FINAL REPORT

Carbon Monoxide Analysis for Highway Projects

Project IIIA-H1, FY 97

Report No. ITRC FR 97-2

Prepared by

Susan M. Larson, Fred Coleman, III,
Scott Peters, and Padmini K. Gollapalli
Department of Civil Engineering
University of Illinois
Urbana, Illinois

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16. Abstract

Air quality analysis for highway projects are conducted to determine if projects have the potential to cause exceedances of the National Ambient Air Quality Standards (NAAQS). Prior to construction, detailed air quality modeling analysis are often used to estimate a project's impact on the ambient concentration of atmospheric pollutants. One polluntant of concern is carbon monoxice (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 expenditures.

Because the NAAQS for CO are xpressed as maximum concentrations not to be exceeded more that once a year, a screening analysis may be an appropriate tool which can be used to determine if a detailed analysis is necessary. The screening analysis is used to determine if a project may cause a NAAQS violation. A screening model usses readily available data to make a conservative worst-case estimate of a project's impact. Projects that pass worst-case screening analysis would not require a detailed analysis. (The screening procedure must be approved by the appropriate regulatory agencies). This report summarizes the methods used for establishing a computer CO screening model (Illinois CO Screen for INtersection Modeling, COSIM) that can be used to determine when a detailed CO analysis is needed for highway projects in Illinois, for the Illinois Department of Transportation. This report also evaluates USEPA's model. CAL3QHC, to determine CO levels at three intersections in Illinois.

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CARBON MONOXIDE ANALYSIS FOR HIGHWAY PROJECTS

Final Report
October 1, 1999

Submitted by:

Susan M. Larson
Fred Coleman, III
Scott Peters
Padmini K. Gollapalli

University of Illinois
Department of Civil Engineering
3230 Newmark Laboratory
205 N. Mathews Avenue, MC-250
Urbana, Illinois 61801

EXECUTIVE SUMMARY

CARBON MONOXIDE ANALYSIS FOR HIGHWAY PROJECTS

Project # IIIA-H1, FY97
Report No ITRC FR97-2

Susan M. Larson, Fred Coleman, III,
Scott Peters, Padmini Gollapalli

If many vehicles travel through or wait to cross an intersection, the emissions from those vehicles can build up to the point that atmospheric concentrations of carbon monoxide (CO) may exceed the National Ambient Air Quality Standards (NAAQS). This potential is often evaluated before the intersection is even built, using two computerized models distributed by the United States Environmental Protection Agency (USEPA): MOBILE5 and CAL3QHC. If a problem is indicated by the models' predictions, the proposed intersection can be redesigned to keep air pollution within acceptable limits. However, an analysis using these models is time consuming at best, as both models require extensive input data and an expert user. The main objective of this project was to address this problem by developing a model for use in Illinois that is easy to use and that would assume worst-case conditions. This "screening model" would indicate whether or not further, more complex modeling of the intersection was warranted. As part of the research, the ability of MOBILE5 and CAL3QHC to predict CO concentrations at signalized intersections typically found in Illinois was evaluated.

To evaluate MOBILE5 and CAL3QHC, we obtained traffic, weather, and CO data for three different intersections in Illinois. One intersection was in Springfield, another in Peoria, and a third in Schiller Park. The traffic and weather data were used to perform detailed CO analyses using MOBILE5 and CAL3QHC for these intersections. At least two sets of nonconsecutive time frames were modeled for each intersection. Three separate methods (Methods 1, 2, and 3) were used to analyze CO concentrations. We then compared predicted and measured CO concentrations.

Method 1 predicted concentrations using wind speed and direction variables as reported at the closest airport. Method 2 used the airport wind speed, but a 10 degree increment search was used to find the angle at which the maximum CO concentration occurred. Method 3 combined a 10 degree wind increment search with a worst-case wind speed of 1 m/s. Method 1 generally under-predicted CO concentrations. Method 2 produced modeled values closest to the measured concentrations, within ±1 ppm for 1-hour averages. Modeled values from Method 3 were always greater than the measured values. The results from the detailed analysis show that the USEPA models may be used to predict CO concentrations at Illinois intersections with reasonable accuracy. The results of Method 3 support the use of a 1 m/s wind speed combined with a 10 degree wind increment search in a worst-case analysis of an intersection. We thus used the 1 m/s wind speed and the10 degree wind increment search in formulating the screening model.

The computerized Windows-based CO screening model we created is called Illinois CO Screen for Intersection Modeling (COSIM) and predicts worst-case CO concentrations at fourteen different types of intersections typically found throughout Illinois. The model is quick

and easy to use, allowing for multiple site evaluations within minutes. Similar to other CO screening models developed by the Florida, Colorado, and Pennsylvania Departments of Transportation (DOTs), COSIM incorporates the use of MOBILE5 and CAL3QHC in a "behind the scenes" manner. COSIM differs from the other current screening models in that it provides the user with more control over critical input variables, allowing for a better representation of the actual intersection while still maintaining the desired attributes of a screening tool. Features of the model were based on recommendations made by project committee members as well as feedback from a survey sent to the DOT in all fifty states.

We also evaluated our three test intersections with COSIM, in order to establish confidence in COSIM's ability to be used as a worst-case screening model. The results of this test showed that COSIM's predictions were consistently above actual measured CO concentrations by a reasonable safety margin. In fact, the worst-case concentrations determined with COSIM were always greater than the Method 3 (1 m/s wind speed and10 degree wind search) values calculated with CAL3QHC and MOBILE5. This indicated that COSIM's worst-case analysis is a good screening tool. That is, if the worst-case CO predictions from COSIM are below the NAAQS, then the CO concentrations actually measured at the intersection would always be within the standard. Therefore, if an intersection "passes" COSIM, no air quality problems are anticipated and additional refined modeling is not necessary.

The use of Illinois COSIM as a screening procedure for project level air quality intersection analysis in Illinois earned verbal approval by the IEPA and FHWA in August, 1999. Training sessions were held in August, 1999 to instruct users on the use of Illinois COSIM. Illinois projects that pass COSIM, no longer need to be evaluated by the detailed analysis.

The contact person for Illinois COSIM is

Walt Zyznieuski
Illinois Department of Transportation
Design and Environment
2300 South Dirksen Parkway
Springfield, Illinois 62764
Telephone: 217-785-4181
Fax: 217-524-9356

PREFACE

Air quality analyses for highway projects are conducted to determine if the projects have the potential to cause exceedances of the National Ambient Air Quality Standards (NAAQS). Prior to construction, detailed air quality modeling analyses are often used 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 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 an appropriate tool which can be used to determine if a detailed analysis is necessary. The screening analysis is used to determine if 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 screening procedure must be approved by the appropriate regulatory agencies.)

This report summarizes the methods used for establishing a computer screening model (Illinois CO Screen for Intersection Modeling, COSIM) that can be used to determine when a detailed CO analysis is needed for highway projects in Illinois for the Illinois Department of Transportation. This report also examines USEPA's model, CAL3QHC, to determine CO levels on Illinois highway projects.

This ITRC research project report, "Carbon Monoxide Analysis for Highway Projects," was compiled by researchers at the University of Illinois, Urbana-Champaign (UIUC). The research was sponsored by the Illinois Transportation Research Center (ITRC) and UIUC for the Illinois Department of Transportation (IDOT). Principal researchers on the project were Scott Peters, Jung-Suk Lee, and Padmini K. Gollapalli under the guidance of Dr. Susan M. Larson and Dr. Fred Coleman III. Project guidance was given from a committee consisting of members from UIUC, ITRC, 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), William Barbel (formerly of IDOT), Sue Stitt (IDOT), Mike Rogers (IEPA), Rob Kaleel (IEPA), Jon-Paul Kohler (FHWA), and Kirk Fauver (FHWA). Additionally, we would like to thank Sam Long (IEPA) for his help with the MOBILE5b input files used in creating COSIM, Shannon Sempsrott (UIUC) and Emmanuelle Gira (UIUC) for their help in data analysis and survey compilation, and Ron Hegwood (IDOT District 4) for performing traffic counts and providing extensive help with data interpretation for the intersection of University and Main in Peoria.

SUMMARY OF TASKS

This ITRC research project, Carbon Monoxide Analysis for Highway Projects, had three main objectives: to study the ability of the USEPA model CAL3QHC to determine CO levels on Illinois highway projects, to establish whether a computer screening model can be used to determine when a detailed carbon monoxide (CO) analysis is needed for highway projects, and if so, to develop an appropriate model for Illinois. To accomplish these goals, the project was divided into nine tasks (labeled A-I). The following is a summary of these tasks.

Task A: Telephone Survey - Develop in consultation with the project Technical Review Panel (TRP) a telephone survey form and perform a telephone survey with other State Highway Offices (Michigan, Indiana, Ohio, Minnesota, Wisconsin, California, and others), FHWA offices, and other air quality researchers to document the requirements of other states and regions with respect to CO analyses.

The researchers and TRP decided that the survey would be more effective as a written questionnaire than as a phone survey. This would allow the recipient agencies to distribute the questionnaire to their employee or employees most qualified to answer the questions. The written survey was also thought to be more convenient for the recipients, allowing them to respond when their schedule allowed. Furthermore, the written format allowed us to survey a larger number of agencies in a more timely manner. The survey was sent to the Department of Transportation in all 50 States, Puerto Rico, and Washington DC.

The purpose of the survey was to document the practices of other states in modeling carbon monoxide and other pollutants for roadway projects. The survey asked questions about the pollutants that the states model, the screening and refined tools that they employ, and the criteria for using them. It also asked for suggestions to make a new screening tool as useful as possible. A copy of the survey is included in Appendix A of this report.

Task B: Literature Survey - Conduct a comprehensive literature review regarding CO air quality issues as related to modeling CO and other pollutant concentrations.

Journal publications, regulatory documentation, and reports were the main sources for the literature survey. The main focus of the project was CO, and therefore research on other pollutants was kept to a minimum.

Task C: Meeting - Meet with IDOT Bureau of Design and Environment (BDE), FHWA Illinois division, and USEPA Region V and IEPA to discuss CO microscale air quality issues as related to modeling CO and other pollutant concentrations.

Periodic meetings with project committee members were held at the IDOT Springfield office to discuss project-related issues. Additional conference calls and meetings with other regulatory personal were held as needed throughout the project. All committee meetings are documented in the project quarterly reports.

Task D: Evaluate Computer Models - Conduct an evaluation of CO levels predicted by computer modeling using CAL3QHC and CALINE. The USEPA's MOBILE model will be used for obtaining emission factors. The researchers will work with BDE and/or IEPA staff to determine appropriate input parameters to be used in the MOBILE models.

The researcher will obtain CO data from two IEPA monitoring sites (one in Chicago region and one downstate). Local meteorological data will be obtained from the nearest weather stations by the researcher. IDOT will provide the researcher real-time traffic counts for these two locations. CO levels predicted through modeling vs. field-measured levels will be compared.

Three different sites located in Illinois were evaluated using MOBILE5b and CAL3QHC. The first site was located in Schiller Park, Cook County, the second in downtown Springfield, Sangamon County, and the third in Peoria, Peoria County. The original goal of the study was to obtain at least two sets of measured versus modeled concentrations at each intersection. One set of measurements would be taken during winter months, the other during summer months. Due to difficulties in collecting winter traffic data (snow and ice events), however, cold weather data were not available. At least two sets of data were evaluated for nonconsecutive time periods at each of the three intersections. The resulting data sets represented both previous traffic volume studies and new studies conducted for this research.

Task E: Evaluate COSCREEN Model - Obtain a copy of Florida DOT's COSCREEN computer model with source codes for determining the CO impacts of highway projects in Florida and evaluate the model.

A copy of both Florida DOT's original COSCREEN model and the latest version COSCREEN98 from the program's principal designer, Dr. C. David Cooper, were obtained. The programs were evaluated and summarized as part of the literature review.

Task F: Develop Illinois Model - Develop and validate a model similar to Florida DOT's COSCREEN appropriate for use in Illinois.

A model called "Illinois COSIM," CO Screen for Intersection Modeling, for use in Illinois has been created. The model is designed to estimate one-hour and eight-hour worst-case CO concentrations at the signalized intersections typically found in Illinois. The model permits 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.

Task G: Prepare a final report containing at least the following:

1. A summary of tasks completed.
2. Conclusions regarding the usefulness of USEPA's CAL3QHC and CALINE computer
   models to quantify existing and projected CO levels on specific highway projects.
3. The development of a COSCREEN-like Windows-based model for Illinois, including necessary validation and operating instructions.

The draft version of the final report was submitted to the TRP for review August 4, 1999. Comments and corrections were received by the researchers on September 14, 1999. This document is the final report specified in Task G.

Task H: Presentation of Results - Meet with IDOT, IEPA, and FHWA personnel to present the project findings and to get concurrence on the use of the screening model.

As stated in task C, meetings were held at the IDOT Springfield, IL office periodically to discuss project-related issues and get agreement on the development of the screening model. The research group began these meetings by briefing committee members on the progress made since the previous meeting. IDOT has been given verbal approval by IEPA and FHWA to use Illinois COSIM as of August, 1999.

Task I: Training Sessions - Conduct a training session to be held in Springfield to train up to 20 staff on the use of the new screening model.

Two training sessions have been held to introduce IDOT personnel to COSIM. The first session was held August 23, 1999, the second August 30, 1999.

This report is divided into four main sections. The first is a literature review that provides an introduction to CO and to CO modeling for roadway projects. The second section summarizes the results of the pollutant modeling survey, and the third section describes the assessment study of CAL3QHC and Mobile 5b applied to three Illinois intersections. The final section describes the formulation and documentation for the Illinois COSIM model developed in this project. Appendices contain much of the technical data for the project and the COSIM manual.

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Chapter 1: Carbon Monoxide Air Quality Modeling For Mobile Sources

Air pollution, stemming from industrialization and the extensive burning of fossil fuels, is a problem in today's global ecosystem, having the potential to 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 pollutant. To address problems caused by excessive air pollution, it is necessary to monitor sources and to regulate their emissions. To develop source control plans, source emissions must somehow 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 models.

Today, models combining physical, statistical, and analytical processes are commonly used to estimate pollutant source strengths and to predict how pollutants will be transported once released into the atmosphere. Using these models one can estimate the concentrations of pollutants at a given location. The modeled concentrations can then be compared to air quality standards. Using the modeled data, control strategies can 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 (NOx), carbon monoxide (CO, the focus of this report), carbon dioxide, sulfur oxides, and particulate matter are the result of both evaporative losses and the combustion of carbonaceous fuels (Flagan and Seinfeld, 1988). To limit the amount of these pollutants entering the atmosphere each year, emission specifications on the vehicles have been made and transportation projects are evaluated to determine if they conform to regulatory standards at the state and federal level. Modeling is an integral part of these design and conformity issues.

1.1 Introduction to Carbon Monoxide

Carbon monoxide 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 thought to be detrimental to human health (Seinfeld, H. J., 1986). At higher concentrations, however, CO can impair psychomotor skills and even cause death.

