hard drive space. Display resolution should be at least 800 x 600 pixels. Small font type is recommended for the best display. However, the program will run adequately using large font type. For information on your computer's current resolution and font size, check settings under your computer's display properties option. Contact your computer systems administrator with questions regarding your display properties.

### Installing COSIM

If COSIM Version 1 (1.0 or 1.1) is currently installed on your computer, you must first uninstall Version 1 before installing Version 2.0. To uninstall, select *Uninstall* in the COSIM program folder on your computer. This will automatically remove all COSIM related program files. COSIM project files will not be removed.

Once Version 1 has been removed from your computer, insert the Illinois COSIM 2.0 installation CD into your computer's CD drive. Access the installation CD and run the *COSIM2\_Setup.exe* file. This will launch the COSIM setup program and guide you through the installation procedure. The default installation folder is *C:\Program Files\COSIM*. A COSIM program folder will be created in your *Programs* folder. The COSIM folder will contain two icons: COSIM and *Remove COSIM 2.0*.

### Uninstalling COSIM

To remove COSIM from your computer, select *Remove COSIM 2.0* in the COSIM program folder. This will automatically remove all COSIM related program files on your computer. COSIM project files will not be erased.



### Limitations and User Warnings

The COSIM model was designed to estimate 1-hr and 8-hr worst-case CO concentrations at signalized intersections located in Illinois. The purpose of the model is to allow the user to conservatively estimate the highest CO concentrations that would be found at an intersection without having to perform a time consuming detailed analysis. This screening model is not applicable to all intersection projects. If the main assumptions used in developing the COSIM model are not appropriate for the intersection project under evaluation, the screening tool should not be used. If any of the following conditions apply to the intersection under evaluation, consult with the IDOT Air Quality Specialist in the Bureau of Design and Environment regarding further evaluation of the intersection.

Do not use COSIM if...

- The intersection is located outside of Illinois. (All emission factors used in COSIM are Illinois specific.)
- The intersection geometry drastically differs from those presented in COSIM.
- The vehicle fleet mix at intersection differs greatly from the default fleet mix used by IDOT (e.g., modeling an intersection near a truck stop.)
- Nearby receptors are located in or near a tunnel or other enclosed area.



## Intersection Analysis Using COSIM

### Opening COSIM

When you are ready to use COSIM, select the COSIM shortcut from the start menu or program files folder on your computer. The first time the program is run you will be presented with an opening title screen. From this screen, you can view general help file information that may be useful for first time users. To view this information, select the *Start Up Info* button. The opening title screen will appear every time COSIM is opened unless you select the *Do not show next time* box. To undo the *Do not show next time* box, select the *Show start box* item found under *Help* in the main menu.

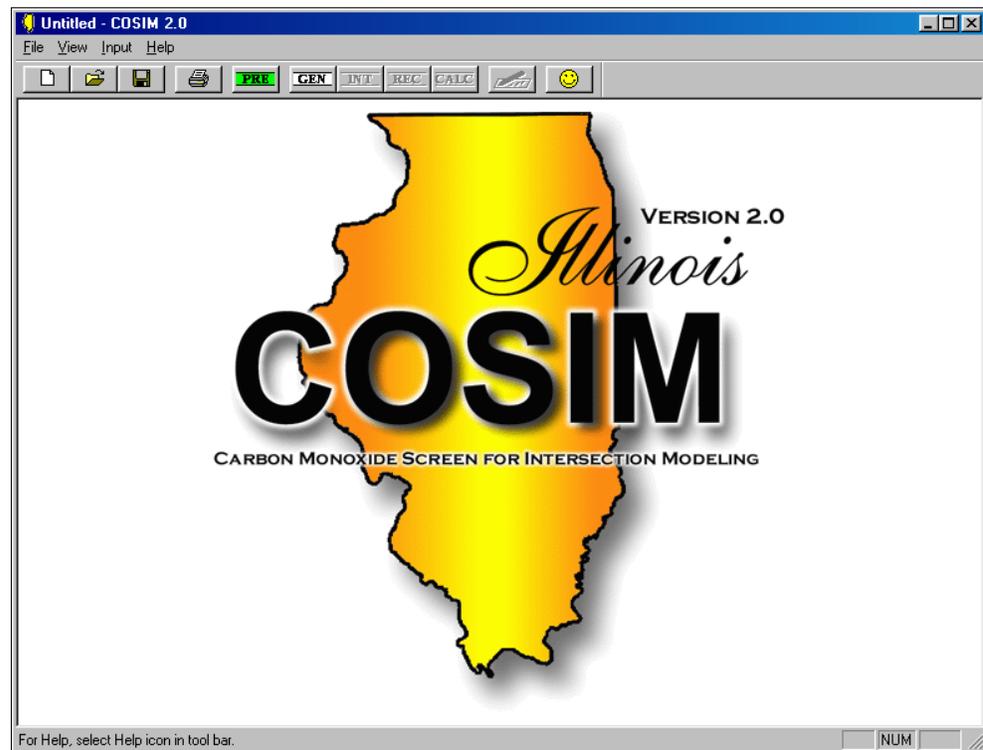
After the start up info box is closed, you are ready to use COSIM. The first step is to either create a new file or to open an existing file. We will assume you are a first time user and will proceed with creating a new file. Opening an existing file will be discussed later.





## Main COSIM Screen

Before entering any input values, take a moment to look over the main program screen. The main COSIM screen consists of several components typical of programs run in Windows. The top of the window contains the program title bar. The left side of the title bar displays the name of the current COSIM project. Until a file is first saved, the program title will be labeled *Untitled*. The right side of the title bar contains a line, a square, and an X. The line will minimize the window, the square will maximize the window, and the X will close the COSIM program. Below the title bar is the main menu. Below the title bar is the main menu.





The main menu consists of four items: *File*, *View*, *Input*, and *Help*. Each item in the main menu is further broken down into submenus. The functions of the menu and submenu items will be discussed as we run through the program. Below the main menu is the tool bar. The tool bar contains icons that allow you to perform certain tasks by simply selecting the icon. COSIM contains eleven icons in the tool bar:

-  Creates a new program file.
-  Opens an existing program file.
-  Saves all the current values input by the user.
-  Prints the report displayed in the main view window.
-  Displays the input box for the Pre-Screen feature.
-  Displays the series of general input boxes.
-  Displays the series of intersection input boxes.
-  Displays the receptor input box.
-  Performs the calculations necessary to compute CO concentrations.
-  Displays the comment editor used to insert comments in the final report.
-  Displays a COSIM help index screen.

Functions of the individual tools found in the tool bar will be discussed further in the following sections. Below the tool bar is the main view area. The title screen will appear in the main view area, until the Pre-Screen feature is run or the CO calculations are made. After the Pre-Screen feature is run, the pre-screen report will be displayed in the main view area. If a complete COSIM analysis is run, the pre-screen report will be replaced with the title screen once the general inputs are entered. After the COSIM calculations are performed, the final COSIM output will be displayed in the main view area. Below the main view area is the message prompt area. This area displays a brief message pertaining to the current mouse position in the main COSIM window.