Carbon monoxide causes health problems by combining with hemoglobin in the bloodstream to form carboxyhemoglobin. This lowers the oxygen carrying capacity of the blood in two ways. CO attaches to receptor sites on the hemoglobin that should be carrying oxygen. The attached CO also interferes with the hemoglobin's ability to release the oxygen it is carrying, thus effectively depriving the body tissues of oxygen. At an average exposure time of 8 hours, concentrations between 10 to 15 ppm can cause impaired time interval discrimination, and concentrations above 30 ppm can adversely effect psychomotor skills (Seinfeld, H. J., 1986). Concentrations of this level can often be measured in traffic-congested urban areas.

The majority of atmospheric CO in United States (US) urban areas is from the incomplete combustion of carbonaceous fuels, namely of natural gas, gasoline, and diesel fuel (Seinfeld, H. J., 1986). National standards have been set for ambient levels of CO. Violations are determined by comparing measurements made from stationary monitors to the national standards; the 1-hour average standard is 35 ppm, the 8-hour average standard is 9 ppm. The 8-hour standard is more frequently violated and thus is usually the standard of concern.

The actual daily CO exposure a person receives is influenced by the individual's personal activity and their proximity to CO sources. Akland et al. (1985) have shown that in both Denver, Colorado and Washington D.C. the percent of maximum daily 8-hour personal exposures exceeding the 9 ppm standard was considerably greater than the percent of violations from 8-hour fixed site measurements. While CO emissions have decreased since the time of this study, the experiment provides evidence that an individual's occupation and lifestyle greatly affect their daily exposure to CO. Some of the most common sources of CO that humans are routinely exposed to include cigarettes, poorly vented gas stoves, furnaces, water heaters, and gasoline and diesel powered vehicles. The national ambient air quality standards are specifically designed to limit the CO emissions from the last category, mobile source emitters.

1.2 Guidelines and Conformity Issues

The Clean Air Act (CAA) of 1970 was the first federal legislation that aggressively dealt with air pollution control. In response to the CAA, the NAAQS were established by the United States Environmental Protection Agency (USEPA), and goals of 90% reduction of CO, HCs, and NOx in automobile emissions were set. Also, for the first time, penalties and fines were established for violations.

The Clean Air Act Amendments (CAAA) of 1990 further updated federal air quality legislation. Titles I and II of the 1990 CAAA deal specifically with non-attainment areas and mobile sources. The 1990 CAAA stated that air quality must be considered in environmental statements for proposed federally funded projects, such as road and highway construction projects. Furthermore, areas in violation of the NAAQS were required to undergo a "conformity process" to ensure that proper measures were being taken to achieve attainment.

The conformity process is the name of the procedure that assures that projects in a non-attainment, maintenance, or transitional area are consistent with the overall reduction goals established in the State Implementation Plan (SIP). In transportation related projects, Transportation Conformity Regulations are enforced by the Federal Highway Administration and the Federal Transit Administration. Both the regional long range (20 + years) Transportation Plan and the near term (2-5 years) Transportation Improvement Program (TIP) must yield vehicle emissions less than the motor vehicle emissions budget included in the SIP. If the Transportation Plan and the TIP are found to conform, the original projects can be included in the State Transportation Improvement Program. 40 Code of Federal Regulations Parts 51 and 93 outline the conformity guidelines.

1.3 Illinois Guidelines

Currently, the Illinois Department of Transportation (IDOT) does not require a detailed or screening analysis if an intersection project is expected to have a traffic volume of less than 16,000 average daily traffic (ADT) by the end of the first year of operation. If traffic volume is expected to exceed 16,000 ADT by the end of the first year of operation, Illinois COSIM should be used to analyze worst-case CO concentrations at nearby sensitive receptors. If the results of COSIM 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 National Environmental Policy Act (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.

1.4 Steps to Reduce Emissions

A number of different techniques and programs have been implemented to meet the common goal of lowering ambient pollutant concentrations. Many of the CO reduction programs have targeted the transportation sector, each with varying degrees of success and failure. In general, CO emissions have been decreasing over the past 15 years. Improved vehicle engine design and emissions control technology are the largest contributing factors to CO reduction. A study by Pierson et al. (1995) reveals that CO emission rates derived from measurements in highway tunnels have decreased by almost a factor of 5 between the years 1976 to 1992. Yu et al. (1996) predicted up to a 60 percent reduction in CO emissions along an arterial highway in California between the years 1991 to 2002. Both studies attribute these reductions mainly to changes in automobile technology.

In addition to one of the most successful steps in reducing mobile emissions from automobiles, the addition of the catalytic converter, some other common reduction practices include the use of oxygenated fuels, carpool campaigns, and vehicle Inspection and Maintenance (I/M) programs. The CAAA requires the use of gasoline containing at least 2.7% oxygen by weight in certain areas not attaining the NAAQS for CO. Several studies have shown that areas with oxygenated fuels have achieved reductions in CO emissions varying from 21% +- 7% to 6% +- 2% (Bishop and Stedman, 1994; Anderson, 1993; Hochhauser et al., 1992; Reuter et al., 1992; Kirchstetter et al. 1996; as referenced in Johnson et al., 1998).

The intent of an I/M program is to periodically test the exhaust of vehicles registered in an area to determine whether the emissions are within the intended limits. If a car fails the test, maintenance must be performed to reduce emissions.

Another way to reduce mobile emissions is through the proper design of roadways, freeways, and intersections for optimal traffic flow. This generally minimizes emissions as well as their environmental impacts. Estimating a project's likely impact on the ambient air before the project is built is often done using simulation models. Modeling is a powerful tool, but is never 100 percent accurate and should always be used with caution. Cooper (1987) gives guidelines to performing air quality analyses that can reduce the amount of error introduced in the modeling process. Steps include estimating background concentrations, defining reasonable receptors, determining fleet emission factors, defining worst case meteorology, running dispersion models, and proposing methods to prevent any violations. Simulation models are an integral part of a good air quality analysis.

1.5 Modeling Discussion

A simulation model is a representation of an object or process. It can be used to predict or describe how something will react to a given set of conditions. A good predictive model should be able to estimate current conditions and should be able to accurately predict future conditions as well. 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, fleet characteristics, and weather conditions at the intersection. The two types of models frequently used in an air quality analysis are mobile emission models and dispersion models.

1.6 Mobile Emission Models

Knowledge of the vehicular emissions from a roadway is imperative 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 was possible, how would one determine what the emissions would be in an hour, a year or even 10 years after the measurements were taken? Emission models are used to estimate the answers to these questions.

A transportation emissions model reports the amount of emissions by giving average emission factors (EFs) for different vehicles in a given fleet for a given year. An EF quantifies the amount or mass of emissions that are emitted per rate of activity. Typical EF units for moving vehicles are mass of CO per miles traveled and, for stationary vehicles in idle mode, mass of CO per idle time. The EFs are then used in a dispersion model to predict the pollutant transport once the pollutant is introduced into the ambient air. The most current emissions model recommended by the USEPA is MOBILE5b. (MOBILE5b is discussed further below.)

A key problem with using EFs in an air analysis is the unavoidable error that is introduced into the analysis. Recall that the emission model only gives estimated average emission values from vehicles that are "most likely" to be at the intersection. Even if the exact fleet make up is known, other factors influencing emissions such as temperature, speed, and engine mode (hot/ cold start) are only averages or estimations. Even vehicles of the same model and year will emit different amounts of pollutants depending on the current condition of vehicle and the driving characteristics of the particular driver. Further complicating the issue, studies (Ireson, 1998) have shown that driver characteristic profiles not only vary from driver to driver but vary regionally as well.

1.7 MOBILE5b

MOBILE5b is most current in a series of mobile source emission models released by the USEPA. The model is used to determine the emissions of hydrocarbons (HCs), nitrogen oxides (NOx), and carbon monoxide (CO) from eight different types of vehicles (gasoline fueled light-duty vehicles (LDGV), light-duty trucks (LDGT1; up to 6000 lb gross vehicle weight (GVW)), light-duty trucks (LDGT2; 6001 to 8500 lb GVW), heavy-duty vehicles (HDGV; over 8501 lb GVW), and motorcycles (MC), and diesel-fueled light-duty vehicles (LDDV), light-duty trucks (LDDT), and heavy-duty vehicles (HDDV)). 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 requirements of the 1990 CAAA. This project is concerned specifically with microscale intersection analysis and only utilizes the MOBILE model's ability to predict CO emissions.

The MOBILE model was first released in 1978 as MOBILE1. It was the EPA's first computerized model used for determining mobile source EFs. Prior to its release, EFs were determined using look-up tables. Since then, the MOBILE model has been updated several times to encompass changes in vehicle technology and regulations and to reflect emission measurements from updated testing data. MOBILE5 was released in draft form in 1992 to replace its predecessor MOBILE4.1. MOBILE5a was released in March of 1993 to accommodate new vehicle and fuel requirements and to correct several errors found in the draft version.

MOBILE5b, the most current MOBILE model, was released in 1996 to account for effects in recent regulations on onboard refueling vapor recovery systems and on reformulated gasoline and detergent additives and to allow for more accurate emission credits for current vehicle inspection/maintenance (I/M) programs. Two other changes were also made to MOBILE5b. The first is the expansion in calendar years that may be modeled (upper limit increased from 2020 to 2050). The second change is the ability for internal calculation of idle EFs.

During the stages of MOBILE versions 5 and 5a development, there was a paucity of available idle emissions data that included new control measures introduced in the 1990 CAAA. Therefore MOBILE versions 5 and 5a did not include algorithms to directly calculate the EFs for vehicles in idling mode. Since idle emissions are the largest contribution of ambient CO concentrations at an intersection they must be included for a valid intersection analysis. Therefore, the USEPA recommended a procedure for estimating the idle EF. The user was to first run MOBILE5a at a speed of 2.5 mph. The resulting mobile EF will be in grams/mile. To convert to an idle factor, the user multiplies the EF by 2.5 mph, resulting in an idle EF in grams/hour that can be used in the dispersion/queuing model (USEPA, 1993). Version 5b uses the same procedure, but runs the calculation internally, eliminating the need for the separate hand calculation. It should be mentioned that the USEPA does not require the use of MOBILE5b. The use of MOBILE5a is acceptable for all highway vehicle EF modeling until the release of MOBILE6 (USEPA, 1997). MOBILE6 is currently under development.

The MOBILE model is based on Basic Emission Rate equations (BER's) for each class of vehicle. These equations were developed at an average speed of 19.6 mph, the average speed for the Federal Test Procedure driving cycle. To determine the proper EF, correction factors based on the model's input parameters are applied to the BER's for each pollutant. The model input file consists of three different sections: Control, One-time, and Scenario. The Control section consists of a series of flags that determines which variables will use default parameters and which variables the user will specify. This section also determines the format of the model output. The One-time data section contains parameters that will be constant for a particular region and therefore will not change with different scenarios in the same region. The Scenario section contains data that change with different scenarios. Some examples are speed, calendar year, and ambient temperature.

1.8 Dispersion Models

Atmospheric dispersion modeling is used to determine how a pollutant will be transported once it is introduced into the atmosphere. Given various 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 are based on dispersion characteristics described in what is known as the Gaussian plume equation (GPE).

The original form of the GPE was used to describe how nonreactive point source pollution moves in a uniform wind field with respect to time. The equation depicts the pollution as dispersing horizontally and vertically in a Gaussian or normal distribution. The point source GPE has been modified to the line source GPE for its 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.

One of the major problems with the GPE equation arises when modeling dispersion at low wind speeds. Actual worst case CO conditions often occur during episodes containing little (less than 1 m/s) or no wind. Since wind speed is in the denominator of the GPE equation, the model's predictions approach infinity as wind speed approaches zero. In addition to problems at low wind speeds, the dispersion parameters used in the GPE are estimated from stability classes that are not directly measurable parameters. These inherent problems with the GPE make some question its use in current dispersion models. On the other hand, with the vast amount of uncertainty involved with estimating emissions factors and future traffic volumes, more complex approaches to dispersion modeling are arguably unnecessary for most applications (Benson, 1984). The CALINE3 dispersion algorithm used in CAL3QHC is based on the finite line source GPE.

1.9 CAL3QHC Version 2.0

CAL3QHC v 2.0 is the latest model recommended by the USEPA for use in modeling dispersion of inert airborne pollutants, more specifically, carbon monoxide at signalized roadway intersections (USEPA, 1995). Previously, CO intersection modeling was done using Volume 9 of the USEPA Guidelines for Air Quality Maintenance Planning and Analysis (1978). This approach however, was not very user-friendly, used outdated modal emissions, and assumed intersection approach capacities were always less than the theoretical capacity. To help remedy the situation, the USEPA developed a model called CALQ.

The CALQ model predicted CO concentrations by combining EFs from an external source with the dispersion model CALINE3 (see following discussion) and a traffic queuing algorithm developed by the Connecticut DOT. Although it was seen as an improvement, this model also had several shortcomings. For example, it could not adequately handle situations near or over intersection capacity. To correct this inadequacy, the model was revised by replacing the existing delay formulations with new methods based on techniques from the 1985 Highway Capacity Manual and the Deterministic Queuing Theory (Newell G.F., 1982; Akcelik Rahmi, 1988; taken from USEPA, 1995). The result was CAL3QHC.

CAL3QHC was tested in 1989-1990 and recommended by the USEPA as the model to be used in CO intersection modeling. In 1991, the model was again revised to better accommodate variation in intersection capacity, signal characteristics, and arrival rates. The resulting model was CAL3QHC version 2.0. In 1991, a CO intersection modeling study was conducted using eight different modeling techniques at six different New York intersections. CAL3QHC version 2.0 was one of the top performing models (USEPA, 1992a). It is currently the model recommended by the USEPA for detailed CO intersection modeling. To better understand how the dispersion components of CAL3QHC works, CALINE3 must be examined.

1.10 CALINE3

CALINE3 is the third model in a series of line source dispersion models developed by the California Department of Transportation. The user enters source strength in the form of an EF (from, e.g., MOBILE5b), as well as parameters describing meteorology, site geometry, and site characteristics. The model predicts inert pollutant concentrations for receptors located at least three meters away from the roadway.

CALINE3 does not model a roadway line source as a series of point sources like the previous CALINE versions. Instead, a roadway is modeled as a series of finite line sources positioned perpendicular to the wind direction (Benson, 1979). In this method, a link of highway that is originally defined by the user is first divided into a series of finite elements. The emissions from each element disperse in a Gaussian fashion according to an x-y coordinate system local to that element and centered at the element's midpoint. The y-axis of each element is aligned with the wind direction. The total concentration measured at a given receptor is then estimated by summing the individual influences each element has on that particular receptor. Another addition to CALINE3 was adjusted vertical dispersion curves that better represent the actual mixing conditions above a roadway.

1.11 Modeling Issues

Performing a CO air quality analysis is complicated by the individual factors that make up the analysis. Intersection selection, site geometry, background concentrations, and persistence factors must all be considered in a proper air quality analysis.

1.11.1 Intersections

Areas that attract a large number of mobile sources are considered indirect sources. When analyzing a new construction project, indirect sources must be analyzed to determine their impact on the ambient air quality. Locations where vehicles accumulate, decelerate, idle, and accelerate, often labeled hot spots, are potential problem areas. Intersections are the most frequent area of concern. CO concentrations near signalized intersections have been shown to be substantially higher than concentrations near freeways with two to three times higher volumes of traffic (Claggett et al., 1981).

1.11.2 Site Geometry

One of the first steps in modeling any highway intersection is to obtain an accurate and detailed site plan. The spatial relationships between sources and receptors greatly impact the modeled concentrations. In general, the highest concentrations will be measured in the queue zone, the lowest in the midblock zone, and there will be a decreasing concentration profile as distance increases 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).