## COSIM Pre-Screen

The COSIM Pre-Screen feature allows you to determine if a complete COSIM analysis is necessary for your project by entering only a minimal amount of information. To run the Pre-Screen, select the submenu item *Pre-Screen Input* found under the *Input* in the main menu, or select the *PRE* icon in the tool bar.

### Pre-Screen Inputs

Three inputs are required to run the Pre-Screen; 1) county in which the intersection is located, 2) traffic volume on the busiest leg of the intersection, and 3) closest receptor distance to any one edge of the proposed roadway. In addition to these three required inputs, user's name, project name, and intersection name should also be entered for documentation purposes.

**INTERSECTION LOCATION** - Enter the county in which the intersection is located. Counties may be selected using a drop down menu that contains the 102 counties in Illinois.

**TRAFFIC VOLUME** - Design year traffic volume for the proposed improvement may be entered in average daily traffic (ADT) or peak hourly traffic volume (in vph) for the busiest leg of the intersection. The volume should include all traffic traveling on the leg (both directions). Be sure to select the units that correspond to the type of traffic volume you entered.

**DISTANCE TO CLOSEST RECEPTOR** - Enter the distance, in feet, to the sensitive receptor closest to the proposed intersection. IDOT defines a sensitive receptor as a building or location where the general public may be expected to remain for the duration of the period specified by the



NAAQS. The distance should be measured from the receptor to the edge of the nearest proposed roadway.

**PROJECT NAME** - Enter a brief description of the project. This description will be included in the header of the report.

**INTERSECTION NAME** - Enter the name of the intersection. This will typically be the names of the intersecting streets. The intersection name will be included in the header of the report.

**USER'S NAME** - Enter your name. This will be included in the header of the report.

If you wish to cancel all current input values and exit the Pre-Screen, select the *Cancel* button.

### Pre-Screen Output Page

After valid Pre-Screen inputs have been entered and the OK button has been selected, a one page report summarizing the results of the Pre-Screen will be displayed in the main view.

#### Pass Result

COSIM PRE-SCREEN MODELING RESULTS	
	
04-30-03 09:24 PM <b>Downtown Springfield</b>	
Performed by:	<b>Lemae C. Yu</b>
Intersection Location:	<b>Sangamon County</b>
Intersection Name:	<b>Sixth and Monroe</b>
Highest Traffic Volume:	<b>662 ADT</b>
Closest Receptor:	<b>10 feet</b>
<b>Pass</b>	
<p>Intersection PASSES Pre-Screen. COSIM analysis not required.            Traffic volume on busiest leg of intersection is below Pre-Screen Cutoff ADT for the closest receptor distance. Traffic volume includes vehicles traveling in both directions on the leg.</p> <p>Please include the following statement in the project report or NEPA document:</p> <p><b>A Pre-Screen analysis was completed for the proposed project. The results from this proposed roadway improvement indicate that a COSIM air quality analysis is not required, as the results for the worst-case receptor are below the 8-hour average National Ambient Air Quality Standard for CO of 9.0 ppm which is necessary to protect the public health and welfare.</b></p>	
Page 1 of 1	

#### Fail Result

COSIM PRE-SCREEN MODELING RESULTS	
	
04-30-03 09:30 PM <b>Hatsville Elevation Gain</b>	
Performed by:	<b>Ira Vontcha</b>
Intersection Location:	<b>Scott County</b>
Intersection Name:	<b>Fourth and Main</b>
Highest Traffic Volume:	<b>9666 ADT</b>
Closest Receptor:	<b>10 feet</b>
<b>Fail</b>	
<p>Intersection FAILS Pre-Screen. Complete COSIM analysis is required.</p> <p>Traffic volume on busiest leg of intersection is above Pre-Screen Cutoff ADT for the chosen receptor distance. Traffic volume includes vehicles traveling in both directions on the leg.</p>	
Page 1 of 1	



The top of the report displays the date and time the Pre-Screen calculations were made. Below the time is the project name. The next five lines show the inputs used to determine whether the intersection passes or fails the Pre-Screen analysis. Below the input information are the results of the Pre-Screen analysis. A *Pass* result does not require you to perform a complete COSIM analysis. A *Fail* result requires you to run a complete COSIM analysis to better estimate the intersection's impact on ambient CO concentrations.

### **Saving a File**

After all inputs are entered, it is good procedure to save your work. Saving a file in COSIM is similar to the procedure in other Windows programs. You may select *Save* or *Save as...* submenu items under *File* in the main menu or the save icon in the tool bar. If you are saving the file for the first time, the *Save as* dialog box will appear. First select the folder you wish to save your file in, or create a new folder. We recommend storing all your files in the *COSIM Project Files* folder. Next, enter a descriptive name to represent the project and select *OK*. The program will automatically save your filename followed by the three-letter extension *.sim* (for *COSIM*) in the designated folder.

### **Print Preview**

To view the Pre-Screen output report as it will be printed, select the *Print Preview* item under *File* in the main menu. This will display the print preview window. The *Print* button at the top of the page will send the current output report to the default printer. The *Zoom In* button magnifies the current view. The *Zoom Out* button decreases the size of the view. The *Close* button returns the user to the main COSIM screen.

It is NOT necessary to use the print preview option before printing the report. The main view in COSIM was designed to look like the printed report, therefore you may feel that viewing the report in the print preview mode before printing is unnecessary.

### **Printing the Report**

To print the Pre-Screen report, the report must be visible in the main window. When the report appears in the main view, select the *Print* item under *File* in the main menu or select the print icon from the tool bar. This will open the print option screen used by the default printer. Set the desired print options and press the *OK* button. This will send the current output report to the default printer.



## Complete COSIM Analysis

If the results from the Pre-Screen indicate a *Fail* result, you will have to perform a complete COSIM analysis. User inputs for a complete COSIM analysis are separated into three categories: general inputs, intersection inputs, and receptor inputs. You must enter the series of input variables in this order. We have created an input worksheet to aid in the model input procedure. Using the worksheet is a recommendation, not a model requirement. The worksheet provides a concise, organized method to expedite the data collection process. A copy of the worksheet and a detailed explanation of its entries are provided in the appendix.

To begin a complete COSIM analysis, select the submenu item *General Input* found under *Input* in the main menu, or select the *GEN* icon in the tool bar.

### General Inputs

This series of input screens prompts you for variables that describe the intersection's general characteristics and aid in the documentation of the modeled intersection.

#### PAGE 1 OF 3

General Inputs: Page 1 of 3

GENERAL INFORMATION

Project Name

User's Name

Year of Analysis  2002 - 2050

Background Concentration (ppm)

Help < Back Next > Cancel

**PROJECT NAME** - Enter a brief description of the project. This description will be included in the header of the final output.

**USER'S NAME** - Enter your name. This will be included in the header of the final output.



**YEAR OF ANALYSIS** - Enter the year you wish to model. This variable is used in determining the appropriate emission factor for the dispersion calculations. CO analyses for IDOT roadway improvement projects are typically performed for four different time frames: existing year (for no-build scenario), time of completion (TOC), TOC + 10 years, and design year. The existing year is the year in which the NEPA document or project report is performed. The TOC is the proposed time of project completion. COSIM has the years 2002 to 2050 built into the model for CO analysis.