1.11.3 Background Concentration

The concentration in the ambient air that cannot directly be attributed to the source is labeled as the background concentration. This is a very important parameter for accurately evaluating an intersection's impact on the surrounding area. The difference between an intersection causing a NAAQS violation and not causing a violation may be in the background concentration. For instance, two intersections that experience the exact the same weather and traffic conditions and that are geometrically the same but in different locations, may see very different ambient concentrations due to differences in the local background concentrations. Since the NAAQS are concerned with the ambient concentrations, it is very important to determine an accurate background concentration for the project analysis. Unfortunately, a methodology to determine the background concentration is not clearly defined. The most common method used to determine background concentrations, is to use default values suggested by regulatory agencies. Illinois Environmental Protection Agency (IEPA) recommends using 1-hour average background concentrations of 3.0 ppm for urban areas and 2.0 ppm for rural areas.

1.11.4 Persistence Factors

Typically, the available traffic data used as inputs for the intersection model will allow the model to predict 1-hr concentrations. As stated previously, the CO NAAQS most frequently of concern for intersection modeling is the 8-hr average of 9 ppm. In order to compare modeled 1-hr average concentrations to the 8-hr standard, an adjustment is needed. The most common method is to multiply the 1-hr concentration by an 8-hr to 1-hr concentration ratio called the total persistence factor (TPF). The TPF takes into account both fluctuations in weather conditions and traffic patterns in the form of a meteorological persistence factor and a vehicular persistence factor.

There is some disagreement on how the TPF should be determined. According to the USEPA, the best way to determine the TPF is from actual measured data. However they concede that if actual relevant data is unavailable a default TPF value of 0.7 may be used (USEPA, 1992b). Cooper et al. (1992) detail another method for determining worst case persistence factors, with results from a Orlando, Florida intersection analysis yielding a significantly lower TPF of 0.55. IEPA recommends a TPF of 0.7 for Illinois.

1.12 Drawbacks and Cautions to the Modeling Process

Many different parameters can affect the over all result of the modeling process making it next to impossible to determine where all the introduced inaccuracies are occurring in the modeling process. For example, errors are introduced in the form of variations between actual and modeled vehicle volumes, speeds, and fleet characteristics, meteorology, signal timing, spatial relationships, and background concentrations. Persistence factors that do not properly represent actual site conditions can be another significant source of introduced error.

Even if all the input model parameters are known with certainty, the model's internal algorithms themselves can be a source of introduced error (Chatterjee, 1997). For example, CAL3QHC only accounts for two operating modes, cruise and idle. Acceleration and deceleration modes are not accounted for in the model. Studies have been conducted comparing modeled concentrations to measured concentrations confirming these discrepancies (USEPA, 1992a; Lindeman, 1994).

The USEPA report, "Evaluation of CO Intersection Modeling Techniques Using a New York City Database," evaluated eight different predictive CO models. Results indicated that the three top performing models were statistically equal; CAL3QHC was one of them. Despite the model's inaccuracies, CAL3QHC is the USEPA recommended CO intersection model (USEPA, 1992b).

Microscale effects specific to individual sites are also difficult to quantify using a general model. The influence on pollutant dispersion by buildings and other obstructions located near an intersection can best be described as complex and unpredictable. Large obstructions, such as buildings, create various wind vortices and wake patterns as a wind field passes over and around the obstruction. As the incident angle of the wind changes, it becomes very difficult to predict the resulting turbulence patterns. When the influences of irregularly shaped objects and multiple obstructions are considered, the turbulence patterns become nearly unpredictable.

Another phenomenon that is difficult to determine is the influence that the moving vehicles have on mixing the pollutants. The models usually account for this by designating a mixing zone, usually the lanes of travel plus an additional 10 feet off each side. The speed of the vehicles, traffic density, vehicle shapes, and heights of emissions influence the actual mixing zone.

1.13 MOBILE5a Sensitivity Analysis

In NCHRP Report 394, Chatterjee et al. (1997) performed both a traditional and a risk-based sensitivity analysis using MOBILE5a to determine how changes in input parameters affect the EFs. The following is a brief summary of the results from the traditional sensitivity analysis with respect to CO EFs. The input parameters of concern were speed, operating mode and temperature, vehicle type, vehicle age mix, and vehicle miles traveled (VMT). The analysis was performed by comparing the output of a constant base case to cases containing variations of one input parameter. As mentioned above, speed is one variable that influences the estimation of the CO EF. As speed increases, CO EFs decrease at an increasing rate until approximately 55 mph. Above 55 mph, CO emissions begin to rise. As example of the magnitude of the error introduced because of poorly known speed, at a speed of 20 mph, an error of 2.3 mph will produce a 10 percent error in CO emissions.

The operating modes, i.e. percent hot/cold starts and hot stabilized operating modes, also greatly affect the calculated EFs. In general, CO emissions are the highest during cold-start operations and the lowest during hot stabilized operations. The ambient temperature also plays an important role in determining the effects of the operating mode. During cold ambient conditions (32°F) CO emissions are approximately three times higher during cold-start operations than during hot-stabilized conditions. During warmer conditions (75-95°F) emissions vary by roughly a factor of two. In terms of introduced error, at 32°F, a 6.6 percent change in cold starts will cause a 10 percent change in CO emissions.

The next input parameter analyzed was vehicle type. The heavy-duty gasoline vehicles (HDGV) produce larger CO emissions than the other seven vehicle types considered in MOBILE5a and between four to six times higher than light-duty gasoline vehicles (LDGVs). When the percent of HDGVs was increased by 2.8 percent and LDGVs reduced by 2.8 percent, the aggregate fleet EF for CO increased by 10 percent.

The vehicle age mix was another input parameter evaluated. The deterioration rates used by MOBILE to determine increased emissions due to deterioration of the pollution control equipment with age are quite high. After four years of vehicle use, or 50,000 miles, modeled CO emissions are about 10 times higher than original levels. In comparisons made with adjusted vehicle age distributions (see the NCHRP report for exact distributions), a 1-year increase in median vehicle age increased the predicted CO EF for LDGVs by 11.7 percent. Conversely, a 1-year decrease in median age caused a 12.9 percent CO EF reduction for LDGVs. Deterioration rates in MOBILE6 will be adjusted to reflect a lower level of deterioration than previously believed and incorporated in MOBILE5.

The final input parameter considered in the NCHRP sensitivity analysis was the vehicle-miles traveled (VMT). Estimates of CO EFs are directly related to VMT, i.e., a 10 percent error in VMT will produce a 10 percent error in the EF.

When using MOBILE, errors in the input parameters will not realistically lie in one parameter but rather occur in several if not in all parameters simultaneously. The combined effect of multiple introduced errors is not as simple as combining the results from the sensitivity analysis of the individual components. The NCHRP study found no existing patterns in the results from combined errors. The study also found problems with the accuracy of the speed correction factors internal to the program. Modelers using MOBILE should be aware that input uncertainty can greatly affect the estimated CO EFs and should try to avoid introducing input error whenever possible.

1.14 Screening vs. Detailed Modeling

The Illinois Department of Transportation currently uses one criterion to determine whether a highway project requires a detailed CO air quality analysis before construction begins: 1) If the project is expected to have a traffic volume of 16,000 ADT or greater by the end of the first year of operation.

If required, the detailed air quality analysis is performed using the two previously discussed USEPA models MOBILE5 and CAL3QHC to predict whether the project will significantly impact ambient CO concentrations and cause a violation of the NAAQS. The detailed analysis requires input data that often times may be very difficult and time consuming to obtain. The detailed analysis also requires the expertise of a user who is familiar with the models. This can increase project expenditures.

Because the NAAQS for CO are expressed as maximum concentrations not to be exceeded more than once a year, a method that may be used to circumvent the detailed analysis without compromising its goals is the use of a screening analysis. A screening analysis is used to determine if a project *may* cause a violation of the NAAQS. The goal of a screening analysis is to use readily available data, in a user-friendly application, to make a conservative estimate of a project's contribution to the ambient conditions. This is done by evaluating a project using a combination of conditions that when occurring simultaneously produce the highest ambient CO concentrations. This is termed a worst-case analysis. The worst-case conditions recommended by the USEPA are discussed below.

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. On the other hand, if the screening model indicates that the project may violate the NAAQS, a more detailed analysis is required to more accurately determine the project's impacts. The development of a screening model for Illinois intersections was a main goal of this research.

The use of a screening analysis will make the current IDOT CO analysis for highway projects more efficient. The Florida DOT has successfully incorporated a user-friendly computer screening model into their CO intersection analysis, COSCREEN98. The Pennsylvania and Colorado DOT have also developed computerized CO screening models for their respective state intersection modeling procedures.

1.15 Worst-case Conditions

The USEPA's Guideline for Modeling Carbon Monoxide from Roadway Intersections (1992b) lists the worst-case meteorological conditions to be used with CAL3QHC as follows:

1.15.1 Temperature

USEPA recommends the following procedure to determine the worst case ambient temperature: Obtain the temperatures corresponding to the 10 highest non-overlapping 8-hour CO concentrations for the last three years, determine the average temperatures over each 8-hour period, and then average the 10, 8-hour values to obtain the worst case temperature. Another simplified approach is to use the average temperature in January.

1.15.2 Wind Speed

Typically, the largest CO concentrations measured at intersections correspond to periods with the lowest wind speeds, often times less than 1 m/s. The lack of wind causes reduced atmospheric mixing, resulting in less pollutant dispersion and thus higher ambient groundlevel concentrations. The lowest valid wind speed for CAL3QHC is 1.0 m/s.

1.15.3 Wind Direction

The USEPA recommends that wind directions from 0 to 360 degrees in at least increments of 10 degrees be analyzed with CAL3QHC. The wind direction producing the highest concentration at the given receptor can then be determined using the model.

1.15.4 Atmospheric Stability Class

Atmospheric stability classes are a measure of the ability of the corresponding weather conditions to mix the air. Classes are represented by the letters A through F, with A being the least stable, F the most stable. The atmospheric stability recommended for urban intersections is class D. Recommended stability for rural intersections is E.

1.15.5 Mixing Height

CAL3QHC is not overly sensitive to mixing height. The recommended mixing height for estimating 1-hour and 8-hour average concentration is 1000 meters.

1.16 Other Methods for Modeling CO

Although the majority of this review is devoted to the discussion of the EPA's Intersection Model CAL3QHC it should be noted that this is not the only available method for analyzing CO concentrations at signalized intersections.

Along with the models tested in the New York Intersection Model report (USEPA, 1992a) and the other USEPA recommended models, TEXIN2 and CALINE4, several new approaches to CO intersection modeling have recently appeared in the literature. Tanaka et al. (1995), used a neuro-fuzzy technique to model CO concentrations in a congested Japanese intersection in Japan. Results showed the neuro-fuzzy model outperformed a linear model based on the same intersection. Moseholm et al. (1996) have investigated the use of neural networks that can be trained to describe the relationships between CO concentrations, local wind conditions, and traffic patterns. Although a neural network is a site specific model (i.e., the specific patterns are based on the training data), the technique has shown to be a useful tool to further understand complex relationships not captured in other dispersion models. Another new intersection model has recently been developed by Cooper et al. (1997) is called FLINT.

FLINT incorporates several new ideas that preliminary studies have shown provide a significant improvement over other intersections models such as CAL3QHC (Cooper et al., 1997). Like CAL3QHC, FLINT uses EFs determined by MOBILE5. Unlike CAL3QHC, FLINT spreads the emissions over the area of the roadway instead of modeling them along a straight line. The method for determining the emission distribution and the dispersion algorithms use methods developed in the PAL2 model. The algorithms used to calculate the sigma dispersion parameters in PAL2, however, were replaced with the CALINE3 algorithms that better represent conditions at an intersection. The emission type and release height are also separated by the type of vehicle, large trucks vs. passenger cars. Where CAL3QHC only splits emissions into cruise and idle modes, FLINT accounts for the four types of modal emissions known to occur at intersections, idling, acceleration, deceleration, and cruise. Also, according to Cooper et al. (1997) the traffic algorithms used by FLINT are more theoretically correct, adding to the improved model accuracy. FLINT is currently undergoing review and validation procedures with the Florida DOT.

The US National Cooperative Highway Research Program has recently awarded a contract to Systems Applications International (SAI) to develop a new intersection air quality model (Smith, 1998). KLD Associates, Inc. has been subcontracted by SAI to develop the traffic portion of the model. The overall model will be modular, incorporating three separate models: a traffic operations model, an emissions model, and a dispersion model. KLD's own traffic model, Traf-Netsim will be adapted for use as the traffic operations model. The latest MOBILE model will be used for the emissions modeling, and the dispersion module will use CALINE4 for most meteorological conditions. A particle-in-cell approach will be applied for conditions with low wind speeds (Yedlin et al., 1998). The three models could be used together or independently allowing for piecewise evaluation of an intersection. The integrated model will be applicable for both screening and detailed analyses.

1.17 Other CO Screening Models

Currently there are three different computerized CO screening models used in the US for project level air quality analysis: COSCREEN98 (Florida), Colorado CO Screening Model, and InterAir (Pennsylvania). (AIRSCREEN and COSCREEN 1.0 are two older computerized CO screening models that have been replaced with COSCREEN98.) AIRSCREEN, COSCREEN 1.0, COSCREEN98, and Colorado CO Screening Model were created by Cooper and his research group. AIRSCREEN was the first model developed by Cooper (1991) for the Florida DOT. The model was designed to automate and update the manual graphical screening curve procedure used by FDOT at the time. AIRSCREEN was designed using two existing USEPA approved models: modal emissions model, MOBILE4, to update the EFs, and line source dispersion model, CALINE3, to estimate CO concentrations. COSCREEN v 1.0 was created in 1993 to replace AIRSCREEN (Cooper, 1993). The model was similar to its predecessor. However, MOBILE5a was used in the creation of the graphical screening curves. Both AIRSCREEN and COSCREEN v 1.0 are currently outdated, and therefore will not be discussed further. COSCREEN98, or COSCREEN v 2.0, was created in 1998, and is presently used by FDOT for screening CO at signalized intersections.

COSCREEN98 incorporates MOBILE5a and CAL3QHC. The model begins by prompting the user for the project name, facility name and user name. The next screen asks the user to select the project location within Florida. This provides the fleet data needed for the calculating vehicle

EFs. On the following screen, the user must select the intersection setting (urban, rural, or suburban), the maximum traffic approach volume on one leg, the approach speed, the year of analysis, project location, and the number of receptors. The intersection setting is used to determine the background concentration and the roughness factor used in CAL3QHC. The year of analysis, and approach speed are used in determining the fleet EFs. The maximum traffic approach volume on one leg is applied to each leg of the intersection, and this value is used by CAL3QHC in calculating roadway emissions and estimating CO concentrations. The final input screen asks the user to specify the locations of the desired receptors. After the inputs are entered, the user must click the Run button to calculate CO concentrations. When the Run button is clicked, COSCREEN98 creates a MOBILE5a input file and runs MOBILE5a. The program then uses the appropriate EFs to create a CAL3QHC input file, and runs CAL3QHC. The results of CAL3QHC and MOBILE5a are then combined and summarized in a text-based final report that may be viewed in the program's own text viewer.

The Colorado CO Screening Model was also created by Cooper's group and is very similar to COSCREEN98. Differences include selecting the location within Colorado, a choice of three types of intersections ("3 Lanes Thru," "2 Lanes Thru," and "T-type"), and the elimination of the intersection setting and choice of receptors. Background concentration, surface roughness, and receptor locations are all fixed inputs. The program runs through the same series of calculations as COSCREEN98 and presents a slightly different text-based final report.

InterAir, like COSCREEN98 , uses both MOBILE5a and CAL3QHC to estimate worst-case CO concentrations. The model was created for use by the Pennsylvania DOT, in 1998 (InterAir Users Manual, May 1998). The model prompts the user for all the required input variables on one input screen. The required inputs are project name, county, setting, year of analysis, background concentration, average cycle length, clearance lost time, and East-West and North-South roadway volumes, number of lanes, approach speeds, and percent of left turns. After the inputs are entered, the program runs MOBILE5a and CAL3QHC and summarizes the results on an output screen.

Chapter 2: Survey Summary

The purpose of the survey was to document the practices of other states modeling carbon monoxide and other pollutants. The survey asked questions about the pollutants that the states model, the screening and refined tools that they employ, and the criteria for using them. It also asked for suggestions to make a new screening tool as useful as possible. A copy of the survey is included in Appendix A of this report.

Of the fifty states that were sent the survey, thirty-six states returned it completed (Table 2.1). Iowa, Hawaii and Mississippi stated that they do not have any significant non-attainment areas, and therefore do not model air pollutants from roadway projects.

Table 2.1 *List of States that responded to the survey.*

Alabama	Massachusetts
Alaska	Michigan
Arkansas	Minnesota
Arizona	Mississippi
California	Montana
Colorado	Nebraska
Connecticut	Nevada
Delaware	New Hampshire
Florida	New Jersey
Georgia	North Carolina
Hawaii	Ohio
Idaho	Oregon
Indiana	**Pennsylvania**
Iowa	South Carolina
Kentucky	**Texas**
Louisiana	Utah
Maine	West Virginia
Maryland	**Wisconsin**

States in bold use CO screening procedures.

Before analyzing the results of the survey it is important to define the researchers' conception of a screening procedure, of a refined modeling tool, and of modeling criteria. For the purposes of this study a screening procedure is defined as one that has some calculation to estimate the same variables as does a refined modeling tool, but only gives a rough estimate as opposed to the calculations of the refined model that give more accurate values. If a state uses a screening procedure, the criterion for whether or not to implement a refined modeling tool is if the project fails the screen.

Examples of criteria for application of screening procedures (or for refined modeling if there is no screen) would be a comparison of some traffic value to a cap or based on project location, e.g. within a non-attainment area.

2.1 Screening Procedures

It is important to note that a number of states had either different definitions of screening and refined modeling tools, or did not differentiate between the two approaches in the survey. Where necessary, phone calls were made to clarify answers. Perhaps this apparent confusion can be explained by the fact that few states actually use screening procedures: only six of the thirty-six states that responded use them for CO air quality analysis.

Table 2.2 shows the different screening tools that are used: five are computer screening methods (Florida also reported the use of manual-screening methods such as charts or spread sheets). California is the only state that relies solely on a manual screening method.

The computer screening methods can be based on refined modeling tools such as the method used by Florida. The model Florida uses is called COSCREEN and is based on the refined models CALINE, CAL3QHC, and MOBILE5a. The first version of COSCREEN gave a critical distance from the roadway beyond which CO concentrations were expected to be within standards. If all receptors were located outside of this critical distance, the project was considered to pass the screen. A newer version gives the CO concentration in ppm at pre-determined receptors. Colorado's screening model is very similar to Florida's. However, set receptor distances are preprogrammed into the model. Pennsylvania's screening model, called INTERAIR, is also based on the refined models CAL3QHC and MOBILE5a. Finally, some states (e.g., Texas and Wisconsin) use refined modeling tools and conduct a worst case analysis.

Table 2.2 *Screening model approaches for states responding to the survey.*

State	Screening Model Name and brief approach description	Pollutants
California	Caltrans/VC Davis, CO protocol (manual)	CO
Colorado	Screening model, Colorado COSCREEN (computer)	CO
Florida	COSCREEN 98- based on CALINE3 and M5a (revised after	CO
	M6 released)	
Pennsylvania	INTERAIR (for PennDOT).CALINE & M5 - Windows based.	CO
	3 min. reqd. for o/p	
Texas	CALINE4,M5a & a data builder for M5a to build worst-case.	CO
	(computer)	
Wisconsin	CAL3QHC, MOBILE5a worst-case analysis at sensitive	CO
	receptors or ROW line or setback line.	

2.2 Screening Tools Criteria

Several states have criteria that must be fulfilled before the screening procedure is applied. These criteria are shown on Table 2.3. If the criteria are not satisfied, the screening procedure is not done.

Three of the states use screening models in their non-attainment regions. Average daily traffic (ADT) cutoffs can also be used to determine if screening is to be performed, as it is done in

Texas: this state screens all NEPA projects with ADT greater than 1500. Florida uses its screening tool for peak-hourly volumes between 1,000 and 10,000 vph, for speeds ranging from 12.5 to 45 mph, and for all modeling years before 2015.

Table 2.3 *State criteria for implementing screening procedures.*

State	Level	Pollutants
California	All projects in CO nonattainment or maintenance areas,	CO
	other projects where localized impact analysis is required	
Colorado	To be determined : probably based on worst case/max	CO
	traffic in max lane.	
Florida	Volume(1000 to 10,000 vph),Speeds(12.5-45 mph),Year<2015	CO
Pennsylvania	CEs and EAs run with INTERAIR	CO
	CMAQ prjs. In non-attainment areas.	
Texas	Within non-attainment areas for CO.	CO
	All NEPA projects with ADT>1,500.	
Wisconsin	Non-exempt projects.	CO

2.3 Refined Modeling Criteria

Most states use some criteria, rather than a screening procedure, to decide whether refined modeling is necessary. Table 2.4 shows these different criteria.

Ten states use attainment status as a criterion for refined modeling. These states perform refined modeling in non-attainment areas for CO, ozone, NO_x or VOCs. Some states use LOS as an indicator. If LOS is D or worse due to a project, refined modeling is done. Other states have given traffic volume levels (mainly ADT) above which they apply refined modeling. For example, Ohio runs refined models when a new project increases projected ADT by more than 20,000 within the first ten years of the project and if an existing project increases projected ADT by more than 10,000 in the first ten project years. Some criteria can also be based on the project classification, e.g., whether the project is non-exempt or regionally significant.

2.4 Refined Modeling Tools

Refined models used by the various state agencies include MOBILE5a, MOBILE5b, CALINE 4, CAL3QHC, Highway Capacity Model, and HIWAY (Table 2.5).

The vehicle EF model MOBIL5a and dispersion model CAL3QHC are the most popular set of refined models in use. Seven states use CALINE 4, while nine use the Highway Capacity Model. TRAF-NETSIM and EMFAC7F are used in only two states. Idaho is the only state reporting the use of PAL, and Wisconsin is the only state reporting the use of TEXIN.

Most states use the emission models MOBILE5a or MOBILE5b along with one or more dispersion models. Six of the states use both MOBILE5a and MOBILE5b, suggesting a transition period between use of the two models. Michigan uses its own model called TRAN-PLAN. Other models mentioned by the states include ISC, ISC Prime, AERMOD, and TRIPS EDMS.

The survey illustrates that there are two basic types of refined modeling: emissions budget

Table 2.4 *Refined model criteria for the states responding to the survey.*

State	Level	Pollutant
Alabama	Network speeds & volumes by functional classification and mileage.	CO,NOx,HC
Alaska	If regionally significant (conformity regulations).	CO, PM
Arizona	Based on speed., ADT, VMT etc.	CO
Arkansas	If environmental assessment or Environmental Impact statement is warranted.	CO
California	If it fails qualitative and quantitative screens in CO protocol.	CO
Colorado	If it fails the Screen.	CO
Connecticut	For conformity/categorical exclusions within a non-attainment area	CO
	and LOS D or worse. For NEPA documents-all signalized intersections	
	affected by project not classified as exempt, or LOS indicates problems.	
Delaware	Nonexempt projects to be tested.	NOx,VOC
Florida	> 10,000 Vph or if it fails the Screen.	CO
Georgia	LOS D or worse for intersections; ADT>10,000 for widening projects.	CO
Idaho	Within CO nonattainment area, regionally significant projects, proximity	CO
	to sensitive receptors.	
Indiana	Within ozone non-attainment areas.	NOx,HC
	Within CO non-attainment areas.	CO
Kentucky	Applied to all projects (two levels of refined modeling)	CO,VOC,NOx,PM
Louisiana	Within non-attainment area and based on highway capacity.	CO
Maine	Within non-attainment areas for VOC and NOx (Mobile 5A).	NOx,VOC
	Regionally Significant projects (Highway Capacity Model),	NOx,VOC
	NEPA projects(CAL3QHC),	CO
Maryland	Traffic volume > 300 vph, near a sensitive receptor w/in 1000 ft.	CO
Massachusetts	Within non-attainment area, regionally significant and non-exempt projects.	VOC, CO,NOx
Michigan	Non-attainment or mainentance area, OTAG strategy.	O3,CO,NOx
Minnesota	If the project is greater than the benchmark AADT and/or LOS the state	CO
	calculates every three years, or if the project involves/affects short list of 3	
	MPCA monitored locations or top 7 intersections.	
Montana	Non-exempt/non conformity projects.	CO
Nebraska	>30,000 ADT.	CO
Nevada	Any capacity increase or new signal in non-attainment area.	CO
New Hampshire	Project not classified as exempt, or LOS indicates problems.	CO
New Jersey	If total peak hour traffic volumes>2,500 vph.	CO
North Carolina	Major roadway improvement (two levels of refined modeling).	CO
Ohio	New project: ADT>= 20k increase from Time of Completion (TOC) to	CO
	TOC + 10. Modified existing projects: ADT>= 10k from TOC to TOC + 10.	
Oregon	NEPA Class1 project.	All
	Plan, program, project conformity determinations.	CO,O3,PM-10
Pennsylvania	If it fails the Screen.	CO
South Carolina	ADT above 10,000 at an intersection, project within maintenance area.	CO, O3
Texas	If it fails the Screen.	CO
	CMAQ projects in non-attainment areas.	VOC, NOx
Utah	W/in CO non-att area; LOS D,E,F would become D,E,F for projected vols.	CO
Wisconsin	Exceed 75% of the NAAQS with screening tools.	CO
West Virginia	VMT-ADT.	VOC, NOx

modeling and hot spot analysis. In emission budget modeling, calculations are performed to determine if a regional emission budget is exceeded. For this analysis, states use a Transport Demand Model or similar calculation to get the VMT, ADT and other traffic parameters such as queue length. These are combined with MOBILE5 EFs to determine an emissions inventory, which is compared to a regional budget. If the emissions inventory is within the budget, the project passes the refined model; if not measures must be taken to reduce the traffic or to redesign the road.

The other approach to refined modeling is a hot spot analysis. A hot spot analysis estimates the concentration of pollutant at a sensitive receptor, using models such as MOBILE and CAL3QHC.

It is interesting to note the very in-depth method Kentucky uses for air quality modeling of

Table 2.5 *Refined models used by the states returning the survey.*

State	M5a	M5b	CALINE4	CAL3QHC	HCM	TEXIN	PAL	TRAF-NETSIM	EMFAC7F	Other
Alabama		X								TRAN-PLAN
Alaska		X		X						
Arkansas	X		X	X						
Arizona	X		X	X						
California			X	X					X	
Colorado	X			X						
Connecticut		X		X						
Delaware	X									Traffic Demand Model
Florida	X			X						
Georgia	X			X	X					
Idaho	X			X			X		X	ISC and ISC Prime, AERMOD,
Indiana		X			X					TRANPLAN,EMME2
Kentucky	X			X						ADT Predictions
Louisana	X			X						
Maine	X			X	X			X		TRIPS
Maryland	X	X		X						
Massachussets		X								Regional Traffic Models
Michigan	X		X							TRAN-PLAN
Minnesota	X			X	X					
Montana	X			X						
Nebraska	X			X						
Nevada	X			X						
New Hampshire	X	X		X	X					
New Jersey	X			X	X					
North Carolina	X			X	X					
Ohio	X			X						
Oregon	X	X		X						
Pennsylvania	X	X		X						INTERAIR after EPA approval.
South Carolina	X	X	X	X						
Texas	X	X	X		X					
Utah	X	X		X	X			X		
Wisconsin	X		X	X		X				

transportation projects. Kentucky has two levels of refined models: for each project the emissions inventory is estimated and compared to a regional budget. For all projects they also perform a hot spot analysis. This is the first level of refined modeling.

Then, two additional criteria considered. If ADT is less than 40,000 and the project is outside a maintenance or non-attainment area then no further modeling is done. However, if one of these criteria is violated, CO refined modeling is performed for the entire physical length of the project.

North Carolina uses a similar technique, that is to say two levels of refined models. For attainment areas, future volumes and speed are estimated. These variables are used in MOBILE5 to determine EFs. A worst case analysis is then conducted with CAL3QHC (under free flow conditions because these projects do not typically have intersections) on receptors along the roadway. For non-attainment areas, a hot spot analysis is performed for signalized intersections using MOBILE5 and CAL3QHC.

The survey responses indicate that there is no consistent nationwide trend on performing a detailed CO analysis. It appears State highway departments are free to suggest and develop methods of analysis for approval by the regulatory agencies.

2.5 Features to be Incorporated In a New CO Screening Tool

In the survey, the states were also asked to express opinions on what important features should be incorporated into a new screening tool for CO concentrations. The results are shown in Table 2.6.

Features frequently mentioned were a good choice of intersection types, directionally dependent traffic volumes and a table output of the results. These features, along with some of the other features mentioned by the survey respondents as well as those recommended by the Technical Review Panel members, are incorporated into the Illinois COSIM screening tool.

Other suggestions offered by respondents were that the model should be capable of being imported to spreadsheets or databases and should be compatible with tools like CAD Microstation and GIS packages. Three states suggested that the tools should be user friendly. There was a suggestion from one state that the tool should be able to model other contributors to pollution other than traffic, and should be able to take into account varying meteorological conditions.

Contact information in the form of address, phone number and email-id of the respondent was solicited at the end of the survey. When required, contact information was used to solicit further explanations of their survey responses. Additional comments made by these individuals are included in the survey compilation. Several states indicated their interest in the screening tool being developed for Illinois, requesting further information.

Table 2.6 *Survey responses to features desired in a new CO screening tool.*

Feature/Capability	No. of States Expressing a Preference
Choice of intersection type	20
Choice of intersection angle	8
Directionally dependent traffic volumes	21
Directionally dependent traffic speeds	21
Graphical output	16
Tabular output	19

Chapter 3: CAL3QHC Illinois Intersection Evaluation

A portion of this project was devoted to evaluating the use of MOBILE5b and CAL3QHC on intersections located in Illinois. Three different sites were evaluated. When choosing the sites, intersections in close proximity to an IEPA CO monitor had to be found. Another consideration was finding intersections near meteorological weather stations, usually an airport. The first site chosen was the intersection of Sixth Street and Monroe Avenue located in downtown Springfield, Sangamon County. This site was considered representative of a medium-volume, downtown intersection of two one-way streets. The second site was the intersection of Main Street and University Street located in Peoria, Peoria County. This site was considered typical of a medium-volume, four-way intersection commonly found throughout Illinois. The third site selected was the intersection of Irving Park Road and Mannheim Road located in Schiller Park, Cook County. This site was considered representative of high volume intersections typically found in high population centers. Its close proximity to an airport and its unobtrusive surroundings made the intersection an ideal choice.