**BACKGROUND CONCENTRATION** - This is the concentration of CO in the ambient air that is not attributed to the intersection. Enter the background concentration of CO in your region of analysis (typically 2.0 or 3.0 ppm). Background concentration is a difficult and costly parameter to measure in the field. Most users will use the default values suggested by regulatory agencies. IDOT suggests the use of 3.0 ppm for urban locations and 2.0 ppm for rural locations. 3.0 ppm is the default background concentration for COSIM. The acceptable range is 0.0 to 9.0 ppm.

When the desired inputs are entered select the *Next* button. If you wish to cancel all current input values and exit the series of general input screens, select the *Cancel* button.

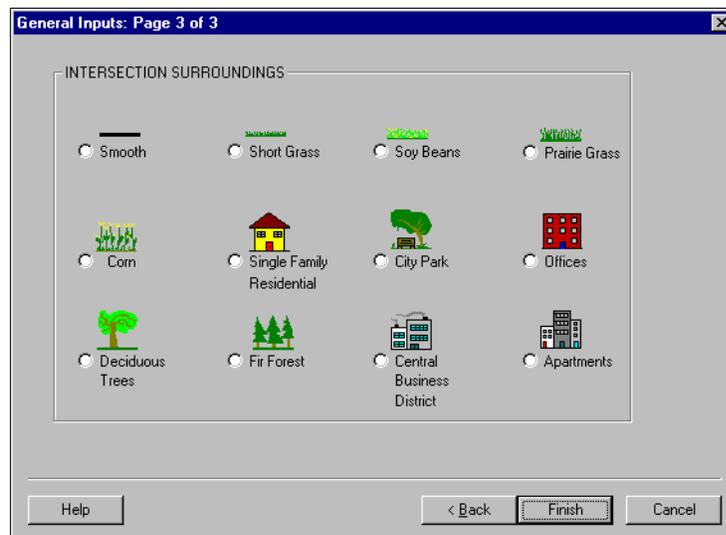
**PAGE 2 OF 3**



*INTERSECTION LOCATION* - First select the IDOT district where the intersection is located. Next, under the appropriate district title, select the county where the intersection is located. This parameter will be used to designate the fleet and fuel characteristics for determining the appropriate EFs. Note: Grundy and Kendall Counties in District 3 contain townships in ozone nonattainment areas. EFs in these areas were calculated using Chicago area MOBILE6 input files. Therefore if your intersection lies in either of these two counties, you will be asked to provide additional township information.

After the location is entered, select the *Next* button. If you wish to cancel all current input values and exit the series of general input screens, select the *Cancel* button. If you wish to return to the first page, select the *Back* button.

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*INTERSECTION SURROUNDINGS* - Select the predominant type of surroundings. If more than one type of surrounding prevails at the intersection, choose the type of surrounding that is closest to ground level. The icons are arranged from left to right, top to bottom in order of increasing height. For example, if the west side of the intersection is city park, and apartment buildings lie to the east, select city park as the predominant surroundings. If your intersection surroundings do not match any of the given choices, select the closest description. This input parameter will be used to determine a surface roughness factor and a stability class within the dispersion model.



After the type of surroundings is entered, select the *Finish* button. If you wish to cancel all current input values and exit the series of general input boxes, select the *Cancel* button. If you wish to return to the second page, select the *Back* button. Once the *Finish* button is pressed, the series of general input screens is complete. To view or change any of your input values select the *GEN* icon or the *General Inputs* item from the main input menu. To continue, select the *INT* icon in the tool bar.

## Intersection Inputs

This series of four input screens prompts the user for information describing the intersection characteristics. Intersection geometry, traffic volume, approach speed, and signal timing are the main variables on the four screens.

### PAGE 1 OF 4

**INTERSECTION TYPE** - The intersections are categorized into three different types; T-type, One-way, and Four-way intersections. Select the description that best describes your intersection. When a type is selected, a representation of the intersection appears in the “DRAWING” box. You may have to rerun the model using two different geometric configurations to properly represent current and future conditions.

**ANGLE BETWEEN LEG A AND NORTH** - In order to accommodate the maximum number of intersections, the model does not consider the compass alignment of your intersection. Instead, the legs of each



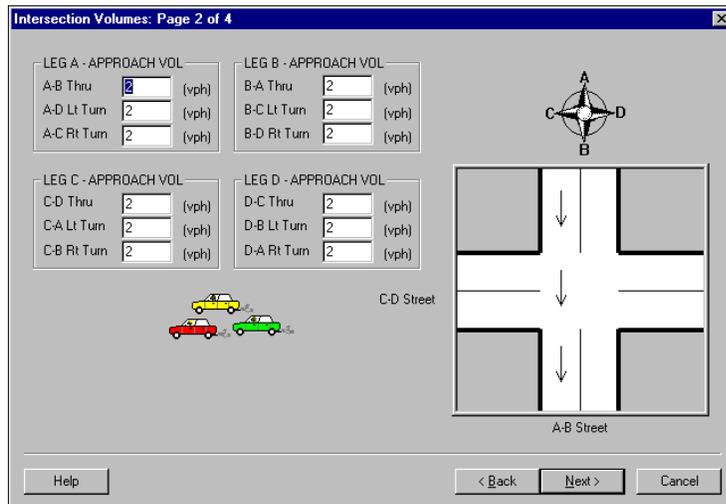
intersection are represented using the letters A, B, C, and D. You must orient your intersection to best match the intersection choices available in the model, and then estimate the difference between leg A and North. This angle is measured in a clockwise direction from leg A. The acceptable range is 0 to 359 degrees, with leg A representing 0 degrees.

**A-B STREET NAME** - Enter the name of the actual street that corresponds to the street aligned A-B as shown in the intersection DRAWING box. The name will appear on the following intersection input screens and in the model output to remind you how the intersection was set up.

**C-D STREET NAME** - Enter the name of the actual street that corresponds to the street aligned C-D as shown in the intersection DRAWING box. The name will appear on the following intersection input screens and in the model output.

When the desired inputs are entered select the *Next* button. If you wish to cancel all current input values and exit the series of intersection input boxes, select the *Cancel* button.

**PAGE 2 OF 4**



**INTERSECTION VOLUMES** - Intersection volumes are separated into three types of movements for each direction: through, left turn, and right turn. All direction designations refer to the direction in which the traffic is approaching the intersection. Through, left turn, and right turn designations refer to the type of movements made once the vehicles are



at the intersection. Enter the values that are typical of the peak-hour volumes observed at the intersection. If this information is not available, use estimated peak-hour values from a traffic analyst. To quickly advance to the next input variable, use the *TAB* button on the keyboard. The intersection drawing will graphically illustrate the corresponding movement designated in the volume box. If a volume box is colored gray, that type of movement is not feasible for the type of intersection selected, and a volume cannot be entered. Volumes must be between 2 and 9999 vph.

After the volumes are entered, select the *Next* button. If you wish to cancel all current input values and exit the series of intersection input boxes, select the *Cancel* button. If you wish to return to the first page, select the *Back* button.