For a complete assessment, traffic and weather data should span a large range of conditions and seasons. The original project goal was to obtain at least two sets of measured versus modeled concentrations at each intersection. One set of measurements would be during winter months (worst-case), the other during summer months. Due to difficulties in obtaining winter traffic data (snow and ice events), the requirement of having a winter data set was dropped. At least two sets of nonconsecutive time periods at each intersection were evaluated. The time periods of the data sets corresponded either to the dates of previous traffic volume studies or to dates when IDOT conducted new traffic volume measurements specifically for this project. See Appendix B for additional information on the detailed modeling of the three intersections.

3.1 Sixth and Monroe

The intersection of Sixth Street and Monroe Avenue is located in downtown Springfield, Illinois. Both streets are three lane, one-way streets with parking on both sides (Figure 3.1). Sixth Street carries north bound traffic, while Monroe carries east bound traffic. Most of the surrounding buildings are two to four stories high.

The intersection was modeled with CAL3QHC v 2.0 using 14 links, 10 free flow, and 4 queue links (Figure 3.1). Wind speeds, wind directions, and ambient temperatures were acquired for the Springfield airport, from the National Climatic Data Center at www.ncdc.gov. Approach speeds used were 25 mph for through and departing links and 15 mph for right and left turn links. These speeds were representative of values measured at the traffic counts. Temperature data, maximum and minimum daily temperatures and hourly temperatures used for the EF calculation were taken from the Springfield airport data. VMT mix was taken from 1996 IDOT data for Urban Local Streets. The fleet mix is as follows: LDGV 0.663, LDGT1 0.199, LDGT2 0.080, HDGV 0.016, LDDV 0.008, LDDT 0.002, HDDV 0.068, and MC 0.010. Fuel Reid Vapor Pressure (RVP) values were set at 9.0.

Due to the low CO concentrations observed at the intersection, background concentration was assumed to be zero for modeling purposes. The measured concentrations were from the IEPA CO monitor (labeled "Receptor" in Figure 3.1) located in the southeast corner of the intersection. The CO data dates, times, and averaging periods corresponded to the traffic data dates, times, and averaging periods.

Traffic data were obtained from IDOT District 6 for July 7, 1997, August 24-26, 1998, and May 24-26, 1999. To further condense the traffic data, only periods of high flow (6 am to 7 pm) were considered.

3.2 University and Main

The intersection of University Street and Main Street is located in Peoria, Illinois. Both streets are two lane, two-way streets with designated left turn lanes (Figure 3.2). University Street carries north/south bound traffic, while Main Street carries east/west bound traffic. South bound traffic on University has an additional right-turn-only lane. The surrounding buildings are one to three stories high.

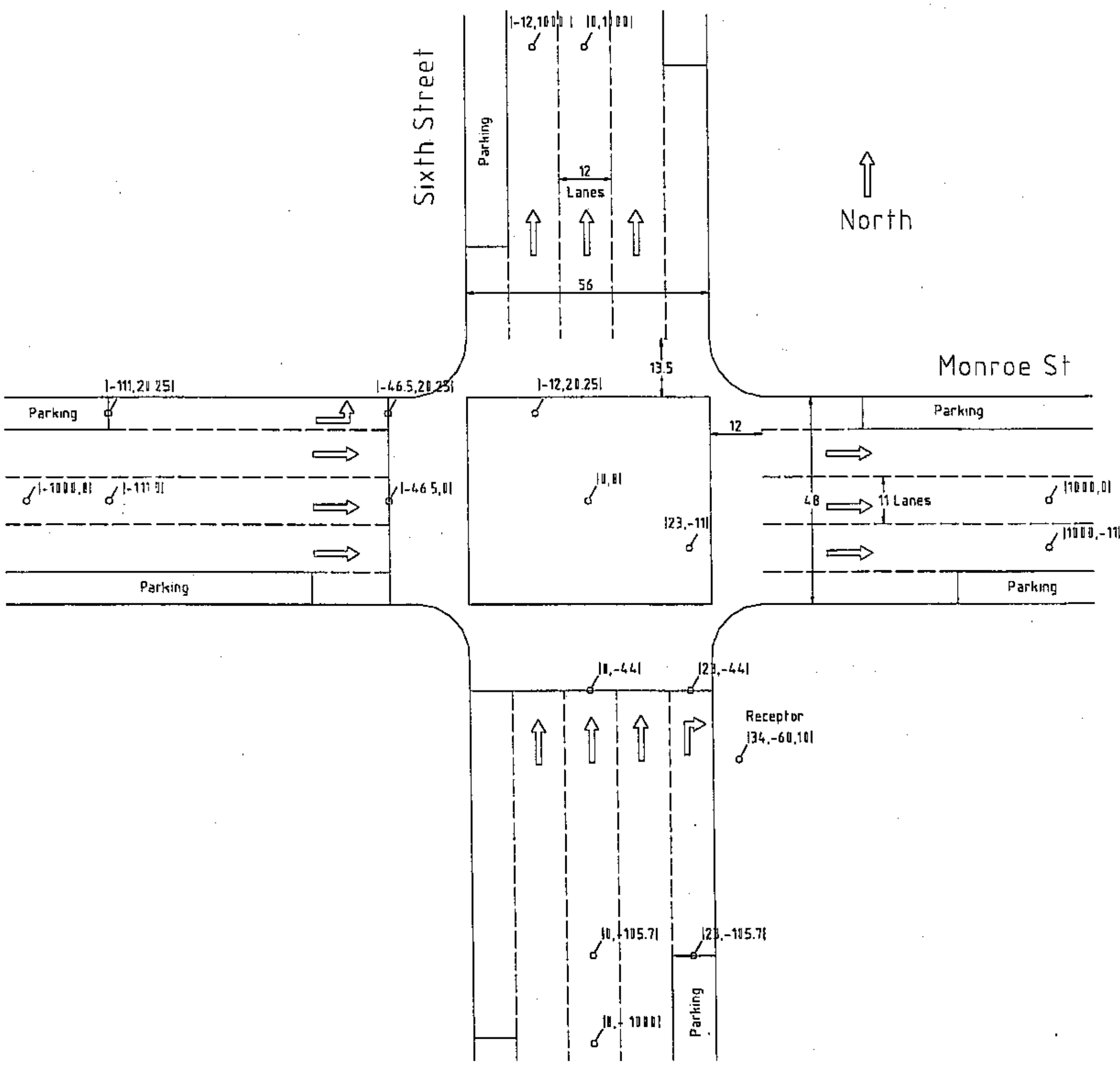

Figure 3.1 *CAL3QHC geometric configuration for Sixth and Monroe.*

The intersection was modeled with CAL3QHC v 2.0 using 38 links, 29 free flow, and 9 queue links (Figure 3.2). Wind speeds, wind directions, and ambient temperatures were acquired for Peoria Greater Peoria Airport from the National Climatic Data Center. EFs were determined using the IDOT default MOBILE5b input file for ozone attainment counties in Illinois North of 40° latitude. Other temperature data used for the EF calculation were the maximum and minimum daily temperatures, the hourly temperatures, and the speeds measured at the intersection (September 1998, data). VMT mix was taken from 1996 IDOT data for Urban Local Streets, and is as follows: LDGV 0.663, LDGT1 0.199, LDGT2 0.080, HDGV 0.016, LDDV 0.008, LDDT 0.002, HDDV 0.068, and MC 0.010. Fuel RVP values were set at 9.0 psi. Left turn movements were all assumed to be 15 mph.

Due to the low CO concentrations observed at the intersection, background concentration was modeled as zero. The measured concentrations were from the IEPA CO monitor (labeled "Receptor" in Figure 3.2) located in the northwest corner of the intersection. The CO data dates, times, and averaging periods corresponded to the traffic data dates, times, and averaging periods.

IDOT District 4 provided signal timing and traffic data for September 22-23, 1998, and March 16-17, 1999. To further condense the traffic data, only periods of high flow (6 am to 5 pm) were considered.

3.3 Irving Park Road and Mannheim Road

The intersection of Irving Park Road and Mannheim Road is located in Schiller Park, Illinois. Irving Park is a two-way, three-lane freeway running east and west (Figure 3.3). There are two designated left turn lanes, and one designated right turn lane in each direction. Mannheim is a two-way, three-lane freeway running North and South. There are two designated left and right turn lanes in each direction. The area surrounding the intersection is mixture of short grass, and deciduous trees. O'Hare International Airport is located just west of the intersection.

Due to the complexity of the intersection, several simplifications were made to the model. Curvature in each approach was removed from the analysis, and traffic lanes approaching the intersection were modeled as straight lines. Each approach was modeled from the center of the intersection to where the approach began to significantly curve. The intersection geometry was setup in AutoCad using an aerial photograph and a pavement marking plan of the intersection provided by IDOT District 1. Volume link coordinates were then established from the AutoCad drawing. The intersection was modeled with CAL3QHC v 2.0 using 48 links, 36 free flow, and 12 queue links (Figure 3.3).

Wind speeds, wind directions, and ambient temperatures were acquired for Chicago O'Hare International Airport from the National Climatic Data Center. A free flow speed of 20 mph was used on the left and right turn links closest to the center of the intersection, while 45 mph was used on all other free flow links. This is consistent with the average speeds given with the IEPA monitoring data (IEPA, 1991).

Due to the low CO concentrations observed at the intersection, background concentration was modeled as zero. The measured concentrations were taken from an IEPA CO monitor positioned on the western edge of a trailer roof, located southeast of the intersection (the monitor was relocated in 1997 after the periods analyzed). The location of the receptor was estimated using the aerial photograph and IEPA documentation to be 31 feet from the edge of Mannheim road, 410 feet from the edge of Irving Park road, and 9.8 feet high. The CO data

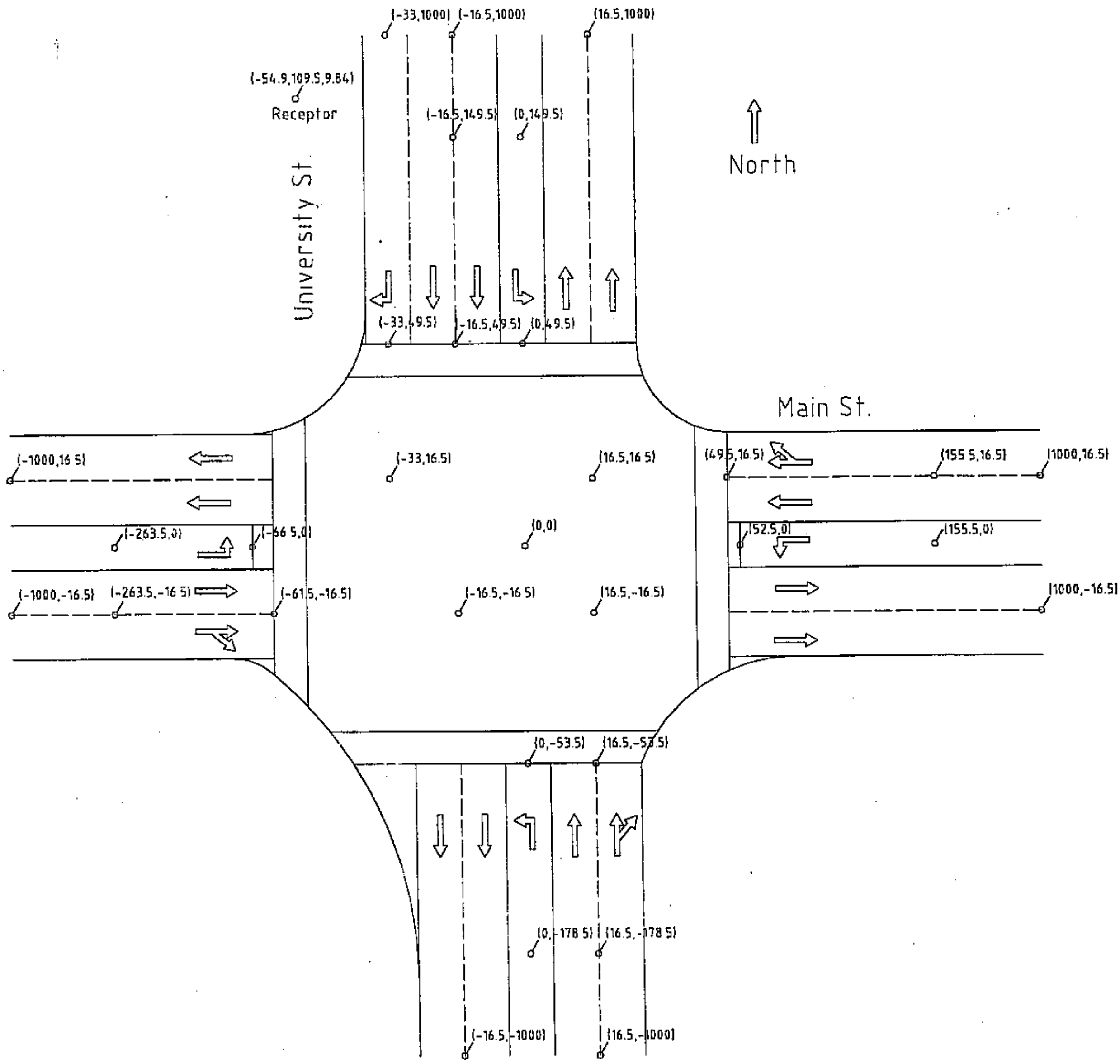

Figure 3.2 *CAL3QHC geometric configuration for University and Main.*

dates, times, and averaging periods correspond to the traffic data.

IDOT District 1 provided traffic data and signal timing for December 16 and 21, 1994, and December 7 and 8, 1995. Other CAL3QHC intersection and dispersion parameters that remained constant for each run were clearance lost time of 3 seconds, saturation flowrate of 1900 vph, arrival type of 3, surface roughness of 1 cm, and stability class of 4.