### PAGE 3 OF 4

Intersection Approach Speeds: Page 3 of 4

PEAK-HOUR AVE. APPROACH SPEED

Leg A  (mph)

Leg B  (mph)

Leg C  (mph)

Leg D  (mph)

Enter an approach speed of 15 mph or less for local roadways.  
Enter an approach speed of 5 mph for highway ramps.

SPEED LIMIT 55  
MINIMUM 5

C-D Street

A-B Street

Help < Back Next > Cancel

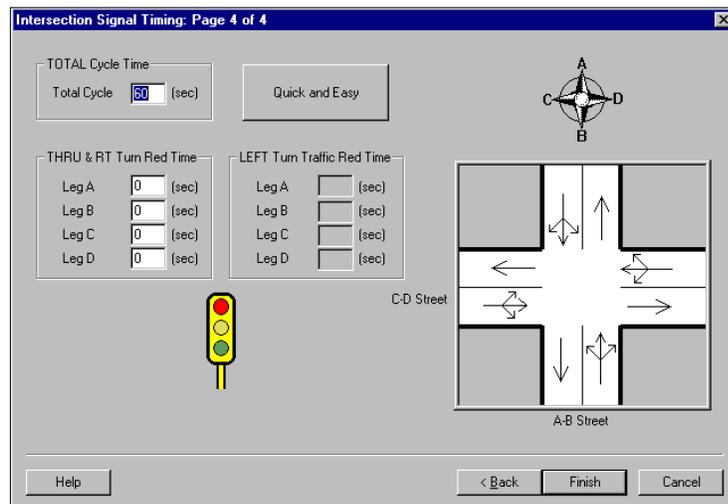
**PEAK-HOUR AVE. APPROACH SPEED** - The average approach speeds are separated into the four approach directions. Enter values that are typical of the peak-hour speeds observed at the intersection. Since vehicles are stopped on each approach, the stop delay experienced by each vehicle will result in the average speed being significantly lower than the posted speed limit. Intersections with high traffic volumes on all approaches with cycle lengths of 90-120 seconds will rarely produce average speeds greater than 5-10 mph. If you are uncertain of peak-hour speeds, select a value significantly lower than the posted speed. Enter an approach speed of 15 mph or less for any leg of an intersection that is a local roadway. Enter an approach speed of 5 mph for any leg of an intersection



consisting of a highway ramp. If a speed box is colored gray, that type of movement is not feasible for the type of intersection selected, and an approach speed cannot be entered. Speed is one of the variables used in determining the CO emission factor. Slower speeds produce larger emission values. Therefore conservative evaluations call for the use of low speeds. Speeds must be between 5 and 55 mph.

After the speeds are entered, select the *Next* button. If you wish to cancel all current input values and exit the series of intersection input boxes, select the *Cancel* button. If you wish to return to the previous page, select the *Back* button.

**PAGE 4 OF 4**



**SIGNAL TIMING** - Signal timing inputs include the total cycle length and the timing of each traffic movement. Unlike typical traffic engineering analysis that describes green time per cycle, COSIM utilizes the red time of each movement. Values should correspond to the signal timing during the peak-hour of operation. All intersections in COSIM are modeled as pre-timed intersections. If the actual intersection is actuated or semi-actuated you must estimate red times that best reflect conditions occurring during the peak-hour. If a timing box is colored gray, that type of movement is not feasible for the type of intersection selected, and a red time cannot be entered. Clearance lost time for each intersection is assumed to be three seconds. This page of input values will have a significant impact on the modeled CO concentrations, because the variables are used to determine how traffic queues form at the intersection. Large red times will create long queues causing greater air degradation at the intersection.



*TOTAL CYCLE TIME* - Enter the time in seconds it takes to complete one timing cycle.

*THRU & RT TURN RED TIME* - Enter the red time in seconds for the through and right turning traffic on each leg of the intersection. For each intersection, it is assumed that there is no right turn on red. That is, each right turn movement is assumed stopped with the through traffic. The model also does not allow you to enter a separate red time for intersections with phasing for right turn overlaps with the left turn phases. These simplifications allow for a conservative evaluation of the intersection.

*LEFT TURN TRAFFIC RED TIME* - Enter the red time in seconds for each protected left turn movement. For a conservative evaluation, any portion of the cycle that is not protected left turn green should be considered left turn red time.

*QUICK AND EASY BUTTON* - If the exact red times are unknown, enter the total cycle length in the first edit box and select the *Quick and Easy* button on the top of the page. This will automatically fill in the red time input boxes with values based on percentages of the total cycle length.

**Note: These values are NOT default values and should not be used as such. Quick and Easy values are red times that represent worst-case values that would almost never be observed at an intersection.**

In most cases, using these values will cause the model to overestimate CO concentrations. If these values are used and the screening tool produces a failing result, please consult a traffic engineer for the most appropriate red times, and rerun the screen model using the new red times.

After the signal timings are entered, select the *Finish* button. If you wish to cancel all current input values and exit the series of intersection input boxes, select the *Cancel* button. If you wish to return to the previous page, select the *Back* button. Once the *Finish* button is pressed, the series of intersection input screens are complete. To view or change any of your input values select the *INT* icon or *Intersection Inputs* under the main *Input* menu. To continue, select the *REC* icon in the tool bar.



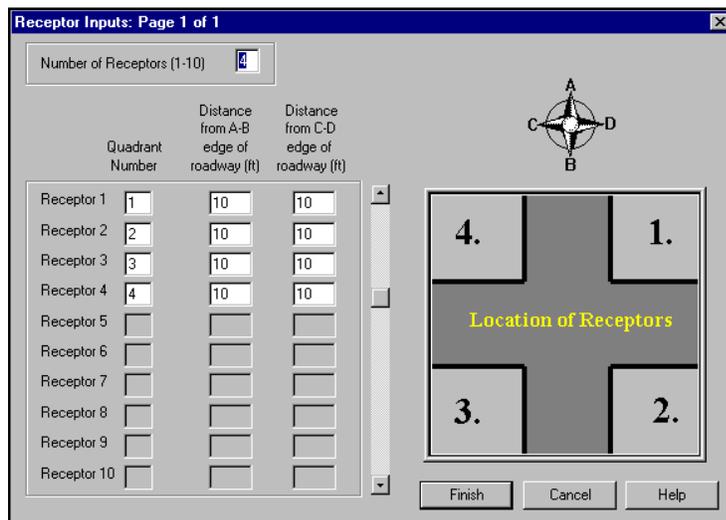
### Receptor Inputs

A receptor is the position where the CO concentration is estimated. The spatial relationships between sources and receptors greatly impact the modeled concentrations. In general, the highest concentrations will be measured in the queue zone and the lowest in the midblock zone. There will be a decreasing concentration profile as you move away from the intersection (Claggett et al., 1981). CO concentrations should be estimated at the sensitive receptors located closest to the intersection. IDOT defines a sensitive receptor as a building or location where the general public may be expected to remain for the duration of the period specified by the NAAQS (IDOT, 1982). In COSIM, you designate receptor locations using three input variables: quadrant number, distance from A-B edge of roadway, and distance from C-D edge of roadway. The edge of roadway is considered to be the edge of the outermost lane of travel. The height of each receptor is automatically set to an average breathing height of six feet.

T-type intersections do not contain an A-B edge of roadway reference for horizontal measurements in quadrants 1 and 4. Instead you should use the A-B roadway centerline as a reference for siting receptor distances in quadrants 1 and 4.

When the receptor screen is first opened, the first four receptors will contain default values located a distance of ten feet from each roadway. Usually you will choose to change or remove these receptors.

**PAGE 1 OF 1**





**NUMBER OF RECEPTORS** - You may model between one and ten receptors at one time. The desired number may be entered directly into designated input box or set by using the slide bar located to the left of the intersection drawing.

**QUADRANT NUMBER** - To ensure that receptors are sited outside of the traffic flow, all receptor distances are specified from the edge of roadway (the outermost lane of travel). Using the displayed intersection drawing, enter the quadrant number the receptor lies in.

**DISTANCE FROM A-B EDGE OF ROADWAY** - Enter the distance in feet the receptor lies from the A-B edge of roadway. The distance must be greater than 10 feet and less than 1000 feet. The dispersion algorithms used to calculate CO concentrations assume that the turbulent mixing effects of moving vehicles extend 10 feet from the lane of travel. Receptor distances closer than 10 feet are considered to lie within the mixing zone and cannot accurately be modeled with the dispersion algorithm (USEPA, 1995). Receptors further than 1000 feet from the roadway will be minimally affected by the intersection.

**DISTANCE FROM C-D EDGE OF ROADWAY** - Enter the distance in feet that the receptor lies from the C-D edge of roadway. The distance must be greater than 10 feet and less than 1000 feet as discussed above.

After the receptor locations are entered, select the *Finish* button. If you wish to cancel all current input values and exit the receptor location screen, select the *Cancel* button. To view or change any of your receptor input values select the *REC* icon from the tool bar or *Receptor Inputs* under the main *Input* menu.



## COSIM Program Information

### Help Screens

For additional information pertaining to the input variables, select the help button on the screen containing the input variable under question. For questions concerning general operating characteristics of the program, select the *Help Topics* submenu provided under *Help* in the main menu or click the help icon in the tool bar. When help is selected, a separate window will open with the selected help file information. The help window operates like a mini web browser. Additional help topics can be viewed by clicking the highlighted links. *Back* and *Next* menu items at the top of the window aid in file navigation. If the contents of the Help screen do not fit in the browser window, use the scroll bars or resize the window. When you are done viewing the help file, you must close the help browser before returning to the main program.

### Saving a File

After all inputs are entered, it is good procedure to save your work. You may select *Save* or *Save as...* submenu items under *File* in the main menu or the save icon in the tool bar to save your file. If you are saving the file for the first time, the *Save as* dialog box will appear. First select the folder you wish to save your file in, or create a new folder. We recommend creating a folder named *COSIM Project Files* to store your files. Next, enter a descriptive name to represent the project and select *OK*. The program will automatically save your filename followed by the three-letter extension *.sim* (for **COSIM**) in the designated folder. You can use this procedure to save your data at any time during data input, i.e., it is not necessary to wait until all input screens are completed before you save the file for the first time. We recommend that you occasionally update your saved work as you progress through data entry using the tool bar save icon.

### Calculating CO Concentrations

When all inputs have been entered, the model is ready to calculate the worst-case CO concentrations. Select the *Calculate* submenu item under *Input* in the main menu, or click on the *CALC* icon in the tool bar. While the model is performing the necessary calculations, COSIM will open an MS-DOS window, the cursor will turn to the wait mode and you will be unable to access anything in the COSIM program. When the concentration calculations are complete, the final output will be displayed in the main view area. If the DOS window does not close automatically, close it by clicking the "x" in the upper right hand corner of the DOS



window. Note: If the DOS window gives a “program terminated” message, be aware that this message does not pertain to the COSIM program. Simply close the DOS window.

### Viewing the Results

After the worst-case CO concentrations are calculated, COSIM will automatically display the results in the main view area in the form of a four-page report. If the main view window is too small, maximize the window by clicking on the small square in the right corner of the main title bar, or resize the window by clicking and dragging one of the window edges. Horizontal and vertical scroll bars may be used to view the contents of the final report.

### The Final Report

The final report consists of four pages. Page one summarizes the results of the model's calculations. The top of the page displays the date and time the calculations were made. Below the time is the project name, followed by the project's district and county location. The next four lines further describe the project details. After these four lines are direction arrows, a drawing of the intersection and receptors, and a compass arrow. The direction arrows refer to the setup of the intersection. The intersection drawing is to the right of the direction arrows. This drawing displays a scale drawing of the roadway boundaries and the locations of the receptors. A circle represents a receptor that passes the screen test. An “x” represents a failing receptor. The drawing scale is located in the lower right hand corner of the drawing and will change based on the relative positions of the receptors entered by the user. To the right of the intersection is an arrow pointing in the direction of North. The difference between North and leg A (the top of the page), measured in a clockwise position from leg A, is displayed above the drawing.

The program will accurately draw to scale all the input receptors. It cannot display two different scales simultaneously. The receptor located the furthest distance from the intersection will determine the scale size. If the drawing appears jumbled, with receptors placed on top of each other, change the receptor coordinates so they are all on a similar scale, and rerun the calculations. For example, if five receptors are within 30 feet of the intersection and two others are over 900 feet from the intersection, in order to display all seven receptors in the same drawing, a scale of 100 feet will be used. To avoid the overlap of receptor locations in



the drawing, the model can be run twice, once with the three nearby receptors and once with the two distant receptors.

Below the intersection drawing is a table that summarizes the results. The one-hour average concentrations are calculated using the USEPA's CAL3QHC model. The eight-hour average concentrations are calculated by multiplying the one-hour concentration (without background) by a persistence factor of 0.7 and then adding the background concentration. If the resulting eight-hour concentration exceeds the NAAQS, the receptor fails. (The NAAQS eight-hour standard for CO is violated when concentrations exceed 9.0 ppm. When comparing data to the standard, concentration should be expressed in terms of the nearest integer, with fractions greater than 0.5 rounded up.) The bottom of the page contains several documentation notes.

Pages two and three summarize the variables entered on the series of input screens. Page two displays the predominant intersection surroundings, and the traffic volumes. Volume information is presented in tabular form showing the index number, the type of movement, and the volume in vehicles per hour. If a volume entry is displayed as a series of dashes, that type of movement is not possible for the type of intersection selected. The volume index numbers refer to the intersection flow diagram given below the table. The flow diagram presents the geometry as well as the traffic movements of the modeled intersection.

Page three summarizes the EF information and the intersection signal timing. The input variables used to determine the vehicle EFs are presented at the top of the page, followed by the actual EFs used for calculating the CO concentrations. The idle EF is the amount of CO emitted in grams per hour from vehicles that are stopped, or in idle mode, at the intersection. The four other EF values presented in tabular form are based on vehicle approach speeds. They represent the amount of CO emitted in grams per mile from vehicles that are traveling through the intersection. The traffic signal timing is presented on the lower half of page three and consists of the input variables entered by the user.