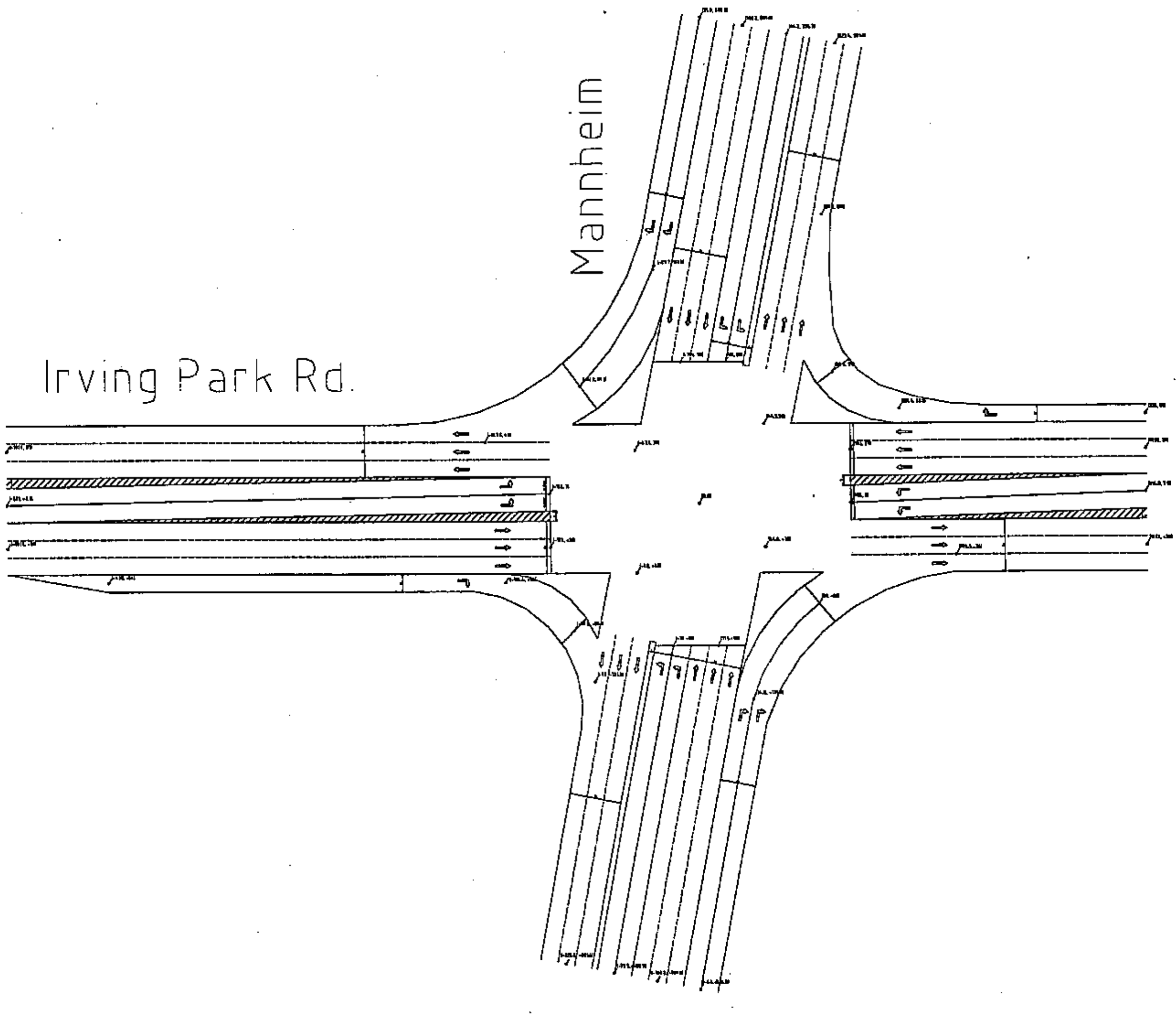

Figure 3.3 *CAL3QHC geometric configuration for Irving and Mannheim.*

3.4 Illinois Intersection Evaluation Results

CO concentrations at each intersection were calculated using CAL3QHC in three ways:

1. Concentrations were estimated using the wind speed and direction as reported at the closest airport. (Note: measured wind speeds less than 1 m/s were assumed to be 1 m/s. For variable or no reported wind direction, the 10 degree incremental wind search was used to find the angle for the maximum CO concentration.)

2. Concentrations were estimated using the airport wind speed but neglecting the wind direction. Instead, a 10 degree wind increment search was used to find the maximum concentrations and the angle at which they occurred.

3. A 10 degree wind increment search was used. However, the measured wind speed was replaced with a worst-case value of 1 m/s.

After completing each intersection analysis the data were analyzed for trends. As expected, for all intersections the lowest concentrations were modeled when the wind was blowing from behind the receptor toward the roadways. The data was further analyzed by looking at the residuals and percent error between the modeled and measured concentrations. This gave us information on how our three methods of estimating CO concentrations compared to the measured concentrations.

The first method (airport wind speed and direction) of modeling generally under-predicted concentrations. The main reason for these under-predictions lie in the wind angle and speed used. The wind angle and speed were single measurements made once each hour. Method 1 assumed that the wind angle and speed were constant over the hour averaging period. This is not a realistic assumption for most days. Even if the wind direction and speed were constant over the entire hour, the measurements from the airport may not have matched the actual wind conditions at the intersection. Method 2 combined the measured wind speed with an angle search.

The second method (airport wind speed plus angle search) both over-predicted and under-predicted. However, this method produced modeled values closest to the measured concentrations. Plots of the frequency of residuals for method 2 show that it generally produced modeled concentrations within 1 ppm from the measured concentrations (Figures 3.4 to 3.6). Method 2 still assumed the wind speed and direction remained constant over the entire averaging period. However, combining a constant wind speed with the most sensitive wind angle tended to produce modeled concentrations very close to the measured concentrations. Recognize, this does not mean that method 2 was truly representative of the actual conditions at the intersection, it simply shows that this modeling method tended to produce values closest to the measured ambient concentrations.

Predictions from the third method (1 m/s wind speed plus angle search) were always over the measured concentrations. This conservative method employed wind conditions normally used in CAL3QHC for a worst-case analysis. The actual wind speed at the measurement sites was rarely recorded as low as 1 m/s, thus leading to the over-estimations. These results lend confidence for using 1 m/s wind speed as a worst-case value for the Illinois screening model.

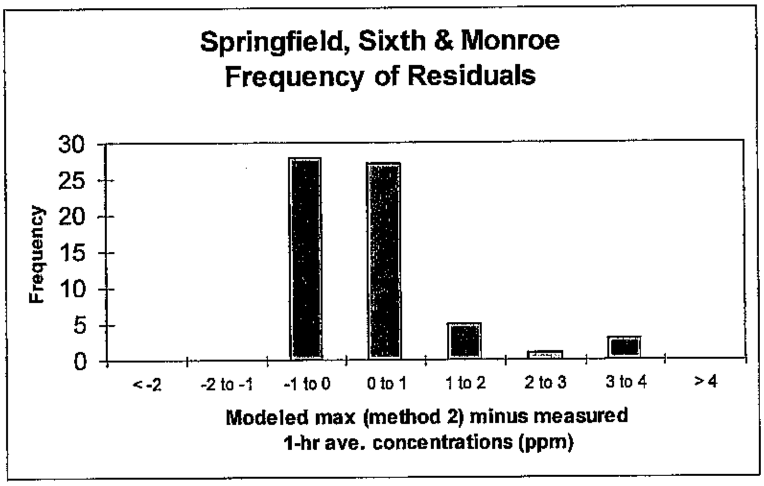

Figure 3.4 *Frequency of residuals for Sixth and Monroe.*

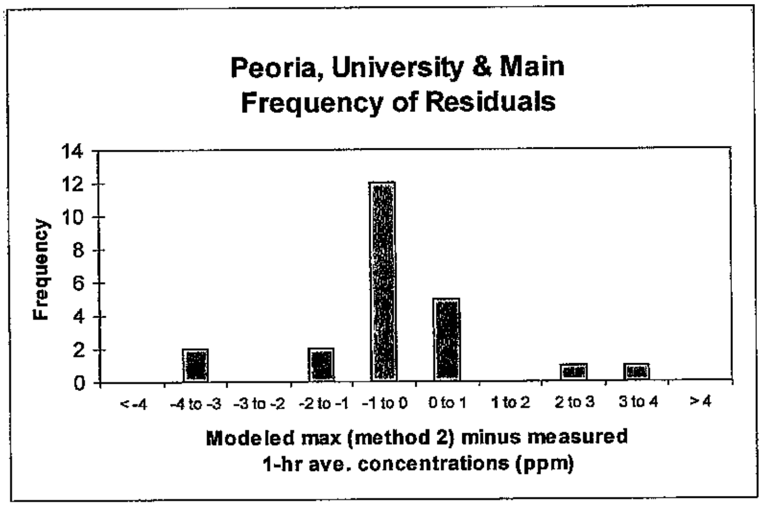

Figure 3.5 *Frequency of residuals for University and Main.*

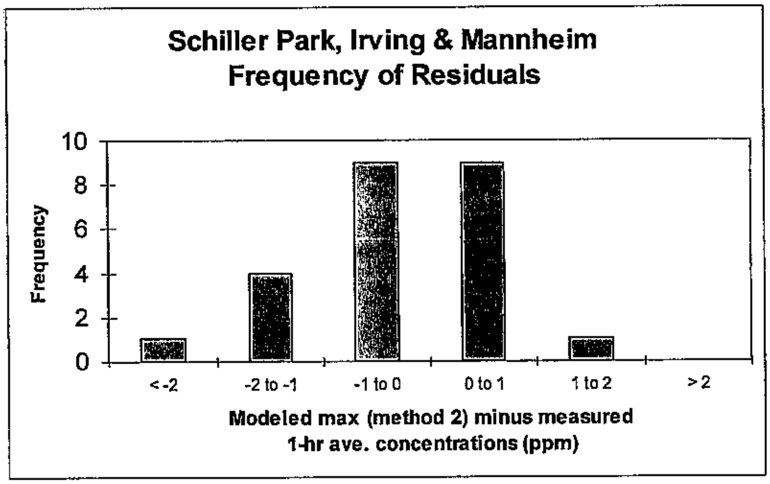

Figure 3.6 *Frequency of residuals for Irving and Mannheim.*

Table 3.1 summarizes the three methods presenting the average residuals (modeled minus measured concentrations) and average percent error (modeled minus measured, divided by measured, multiplied by one hundred percent) for each intersection. Negative values represent under-predictions by the model.

Table 3.1 *Summary of residuals and percent error between modeled and measured concentrations.*

Location	Modeling Method	Average Residual (ppm)	Average Percent Error (%)
Sixth & Monroe	1	-0.4	-50
	2	0.4	53
	3	2.4	310
University & Main	1	-1.5	-72
	2	-0.3	-2
	3	4.2	280
Irving & Mannheim	1	-1.2	-96
	2	-0.2	20
	3	4.1	529

Modeling Method

1. Airport wind speed and direction.
2. Airport wind speed plus angle search.
3. 1 m/s wind speed plus angle search.

Chapter 4: Illinois Carbon Monoxide Screen For Intersection Analysis

Illinois Carbon Monoxide Screen for Intersection Modeling (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 occur simultaneously produce the highest levels of CO. If the results from COSIM do not violate 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.

The model is Windows-based and will run on Windows 95, Windows 98, or Windows NT operating systems. The model was designed to estimate one-hour and eight-hour worst-case CO concentrations at signalized intersections typically found in Illinois. COSIM consists of several components typical of Windows based programs, including a program title bar, a main menu, a tool bar, and a main view area. Until the CO calculations are completed, a title screen appears in the main view area. After all user inputs are entered and calculations are performed, a final report is displayed in the main view area.

Although COSIM is based on USEPA models MOBILE5b and CAL3QHC, all the inputs normally required by these two models are not required to run COSIM. Instead, COSIM uses a combination of worst-case MOBILE5b and CAL3QHC input values based on the simplified intersection data entered by the user. COSIM user inputs are separated into three categories, general inputs, intersection inputs, and receptor inputs. Help buttons on each screen can be used to access information about the variables on that screen.

The general input section prompts the user for several variables that describe the intersection's general characteristics and aid in the documentation of the modeled intersection. These inputs include a brief project description, the user's name, the year of analysis (1999-2030), and background concentrations. A background concentration of 3.0 ppm is pre-entered, although the user can override this value. The general inputs also include the intersection location (IDOT district) and the intersection surroundings (e.g., city park or apartment buildings).

In the intersection inputs section, the user selects one of fourteen different intersections that most closely resembles the project intersection. The intersections are categorized into three different types; T-type, One-way streets, and Four-way intersections. Pictures of the intersections are provided to aid in making the choice. The user may also enter the street names and an angle defining the north direction of the project intersection. Intersection volumes, approach speeds, and signal timing for each direction are also entered in this section.

The last set of user inputs defines the receptor locations. The user designates receptor locations with three input variables: quadrant number and distances from two perpendicular roadways. The height of each receptor is automatically set to an average breathing height of six feet. The user may model between one and ten receptors at one time.

After the three input categories are completed, the worst-case CO concentrations are calculated and results are displayed in the main view area in the form of a four-page report. Page one summarizes the results of the model's calculations and indicates if CO levels at any of the sensitive receptors *may* violate NAAQS. Pages two and three of the output summarize the variables entered on the series of input screens. Page four allows the user to add comments to the output report.

For additional information regarding the use of COSIM as well as the COSIM output report, see the Illinois COSIM User's Manual included in Appendix G of this report.

4.1 COSIM Technical Documentation

COSIM contains 14 CAL3QHC input files, one for each intersection included in the model. One of these input files is called each time CO concentrations are calculated. COSIM reads the contents of the input file (labeled Int1-Int14), replaces certain parameters based on the COSIM inputs entered by the user, and creates a new input file for use in CAL3QHC (labeled tempint.in), which is linked to the COSIM model. See Appendix C for additional information on the 14 CAL3QHC input files.

The CAL3QHC input files used in COSIM contain three types of variables: preset variables that do not change from intersection to intersection, variables set with intersection type, and variables set based on COSIM inputs. The preset variables and their values are summarized in Table 4.1. Receptor height was fixed at an average breathing height of six feet per USEPA's guidance. A saturation flowrate of 1900 vph was used to represent typical roadway capacities in Illinois. A wind increment search of ten degrees was used per USEPA's guidance. The other preset variables in Table 4.1 are typically used for CO modeling and were preset to preserve consistency between model runs. The following CAL3QHC variables are dependent on the type of intersection selected by the user: current job title, current run title, number of links, link indicator, link description, link coordinates, mixing zone width, and number of travel lanes. Once an intersection is selected in COSIM, the intersection variables listed above will remain constant. The variables based on COSIM inputs are surface roughness factor, atmospheric stability class, number of receptors, X and Y receptor coordinates, total signal cycle length, red time cycle length, traffic volumes, idle EF, and free flow EFs. COSIM uses different methods to set these CAL3QHC variables from the user inputs. The various methods are discussed below.

Table 4.1 *CAL3QHC variables that are preset in COSIM.*

Variable Name	Value	Variable Name	Value
Averaging Time	60 min	Source Height	0 ft
Settling Velocity	0 cm/s	Clearance Lost Time	3 sec
Deposition Velocity	0 cm/s	Saturation Flowrate	1900 vph
Scale Conversion Factor	0.3048	Signal Type	1-pretimed
Metric to English	1	Arrival Rate	3-average
Debugging Option	1	Wind Direction	0
Receptor Name	Receptor	Mixing Height	1000 m
Receptor Height	6 ft	Background Concentration	0 ppm
Meteorological Conditions	1	Wind Direction Variation	Y
Output Type	1	Wind Increment Angle	10
Mode	C	Lower Angle Multiplier	0
Link Type	AG	Upper Angle Multiplier	35

4.1.1 *Surface Roughness and Stability Class*

The type of intersection surroundings that are selected in COSIM determines surface roughness and stability class used in CAL3QHC (Table 4.2). The surface roughness values are taken from the CAL3QHC users manual (USEPA, 1995). The exceptions to this are smooth, soy beans, and deciduous trees values, which are taken from the smooth desert, alfalfa, and citrus orchard values, respectively, in the CAL3QHC manual.