Page four is the user comments page. Comments entered using the *Comment Editor* (discussed further in the next section) are listed on the page. Comments should further clarify any assumptions made in the modeling procedure. Differences in intersection geometry and receptor descriptions are examples of items that should be included in the comment section.



**Illinois CO Screen for Intersection Modeling 2.0**

02-08-03  
07:51 PM

**Sith and Monroe, Downtown Springfield - District 6 - Sangamon County**

Performed by: I. C. Waters  
 Intersection Type: **One-way Streets, 3 x 3**  
 A-B Street Name: **Sixth Street**  
 C-D Street Name: **Monroe Ave.**

**RESULTS:**

Receptor#	Quadrant	Distance from A-B roadway (feet)	Distance from C-D roadway (feet)	1-hour ave. Conc. (ppm)	8-hour ave. Conc. (ppm)	Pass/Fail*
1	1	10	10	6.4	5.4	Pass
2	2	10	10	7.2	5.9	Pass
3	3	10	10	7.1	5.9	Pass
4	4	10	10	7.8	6.4	Pass
5	2	10	36	7.2	5.9	Pass
6	4	30	10	7.7	6.3	Pass

\*Project **PASSES** 8-hr NAAQS. Largest 8-hr concentration is 6.4 ppm, at receptor 4

**NOTES:**  
 - All concentrations include a background concentration of 3.0 ppm.  
 - 8-hr average concentrations are calculated by multiplying the 1-hr average concentrations (without background) by a persistence factor of 0.7 and then adding the background concentration.

Page 1 of 4

**Illinois COSIM 2.0**

**USER INPUTS**

**Sith and Monroe, Downtown Springfield - District 6 - Sangamon County**

Intersection Data:  
 Predominant Surroundings: **Offices**

Traffic Volumes:

Vol. Index	Movement	Volume (vph)
1	A-B Thru	-----
2	A-D Left Turn	-----
3	A-C Right Turn	-----
4	B-A Thru	939
5	B-C Left Turn	-----
6	B-D Right Turn	143
7	C-D Thru	420
8	C-A Left Turn	190
9	C-B Right Turn	-----
10	D-C Thru	-----
11	D-B Left Turn	-----
12	D-A Right Turn	-----

Page 2 of 4

**Illinois COSIM 2.0**

**USER INPUTS continued...**

**Sith and Monroe, Downtown Springfield - District 6 - Sangamon County**

Emission Factors Based On:  
 District: 6  
 County: Sangamon  
 Township: **Not Relevant For Analysis**  
 Year: 2003

MOBILE6 Emission Factors:  
 Idle Emission Factor (g/hr): **201.66**

Approach	Speed (mph)	EF (g/mile)
Leg A	---	-----
Leg B	20	30.41
Leg C	20	30.41
Leg D	---	-----

\*Note: Local roadways should be modeled using an approach speed of 15 mph or less.  
 Highway ramps should be modeled using an approach speed of 5 mph.

Traffic Signal Timing:  
 Total Cycle Length (sec): 80

Red Times:

Type of Movement	Red Times (sec)
Leg A Thru & Rt	---
Leg A Left Turn	---
Leg B Thru & Rt	36
Leg B Left Turn	---
Leg C Thru & Rt	44
Leg C Left Turn	---
Leg D Thru & Rt	---
Leg D Left Turn	---

Page 3 of 4

**Illinois COSIM 2.0**

**USER COMMENTS**

**Sith and Monroe, Downtown Springfield - District 6 - Sangamon County**

User Comments:

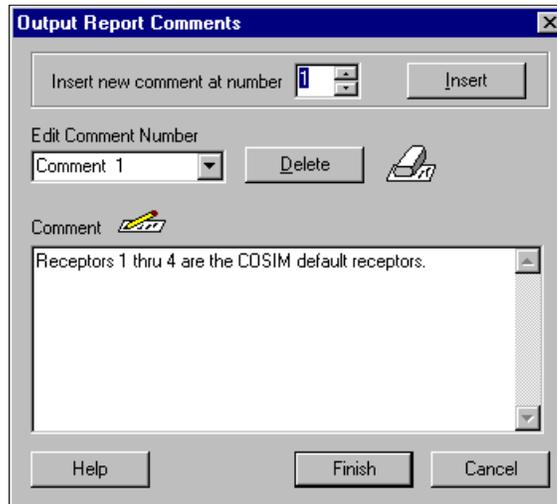
- Receptors 1 thru 4 are the COSIM default receptors.
- Receptor 5 is an EPA SLAM site.
- Receptor 6 is Cafe Brno.
- This project is a no-build analysis of the intersection. Traffic volumes were typical of volumes measured during the peak-hour.
- Both roadways contain offset parking.

Page 4 of 4



## Comment Editor

If the final report is in the main view, you may add comments to the fourth page of the report using the Comment Editor. To open the Comment Editor, select *User Comments* under *Input* in the main menu, or click the Comment Editor icon in the tool bar.



Comments will be listed on the fourth page of the report. To enter a comment, first select a comment number in the *Edit Comment Number* box. Next, move the cursor to the comment area, and enter the desired text. To insert a new comment, go to the top of the editor, select the number of the comment you wish to insert, and press the *Insert* button. Then go to the comment area and enter your comment. To change an existing comment, simply select the comment in the *Edit Comment Number* box, and edit the desired text in the comment area. To delete an entire comment, select the comment you wish to delete in the *Edit Comment Number* box and press the *Delete* button. When you are finished with the Comment Editor, press the *Finish* button, and the comments will be added to the fourth page of the final report.

Typical user comments include differences in intersection geometry, receptor descriptions, project notes, build or no-build scenario, and any other assumptions made during the input procedure.

## Print Preview

Before printing the final report it is good practice to save your work. Select the save icon from the tool bar or select the *Save*, or *Save as...* submenu items under *File* in the main menu.



To view the output report as it will be printed, select the *Print Preview* item under *File* in the main menu. This will display the print preview window. The top of the window contains seven buttons. The *Print* button will send the current output report to the default printer. The *Next Page* button allows the user to view the next page in the report. The *Prev. Page* button will return the view to the previous page in the report. The *One Page/Two Page* button changes the view to display either one or two pages at a time. The *Zoom In* button magnifies the current view. The *Zoom Out* button decreases the size of the current view. The *Close* button returns the user to the main COSIM screen.

It is NOT necessary to use the print preview option before printing the report. The main view in COSIM was designed to look like the printed final report, therefore you may feel that viewing the report in the print preview mode before printing is unnecessary.

### Printing the Report

To print the final report, COSIM must be finished calculating all CO concentrations and the output report must be visible in the main window. If the title screen appears in the main view, you must first finish entering the input variables and perform the CO calculations. When the report appears in the main view, select the *Print* item under *File* in the main menu or select the print icon from the tool bar. This will open the print option screen used by the default printer. Set the desired print options and press the *OK* button. This will send the current output report to the default printer.

### New Screen Test

You may start a new CO screening test in two ways. If the previous run still appears on the screen and if the new test only requires a few input variable changes, i.e. modeling the same intersection but using different receptors, first make sure the previous run is saved, then select the appropriate series of inputs and make the desired changes. When all the necessary changes have been made, calculate the new CO concentrations, and the new final report will appear in the main view. We recommend that you save the new run using a file name different than the previous run.