4.1.2 *Receptor Coordinates*

The number of receptors and their X and Y coordinates are determined by the COSIM values entered on the receptor input screen. In COSIM, the user defines receptor locations by specifying a quadrant number and the north/south and east/west distances from the roadway. After the user has entered these values, COSIM uses equations that are dependent on the intersection geometry to calculate the X and Y receptor coordinates needed in the CAL3QHC input file. The number of receptors is taken directly from the *number of receptors* input box in COSIM.

Table 4.2 *Atmospheric stability class and surface roughness values.*

Type of Surroundings	Stability Class	Surface Roughness (cm)
Smooth	5 (E)	0.03
Short Grass	5 (E)	0.75
Soy Beans	5 (E)	2.72
Prairie Grass	5 (E)	11.4
Corn	5 (E)	74
Single Family Residential	4 (D)	108
City Park	4 (D)	127
Offices	4 (D)	175
Deciduous Trees	5 (E)	198
Fir Forest	5 (E)	283
Central Business District	4 (D)	321
Apartments	4 (D)	370

4.1.3 *Signal Timing*

Total signal cycle length, red time cycle lengths, and traffic volumes are taken from the traffic volumes and signal timing COSIM screens and placed into the CAL3QHC input file.

4.1.4 *Emission Factors*

COSIM uses a three-dimensional lookup table to determine EFs. The first index represents the intersection location, the second is the year, and the third is the peak-hour approach speeds. The table was created using eight different MOBILE5b input files provided by the IEPA (Long, 1999). Four criteria were used for determining the MOBILE5b input files necessary to cover all areas in Illinois. They are 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 of the region – in attainment or non-attainment for ozone. (The entire state is attainment for CO).
3. Presence or absence of an I/M Program in the region.
4. The year for which the modeling needs to be performed - before year 2000 or after 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 in Illinois on a countywide basis. These files are 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.

The MOBILE5b 5b input files were created using a combination of worst-case values, Illinois State default values, and MOBILE5b default values, under guidance from IEPA (see Appendix D for MOBILE5b input files). A summary of the inputs used for building the MOBILE5b files are listed below in the order in which they appear in the files.

VMT Mix by Vehicle Type
This is used to calculate the all-vehicle EFs. It is required only in the Chicago and Metro East non-attainment regions. The data used are applicable for the years 1996 and later. VMFLAG is set to 3 (single VMT mix for all scenarios).

Chicago and Metro-East VMT Mix
0.614 0.184 0.079 0.018 0.008 0.002 0.085 0.010

For areas outside the Chicago and Metro-East areas, the MOBILE defaults for VMT Mix were used (with VMFLAG set to 1).

Registration Distribution Data
This gives the average annual mileage accumulation data based on the vehicle types. This is also applicable only to the non-attainment regions in the state (with MYMRFG set to 3).

Chicago Registration Distribution
.051 .075 .086 .077 .073 .069 .067 .071 .068 .068 LDGV '96
.063 .052 .042 .028 .018 .014 .015 .018 .009 .007 Chicago
.006 .005 .004 .004 .010
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065 LDGT1 '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017 Chic/M-E
.010 .007 .005 .004 .025
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065 LDGT2 '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017 Chic/M-E
.010 .007 .005 .004 .025 = LDGT1
.025 .050 .061 .050 .042 .038 .045 .056 .060 .062 HDGV '96
.055 .054 .045 .035 .027 .021 .023 .043 .039 .030 Chic/M-E
.026 .020 .018 .015 .060
.051 .075 .086 .077 .073 .069 .067 .071 .068 .068 LDDV '96
.063 .052 .042 .028 .018 .014 .015 .018 .009 .007 Chicago
.006 .005 .004 .004 .010 = LDGV
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065 LDDT '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017 Chic/M-E
.010 .007 .005 .004 .025 = LDGT1/2
.034 .067 .067 .067 .067 .073 .061 .040 .041 .051 HDGV = M5a
.053 .066 .055 .057 .045 .019 .023 .028 .024 .016 default
.011 .009 .007 .005 .016
.144 .168 .135 .109 .088 .070 .056 .045 .036 .029 MC=M5a
.023 .097 .000 .000 .000 .000 .000 .000 .000 .000 default
.000 .000 .000 .000 .000

Metro East Registration Distribution

.022 .050 .065 .059 .060 .059 .061 .059 .063 .065 LDGV '96
.061 .064 .061 .051 .034 .030 .027 .031 .024 .017 Metro-East
.010 .007 .005 .004 .011
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065 LDGT1 '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017 Chic/M-E
.010 .007 .005 .004 .025
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065 LDGT2 '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017 Chic/M-E
.010 .007 .005 .004 .025 = LDGT1

```
.025 .050 .061 .050 .042 .038 .045 .056 .060 .062  HDGV '96
.055 .054 .045 .035 .027 .021 .023 .043 .039 .030  Chic/M-E
.026 .020 .018 .015 .060
.022 .050 .065 .059 .060 .059 .061 .059 .063 .065  LDDV '96
.061 .064 .061 .051 .034 .030 .027 .031 .024 .017  Metro-East
.010 .007 .005 .004 .011                  = LDGV
.030 .055 .071 .078 .058 .056 .057 .056 .064 .065  LDDT '96
.054 .064 .051 .041 .034 .025 .018 .031 .024 .017  Chic/M-E
.010 .007 .005 .004 .025                  = LDGT1/2
.034 .067 .067 .067 .067 .073 .061 .040 .041 .051  HDGV = M5a
.053 .066 .055 .057 .045 .019 .023 .028 .024 .016  default
.011 .009 .007 .005 .016
.144 .168 .135 .109 .088 .070 .056 .045 .036 .029  MC=M5a
.023 .097 .000 .000 .000 .000 .000 .000 .000 .000  default
.000 .000 .000 .000 .000
```

Note that the Chicago and Metro-East registration distributions differ only in the values for LDGVs and LDDVs. For areas outside the Chicago and Metro-East areas (in the attainment regions of the state), the MOBILE defaults for Registration Distribution were used (with MYMRFG set to 1).

Inspection & Maintenance (I/M) Inputs (This section was written by Sam Long, IEPA)
I/M inputs are applicable only in areas where a vehicle inspection and maintenance program is in operation, such as the Chicago and Metro-East non-attainment areas (NAAs) of Illinois. The I/M programs in these two NAAs are the same.

In the following examples of Illinois I/M input to the MOBILE model, the input's IMFLAG must be set to 3 and the ATPFLG to 8. The first line of the I/M input represents the I/M program established for older (before model-year [MY]1981) vehicles. The second line represents the Enhanced I/M program, including the IM240 test method, for newer vehicles. The third line represents the anti-tampering program (ATP) that is part of the I/M test until 2001. There is no ATP after 2000, so the ATP line has been "zero'd out", i.e., nullified, so that no ATP credits are calculated after 2000. The fourth line represents the modified fuel system pressure test. Illinois gets partial credit from USEPA for a pressure test, as shown by the 50 at the end of this line. The fifth line represents the fuel system purge test. As there is no purge test in the Illinois program, this line too has been zero'd out.

Zeroing out the ATP and purge tests is accomplished by setting the four "vehicle types affected" inputs (the four numbers in the fourth group) to 1111, meaning that no LDGVs, LDGT1s, LDGT2s, or HDGVs are affected. Doing this disables that part of the MOBILE model that calculates ATP and purge credits. Setting the eight "ATP tests carried out" inputs at the end of the third line to all 1s (i.e., 11111111) accomplishes the same thing for the ATP program only. One can, of course, remove the ATP and Purge inputs completely, after making appropriate changes in the ATPFLG input, but Illinois EPA has often found it convenient to leave all five lines in and zero out those not needed.

For further information on interpretation of the I/M inputs, see the *Users Guide to MOBILE5 (Mobile Source Emission Factor Model)*, Chapter 2, available from USEPA's Office of Mobile Sources (www.epa.gov/OMSWWW). For further information on the Illinois I/M program, contact the Illinois EPA at (217) 524-4343.

Chicago and Metro-East I/M Inputs for 1999-2000

86 20 68 80 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
86 20 81 20 3. 3. 96. 1 2 2221 4211 1.20 20.0 2.50
86 68 20 2221 12 96.0 11111112
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0

Chicago and Metro-East I/M Inputs for 2001-2030

86 20 68 20 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
99 20 81 20 3. 3. 96. 1 2 2221 4211 .800 15.0 2.00
86 68 20 1111 12 96.0 11111111
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0

Temperature

For worst-case CO concentrations, winter temperatures (in January) are used. These temperatures are as listed below in Table 4.3.

Table 4.3 *Temperatures used in MOBILE5b files for Illinois.*

Ambient Temp. (°F)	Maximum Temp. (°F)	Minimum Temp. (°F)	Ambient Temp. (°F)
North of 40 degree N latitude	29	13	24
South of 40 degree N latitude	38	21	32

Fuel Volatility

Fuel Volatility class for all regions is taken as 'C.'
Winter RVP (Reid Vapor Pressure) is taken as follows (for both periods 1 and 2):
All attainment areas in the state: 13.5 psi (from 1991 onwards)
Chicago non-attainment area 13.5 psi (from 1995 onwards; with Reformulated Gasoline, RFG, type C, the model ignores this input)
Metro East non-attainment area 13.5 psi (from 1995 onwards; for ordinary gasoline)

Setting of Flags
Flags for the MOBILE5b files pertaining to the use of specific types of fuels in the different regions in Illinois are shown in Table 4.4.

Note: 1 = No; 2 = Yes

Table 4.4. *Fuel Flag Settings for Illinois.*

Region	Oxygenated Fuel Flag	Diesel Sales Fraction Flag	Reformulated Gasoline Flag
North-Attainment	2	1	1
South-Attainment	2	1	1
Chicago Non-Attainment (with I/M)	1	1	2
Chicago Non-Attainment (w/o I/M)	1	1	2
MetroEast Non-Attainment (with I/M)	2	1	1
MetroEast Non-Attainment (w/o I/M)	2	1	1

Note: when Oxygenated Fuel Flag = 2, an Oxfuel input line must be included in the input. This line is as follows: .000 .300 .000 .035 2 and follows the scenario record line.

Scenario Description Records
This record is repeated for the year and speed inputs in the MOBILE5b input files. The EFs are evaluated for a single (ambient) temperature based on the region under evaluation. The scenario description consists of several entries, including

- Region for which EFs are to be calculated: set to 1 (Low altitude region)
- Calendar Year of evaluation: Ranges from 1999 to 2030.
- Average speed(s) to be used in EF calculations: Ranges from 5 mph to 55 mph.
- Ambient temperature (°F): as given in Table 4.3.
- Operating mode fractions
- Percent of VMT accumulated by non-catalyst vehicles in cold-start mode (PCCN): 20.6
- Percent of VMT accumulated by catalyst-equipped vehicles in hot-start mode (PCHC): 27.3
- Percent of VMT accumulated by catalyst-equipped vehicles in cold-start mode (PCCC): 20.6
- Month of evaluation: 1 (January)

To identify the appropriate Illinois region, COSIM uses a Region Index, which ranges from 0 to 5, covering the six regions in Illinois.

0 = North attainment region
1 = Chicago area with Inspection Maintenance
2 = Chicago area without Inspection Maintenance
3 = South Attainment Region
4 = MetroEast area with Inspection Maintenance
5 = MetroEast area without Inspection Maintenance

The results from running all eight input files in MOBILE5b have been arranged in a series of six tables. When a user enters the county, COSIM assigns a number to the county selected. Based on the county number, at least one region index is assigned to the current project. The region index references a year index versus speed index EF table to calculate the idle and free flow EFs.

The year index ranges from 0 to 11, covering the years 1999 to 2010. Due to the small differences observed between EFs in 2010 and in those beyond 2010, and also due to the increased uncertainty in predicting EFs more than ten years from now, all EFs for years greater than 2010 are assumed equal to the 2010 EFs. (This approach was approved by Sam Long of IEPA).

The speed index ranges from 0 to 11, covering speeds from 0 mph 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 by comparing the exact EFs calculated by MOBILE5b to the EFs interpolated by COSIM (see Appendix E for the analysis details). This was done from 5 mph to 55 mph, from 1999 to 2010, and for six regions. The maximum percent error between EFs was approximately 9% and occurred at 7 mph for all areas and all years. To make sure this amount of error was acceptable, CAL3QHC was run to see how sensitive the CO concentration was to a 9% change in EF. CAL3QHC runs were made using the exact EF and the interpolated EF. All other CAL3QHC inputs remained fixed. The EF error caused a maximum CO concentration increase of approximately 4%. This small error resulted in an overall conservative CO (over) estimate of a maximum of 0.6 ppm. Therefore, the linear interpolation is considered to be acceptable within the 5 mph increments.

In counties where I/M and non I/M regions adjoin, it is likely that the average vehicle fleet in the county will be a mixture of those registered in I/M and non-I/M areas. To account for this EF overlap IEPA provided us with the fractions of counties covered by the I/M programs (Tables 4.5 and 4.6). If the project is located in one of the counties listed in Tables 12 or 13, EFs are taken from both regions (I/M and no I/M), weighted accordingly, and added together to determine an average EF (AEF). Equation (1) describes how COSIM calculates an AEF for a county partially covered by an I/M program.

$$(1) \qquad AEF = (IMfrac*[I/M\ EF] + [1 - IMfrac]*[no\text{-}I/M\ EF])$$

where:

IMfrac = fraction of VMT from I/M vehicles, given in the above tables
I/M EF = MOBILE emission factor assuming I/M and
no-I/M EF = MOBILE emission factor assuming no I/M.

Table 4.5 *Chicago Non-attainment Area.*

County	% of VMT from I/M Vehicles
Cook	98
DuPage	98
Grundy	25
Kane	60
Kendall	81
Lake	95
McHenry	50
Will	65

Table 4.6 *Metro-East Non-attainment Area.*

County	% of VMT from I/M Vehicles
Madison	90
Monroe	20
St Clair	90

After the idle and free-flow EFs are determined for the current project, COSIM inserts the EFs into the input file and runs CAL3QHC. CAL3QHC creates an output file called Final.out that contains the modeled concentrations. COSIM reads the highest CO concentrations modeled at each receptor and uses the values for creating the final report.

4.2 COSIM, the Program

IDOT has been given verbal approval from IEPA and FHWA to use COSIM for worst-case CO analysis on intersection projects as of August 1999. Copies of the Illinois COSIM program are available at IDOT, office of Design and Environment in Springfield. COSIM was programmed using Microsoft Visual C++ version 5.0. The source code is on file at IDOT.

Chapter 5: Case Study Tests Using Three Different Screening Tools

In this portion of the study, CO predictions from Illinois COSIM were compared to those from other available CO screening models and to those from detailed modeling (CAL3QHC/ MOBILE5b). For the comparison, Florida's screening model, COSCREEN98, and Colorado's model, Colorado CO Screening Model were used. General operating characteristics of both models are discussed in the literature review section of this report. Each model was tested under the hourly conditions measured for the previously discussed Illinois case study intersections: Sixth and Monroe, University and Main, and Irving and Mannheim.

It should be noted that COSCREEN 98 and the Colorado CO Screening Model are not designed to model Illinois conditions, so the comparisons must be made with this in mind. In the next sections the input variables for each model are described. The results of the model runs are discussed in a concluding section.