If the new screen test is completely different from the previous project, i.e. modeling a different intersection, save the previous run, then select



New under the main menu *File* item or click on the new icon in the tool bar. This will close the previous project file and create an entirely new project.

### **Version 1 File Compatibility**

COSIM Version 2.0 has the ability to open project files saved using Version 1 (this includes Versions 1.0 or 1.1). If a Version 1 file is opened, all the saved input variables will appear but you will have to run through the entire series of input screens before CO concentrations can be calculated. If the previously saved model year was 1999 through 2001, a new valid model year (2002 through 2050) will have to be entered. If a Version 1 file is opened and calculations were made before the file was saved, the final report in Version 1 format (with the exception of the year being shown as 2 digits) will be displayed in the main view. You will be able to print the old report. However, to rerun the calculations, you will have to step through all of the input screens. The variables saved to the Version 1 file will appear in the input boxes as you step through the screens. When the calculate button is selected, CO concentrations will be recalculated using MOBILE6 emission factors. Once the calculate button is pressed, the previously saved CO concentrations that were calculated using MOBILE5b emission factors will be lost. COSIM Version 2.0 is not able to calculate CO concentrations using MOBILE5b emission factors.

### **Closing COSIM**

When you are finished running COSIM, the program should be closed properly. To close, select *Exit* under *File* in the main menu or click on the X located in the upper right hand corner of the main window title bar. If any of your input values have changed since the last time you saved your work, you will be prompted to save the changes.

### **IDOT Guidance for Model Usage**

Contact IDOT Air Quality Specialist Walt Zyznieuski at (217) 785-4181 with any comments or questions pertaining to Illinois COSIM.



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## References

- Claggett M., Shrock J. and Noll K. E., Carbon monoxide near an urban intersection. Atmos. Environ. 15, 1633-1642, (1981).
- Illinois Department of Transportation, Air Quality Manual, Revised May, (1982).
- Seinfeld, H. J., Atmospheric Chemistry and Physics of Air Pollution. John Wiley & Sons, (1986).
- U.S. Environmental Protection Agency, User's Guide to MOBILE6.0 (Mobile Source Emissions Factor Model), U.S. EPA, Ann Arbor, Michigan, EPA420-R-02-001, January (2002).
- U.S. Environmental Protection Agency, User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-92-006, Sept., (1995).



## Appendix

### Worksheet Information

To aid in the model input procedure, input worksheets have been prepared for the Pre-Screen and complete COSIM analysis. Using the worksheets is a recommendation, not a model requirement. The worksheets provide a concise, organized method to expedite the data collection process. Data required for the worksheets are explained below. Copies of the worksheets follow the data explanations.

### Pre-Screen Worksheet

*INTERSECTION LOCATION* - Enter the county in which the intersection is located.

*AVERAGE DAILY TRAFFIC OR PEAK HOURLY TRAFFIC* - Enter the design year average daily traffic (ADT) or peak hourly traffic volume (in vph) for the proposed improvement. Traffic volume should be for the busiest leg of the intersection and should include all traffic traveling on the leg (both directions).

*CLOSEST RECEPTOR DISTANCE* - Enter the distance, in feet, to the sensitive receptor closest to the proposed intersection. IDOT defines a sensitive receptor as a building or location where the general public may be expected to remain for the duration of the period specified by the NAAQS. The distance should be measured from the receptor to the edge of the nearest proposed roadway.

*PROJECT NAME* - Enter a brief description of the project. This description will be included in the header of the report.

*INTERSECTION NAME* - Enter the name of the intersection. This will typically be the names of the intersecting streets.

**WORKSHEET for COSIM PRE-SCREEN ANALYSIS**



Intersection Location:

\_\_\_\_\_

(county the project is located in)

Average Daily Traffic or Peak Hourly Traffic:

\_\_\_\_\_ ADT  
\_\_\_\_\_ or \_\_\_\_\_  
\_\_\_\_\_ vph

(design year volume on the busiest leg of the intersection, both directions, for the proposed improvement)

Closest Receptor Distance:

\_\_\_\_\_ feet  
(to any one edge of roadway after the proposed improvement)

Project Name:

\_\_\_\_\_

(route name and project limits)

Intersection Name:

\_\_\_\_\_

(names of the intersecting streets)



## Complete COSIM Analysis Worksheet

**PROJECT NAME** - Enter a brief description of the project. This description will be included in the header of the final output.

**YEARS OF INTEREST** - These are the years you wish to model. CO analyses for IDOT roadway improvement projects are typically performed for four different timeframes: existing year (for no-build scenario), time of completion (TOC), TOC + 10 years, and design year. The existing year is the year in which the NEPA document or project report is performed. The TOC is the proposed time of project completion. COSIM Version 2.0 has the years 2002 to 2050 built into the model for CO analysis.

**INTERSECTION LOCATION** - Determine the IDOT district and the county where the intersection is located and briefly describe the intersection surroundings (e.g., office buildings, single family homes). If the intersection lies in District 3, in either Grundy or Kendall counties, you will also need the township where the intersection is located.

**BACKGROUND CONCENTRATION** - This is the concentration of CO in the ambient air that is not attributed to the intersection. IDOT suggests the use of 3.0 ppm for urban locations and 2.0 ppm for rural locations. 3.0 is the default background concentration. The acceptable range is 0.0 to 9.0.

**INTERSECTION SKETCH** - Draw a rough sketch of the intersection in the box provided. Be sure to include each travel lane, turn lane, and direction of travel. Align the road with the largest number of lanes vertically (designated as A-B). Also draw an arrow indicating North.

**ANGLE BETWEEN LEG A AND NORTH** - In order to accommodate the maximum number of intersections, the model does not consider the compass alignment of your intersection. Instead, the legs of each intersection are represented using the letters A, B, C, and D. You must orient your intersection to best match the intersection choices available in the model, and then estimate the difference between leg A and magnetic North. This angle is measured in a clockwise (CW) direction from leg A. Acceptable range is 0 to 359 degrees, with leg A representing 0 degrees.

**STREET NAMES** - The names of the streets that correspond to the streets aligned in direction A-B and C-D as shown in the intersection sketch box.



**TRAFFIC VOLUMES** - Intersection volumes are separated into three types of movements for each direction: through, left turn, and right turn. All direction designations refer to the direction in which the traffic is approaching the intersection. Through, left turn, and right turn designations refer to the type of movements made once the vehicle is at the intersection. Enter the values that are typical of the peak-hour volumes observed at the intersection. If this information is not available, use estimated peak hour values from a traffic analyst. If the type of movement corresponding to the table entry is infeasible for the intersection being modeled, draw a line through the box. Volumes must be between 2 and 9999 vph.

**APPROACH SPEEDS** - Approach speeds are separated into the four approach directions. Enter values that are typical of the peak-hour speeds observed at the intersection. If the type of movement is not feasible for the type of intersection selected, draw a line through the box. If you are uncertain of peak hour speeds, select a value significantly lower than the posted speed. Speeds must be between 5 and 55 mph.

**INTERSECTION SIGNAL TIMING** - Signal timing is described using three types of inputs: total signal time, through and right turn red time, and left turn red time. Values should correspond to the signal timing during the peak-hour of operation. All intersections in the screening tool are modeled as pre-timed intersections. If the actual intersection is actuated or semi-actuated you must estimate red times that best reflect conditions occurring during the peak hour. If the type of movement corresponding to the table entry is not possible for the type of intersection being modeled, draw a line through the box. Note that the model has a "Quick and Easy" option to estimate red times from the total cycle time. Thus, if individual red times are not available, be sure to at least have the total cycle time.

**RECEPTOR LOCATIONS** - A receptor is the position where the CO concentration is estimated. CO concentrations should be estimated at the sensitive receptors located closest to the intersection. IDOT defines a sensitive receptor as a building or location where the general public may be expected to remain for the duration of the period specified by the NAAQS (IDOT 1982). Return to the sketch of the intersection on the first page of the complete COSIM worksheet and mark the location of the



receptors. Designate receptor locations using three input variables: quadrant number, distance from A-B edge of roadway, and distance from C-D edge of roadway.

T-type intersections do not contain an A-B edge of roadway reference for horizontal measurements in quadrants 1 and 4. Instead the user should use the A-B roadway centerline as a reference for siting receptor distances in quadrants 1 and 4.

*NUMBER OF RECEPTORS* - You may model between one and ten receptors at one time.

*RECEPTOR DESCRIPTION* - Briefly describe each receptor, e.g., school, hospital, house.

*QUADRANT NUMBER* - To ensure that receptors are sited outside traffic flow, all distances are specified from the edge of roadway (edge of furthest lane of travel). The intersection divides the surrounding area into four quadrants, labeled as follows; upper right - quadrant 1, lower right - quadrant 2, lower left - quadrant 3, and upper left - quadrant 4. Using the intersection sketch, enter the quadrant number each receptor lies in.

*DISTANCE FROM A-B* - Enter the distance in feet the receptor lies from the A-B edge of roadway. The distance must be greater than 10 feet and less than 1000 feet.

*DISTANCE FROM C-D* - Enter the distance in feet the receptor lies from the C-D edge of roadway. The distance must be greater than 10 feet and less than 1000 feet.

**WORKSHEET for COMPLETE COSIM ANALYSIS**



Project Name: \_\_\_\_\_

Years of Interest: \_\_\_\_\_

**Intersection Location**

IDOT District (1-9): \_\_\_\_\_

County: \_\_\_\_\_

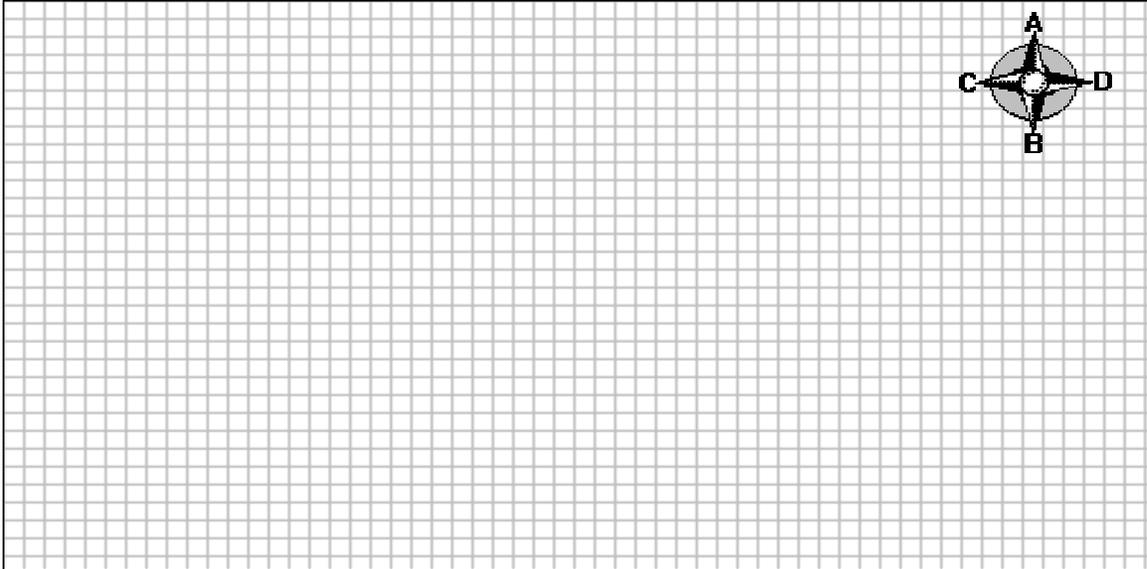
Predominant Surroundings: \_\_\_\_\_

Background Concentration (0.0-9.0 ppm): \_\_\_\_\_

(Recommended Values: 3.0 Urban Setting, 2.0 Rural Setting)

**Intersection Sketch**

Align the road with the greater number of lanes vertically (A-B direction)



Estimate the CW angle between leg A and North (0-359°): \_\_\_\_\_

**Street Names**

A-B Street: \_\_\_\_\_

C-D Street: \_\_\_\_\_

## WORKSHEET for COMPLETE COSIM ANALYSIS



### Traffic Volumes (2 - 9,999 vph)

Type of Movement	Volume (vph)
A-B Thru	
A-D Left Turn	
A-C Right Turn	
B-A Thru	
B-C Left Turn	
B-D Right Turn	
C-D Thru	
C-A Left Turn	
C-B Right Turn	
D-C Thru	
D-B Left Turn	
D-A Right Turn	

### Approach Speeds (5 - 55 mph)

Approach	Speed (mph)
Leg A	
Leg B	
Leg C	
Leg D	

Total Cycle Length (sec): \_\_\_\_\_

Red Times (if unknown, first try *Quick and Easy* button in program)

Type of Movement	Red Time (sec)
Leg A Thru & Rt	
Leg A Left Turn	
Leg B Thru & Rt	
Leg B Left Turn	
Leg C Thru & Rt	
Leg C Left Turn	
Leg D Thru & Rt	
Leg D Left Turn	

## WORKSHEET for COMPLETE COSIM ANALYSIS



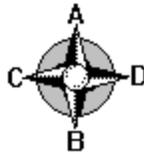
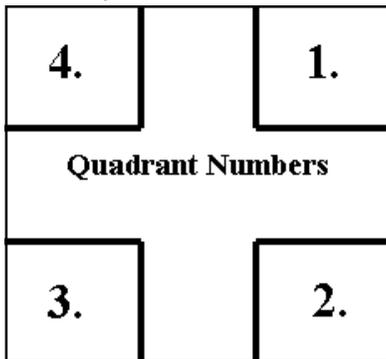
### Receptor Locations

Number of Receptors (1-10): \_\_\_\_\_

Receptor #	Receptor Description (e.g., hospital, school, house)	Quadrant #	Dist. From A-B (feet)	Dist. From C-D (feet)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

For receptor distances, use horizontal and vertical distances from quadrant boundaries (edge of roadway). For T-type intersections, quadrant 1 and 4, use horizontal distance from leg B centerline. Refer to the intersection drawings below.

Four-way Intersections



T-type Intersections