5.1 Sixth and Monroe

COSIM was the only model that matched the intersection configuration of Sixth and Monroe, where both streets are three lane, one-way streets. For COSCREEN98, the closest configuration was a four-way, 4 x 4 lane intersection with designated left turn lanes. For Colorado's model, the closest intersection geometry was a four-way, 6 x 6 lane intersection with dual designated left turn lanes. Input variables used in the three models are given in Tables 5.1 to 5.3. Resulting average residuals are presented in Table 5.12 and are discussed below. The volumes used for each hour and the maximum 1-hour average CO concentrations for each modeled hour are given in Table F1 in the Appendix. Background concentration has been removed from all reported 1-hour averages.

Table 5.1 *COSIM input variables for Sixth and Monroe.*

COSIM Input Variables	Value
Year	1999
County	Sangamon
Surroundings	Offices
Intersection Type	One-way, 3x3
Volumes	See vol table
Speed Leg B	20 mph
Speed Leg C	20 mph
Cycle Length	80 sec
Leg B red time	36 sec
Leg C red time	44 sec
Receptor Quad	2
Recp Dist from AB	10 feet
Recp Dist from CD	36 feet

Table 5.2 *COSCREEN98 input variables for Sixth and Monroe.*

COSCREEN98 Input Variables	Value
Year	1997 - 1999
Area	North Florida
Surroundings	Urban
Speed	20 mph
Recp X Dist	10 feet
Recp Y Dist	36 feet
Recp Height	6 feet

Table 5.3 *Colorado's screening model input variables for Sixth and Monroe.*

Colorado's Input Variables	Value
Year	1997 - 1999
Area	Denver
Intersection Type	3 Thru Lanes
Speed	20 mph
Recp X Dist	10 feet
Recp Y Dist	40 feet

5.1 University and Main

None of the screening models exactly matched the geometry at University and Main, where both streets are two lane, two-way streets with designated left turn lanes. For this intersection, all three models were set up for a 4 x 4 lane intersection with designated left turn lanes. However, no model could account for the designated right turn lane on University. Input variables used in the three models are given in Tables 5.4 to 5.6. The volumes used for each hour and the signal timing used in COSIM are given in Table 5.7. The maximum 1-hour average CO concentrations are given in Table F2 in the Appendix. Background concentration has been removed from all reported 1-hour averages.

5.3 Irving and Mannheim

This is an intersection of two freeways, each a two-way, three-lane highway, with designated left and right turn lanes. COSIM and Colorado's model were set up using a 6 x 6 lane intersection. COSIM had one designated left turn lane in each direction while Colorado's model used two. For COSCREEN98, the configuration was a four-way, 4 x 4 lane intersection with a single designated left turn lane in each direction. Input variables used in the three models are given in Tables 5.8 to 5.10. The volumes used for each hour and the signal timing used in COSIM are given in Table 5.11. The maximum 1-hour average CO concentrations are given in Table F3 in the Appendix. Background concentration has been removed from all reported 1-hour averages.

Table 5.4 *COSIM input variables for University and Main.*

COSIM Input Variables	Value
Year	1999
County	Peoria
Surroundings	Offices
Intersection Type	4x4 w/ 4 Lt turns
Volumes	See vol table
Speed Leg A	30 mph
Speed Leg B	26 mph
Speed Leg C	28 mph
Speed Leg D	25 mph
Signal Timing	See signal table
Receptor Quad	4
Recp Dist from AB	16 feet
Recp Dist from CD	81 feet

Table 5.5 *COSCREEN98 input variables for University and Main.*

COSCREEN98 Input Variables	Value
Year	1998 - 1999
Area	North Florida
Surroundings	Urban
Speed	25 mph
Recp X Dist	16 feet
Recp Y Dist	81 feet
Recp Height	6 feet

Table 5.6 *Colorado's screening model input variables for University and Main.*

Colorado's Input Variables	Value
Year	1998 -1999
Area	Denver
Intersection Type	2 Thru Lanes
Speed	25 mph
Recp X Dist	10 feet
Recp Y Dist	70 feet

Table 5.7 *Volume and COSIM signal timing inputs for University and Main.*

Date	Model Averaging Hour	COSIM Volumes A-B Thru (vph)	A-D Left (vph)	A-C Right (vph)	B-A Thru (vph)	B-C Left (vph)	B-D Right (vph)	C-D Thru (vph)	C-A Left (vph)	C-B Right (vph)	D-C Thru (vph)	D-B Left (vph)	D-A Right (vph)	COSIM Signal Timing Total Time (sec)	A Red (sec)	A Left Red (sec)	B Red (sec)	B Left Red (sec)	C Red (sec)	C Left Red (sec)	D Red (sec)	D Left Red (sec)	COSCREEN98 & Colorado Volumes (vph)
9/23/98	6	199	61	154	123	15	9	354	302	68	68	8	40	90	63	76.5	63	76.5	63	67.5	63	67.5	724
	7	479	143	424	279	56	20	514	440	95	198	29	78	90	63	76.5	63	76.5	63	67.5	63	67.5	1049
	8	421	172	476	243	55	14	495	409	59	195	26	80	90	63	76.5	63	76.5	63	67.5	63	67.5	1069
	9	329	155	395	208	67	25	391	344	48	276	28	119	80	56	68	56	68	56	60	56	60	879
	10	305	143	396	236	53	20	339	308	62	371	43	170	80	56	68	56	68	56	60	56	60	844
	11	265	171	315	332	71	34	435	389	34	392	38	241	100	75	85	75	85	70	70	70	70	858
9/22/98	12	277	199	395	364	87	51	501	435	64	240	40	217	100	75	85	75	85	70	70	70	70	1000
	13	289	178	406	341	69	44	440	423	53	325	48	80	100	75	85	75	85	70	70	70	70	916
	14	372	174	407	423	117	26	460	394	84	348	32	187	80	56	68	56	68	56	60	56	60	953
	15	343	161	468	483	147	32	467	404	73	390	44	196	100	75	85	75	85	70	70	70	70	972
	16	428	172	527	622	158	36	577	502	67	522	62	242	100	75	85	75	85	70	70	70	70	1146
	17	386	148	514	679	145	54	452	490	76	572	67	258	100	75	85	75	85	70	70	70	70	1048
3/17/99	6	162	60	187	100	18	4	373	282	58	61	4	38	90	63	76.5	63	76.5	63	67.5	63	67.5	713
	7	313	147	404	247	39	16	554	479	99	218	29	70	90	63	76.5	63	76.5	63	67.5	63	67.5	1132
	8	324	175	372	241	51	17	516	361	55	217	41	120	90	63	76.5	63	76.5	63	67.5	63	67.5	932
	9	235	151	332	200	50	24	433	302	46	274	33	146	80	56	68	56	68	56	60	56	60	781
	10	200	195	337	252	55	31	488	349	39	241	38	150	80	56	68	56	68	56	60	56	60	876
	11	247	183	363	306	78	37	392	341	45	304	30	203	100	75	85	75	85	70	70	70	70	793
3/16/99	12	301	216	406	384	83	37	498	405	53	344	52	257	100	75	85	75	85	70	70	70	70	956
	13	307	186	339	305	73	45	471	401	50	292	32	220	100	75	85	75	85	70	70	70	70	922
	14	300	169	424	368	80	32	471	392	60	339	46	210	80	56	68	56	68	56	60	56	60	923
	15	346	164	434	464	128	43	532	410	57	470	51	203	100	75	85	75	85	70	70	70	70	999
	16	367	170	557	526	144	32	507	476	64	498	43	238	100	75	85	75	85	70	70	70	70	1094
	17	303	155	476	477	135	30	486	521	54	430	36	201	100	75	85	75	85	70	70	70	70	1061

Table 5.8 *COSIM input variables for Irving and Mannheim.*

COSIM Input Variables	Value
Year	1999
County	Cook
Surroundings	Short Grass
Intersection Type	6x6 w/ 4 Lt turn
Volumes	See vol table
Speed - All Legs	45 mph
Signal Timing	See signal table
Receptor Quad	2
Recp Dist from AB	31 feet
Recp Dist from CD	410 feet

Table 5.9 *COSCREEN98 input variables for Irving and Mannheim.*

COSCREEN98 Input Variables	Value
Year	1994 - 1995
Area	North Florida
Surroundings	Urban
Speed	45 mph
Recp X Dist	31 feet
Recp Y Dist	410 feet
Recp Height	6 feet

Table 5.10 *Colorado's screening model input variables for Irving and Mannheim.*

Colorado's Input Variables	Value
Year	1994 -1995
Area	Denver
Intersection Type	3 Thru Lanes
Speed	45 mph
Recp X Dist	10 feet
Recp Y Dist	100 feet

Table 5.11 *Volume and COSIM signal timing inputs for Irving and Mannheim.*

		COSIM Volumes												COSIM Signal Timing									COSCREEN98
Date	Model Averaging Hour	A-B Thru (vph)	A-D Left (vph)	A-C Right (vph)	B-A Thru (vph)	B-C Left (vph)	B-D Right (vph)	C-D Thru (vph)	C-A Left (vph)	C-B Right (vph)	D-C Thru (vph)	D-B Left (vph)	D-A Right (vph)	Total Time (sec)	A Red (sec)	A Left Red (sec)	B Red (sec)	B Left Red (sec)	C Red (sec)	C Left Red (sec)	D Red (sec)	D Left Red (sec)	& Colorado Volumes (vph)
12/16/94	6	815	17	412	1123	228	591	1079	715	260	958	596	183	120	80	103	80	103	92	85	92	85	2054
	7	720	99	378	1014	137	543	794	774	180	849	496	119	120	80	103	80	103	92	85	92	85	1748
	8	1043	96	320	914	125	484	845	689	185	683	451	106	120	80	103	80	103	92	85	92	85	1719
	9	926	65	357	822	164	442	601	597	137	617	452	77	120	80	103	80	103	92	85	92	85	1428
	10	869	42	474	734	215	400	353	484	130	560	469	58	120	80	103	80	103	92	85	92	85	1385
	11	703	58	322	1092	168	453	269	312	145	2228	506	97	100	67	83	67	83	77	73	77	73	1713
12/21/94	12	754	34	455	1101	223	374	566	470	140	551	277	132	100	67	83	67	83	77	73	77	73	1698
	13	922	137	503	1390	264	439	656	414	158	593	337	151	100	67	83	67	83	77	73	77	73	2093
	14	1034	154	497	1339	231	509	956	523	225	562	337	98	125	82	108	82	108	91	94	91	94	2079
	15	1181	217	519	1392	176	572	1125	721	264	578	423	77	125	82	108	82	108	91	94	91	94	2140
	16	1143	74	652	1295	153	488	1118	688	228	594	372	84	125	82	108	82	108	91	94	91	94	2034
	17	1206	82	706	1410	167	536	1197	742	268	687	309	130	125	82	108	82	108	91	94	91	94	2207
12/8/95	6	1112	67	281	605	162	683	856	782	301	741	923	80	120	80	103	80	103	92	85	92	85	1939
	7	1252	300	402	1035	174	237	857	774	247	896	950	104	120	80	103	80	103	92	85	92	85	1954
	8	1167	175	353	1014	177	764	658	593	200	830	746	108	120	80	103	80	103	92	85	92	85	1955
	9	599	66	245	950	172	588	580	498	219	369	413	105	120	80	103	80	103	92	85	92	85	1710
	10	591	145	241	891	167	581	471	455	222	587	447	167	120	80	103	80	103	92	85	92	65	1639
	11	749	104	318	826	157	490	423	394	165	484	422	177	100	67	83	67	83	77	73	77	73	1473
12/7/95	12	882	80	385	793	142	472	381	318	130	399	363	163	100	67	83	67	83	77	73	77	73	1407
	13	682	95	441	718	124	424	404	341	161	515	483	204	100	67	83	67	83	77	73	77	73	1266
	14	792	113	417	810	122	543	542	442	197	672	405	163	125	82	108	82	108	91	94	91	94	1475
	15	1591	147	458	901	113	696	819	558	227	573	513	152	125	82	108	82	108	91	94	91	94	2196
	16	1747	149	357	1256	130	833	1136	713	253	536	574	141	125	82	108	82	108	91	94	91	94	2253
	17	1325	118	518	1238	213	820	1084	533	214	722	502	173	125	82	108	82	108	91	94	91	94	2271

5.4 Results of Screening Model Tests

The concentrations modeled by each screening tool were compared to the highest concentrations modeled by the detailed CAL3QHC analysis. The average results are presented in Table 5.12. (A complete listing of the results is in appendix F.) As is to be expected, the CO concentrations calculated by each screening model were almost always greater than the values calculated by the detailed analysis.

Obvious differences in the model input variables for the three case study intersections, such as differences in intersection geometry, vehicle EFs, traffic volumes, and signal timing, do not completely explain why the modeled concentrations from each screening tool differ from the detailed analysis. To gain a better understanding of how the screening models analyze the Illinois case study intersections, the actual input files created for CAL3QHC must be considered.

One internal difference in the CAL3QHC input files is the saturation flowrate used by the models. COSIM and COSCREEN98 use 1900 vphpl (vehicles/hour/lane) while Colorado uses 1500 vphpl. The saturation flowrate is proportional to the capacity vairable used in the queuing algorithm. With all other variables remaining the same, a lower saturation flowrate will produce a lower capacity for the queue link. With high traffic volumes, a lower capacity link will become over-saturated at a lower volume, producing larger queue lengths and thus slightly increasing the CO concentrations calculated in Colorado's model.

Another difference in the CAL3QHC input files is the surface roughness and stability class values used in the model. For Sixth and Monroe and University and Main, COSIM and Colorado both use a surface roughness height of 175 cm, while COSCREEN98 uses a height of 321 cm. Based on the surface roughness differences alone, concentrations predicted by COSCREEN98 will be lower than the other two models. For Irving and Mannheim, COSIM, Colorado, and COSCREEN98 use surface roughness values of 0.75 cm, 175 cm, and 321 cm respectively. COSIM also uses a stability class of 5 (E) while Colorado, and COSCREEN98 use 4 (D). The combination of small surface roughness and high stability class causes concentrations predicted by COSIM to be several ppm greater than Colorado and COSCREEN98.

When reviewing the results of this analysis, note that the purpose of this comparison was not to determine which is the best screening model, as COSIM is the only model specifically designed for Illinois conditions. The comparison was done to simply compare and contrast the models using actual intersections. The results of this analysis do show that CO concentrations calculated using COSIM are truly worst-case concentrations. In all model runs, COSIM calculated CO concentrations that were slightly higher than concentrations calculated by the detailed analysis, and much higher than the actual measured concentrations. This establishes confidence in COSIM's ability to be used as a CO screening model for intersection projects in Illinois.

Table 5.12 *The average difference in CO concentrations between the screening models and the highest CAL3QHC detailed analysis concentrations.*

	Average Difference in Modeled Concentration Between COSIM and CAL3QHC (ppm)	Average Difference in Modeled Concentration Between COSCREEN98 and CAL3QHC (ppm)	Average Difference in Modeled Concentration Between Colorado's Model and CAL3QHC (ppm)
Sixth and Monroe	3.2	4.3	7.4
University and Main	2.9	0.2	2.4
Irving and Mannheim	4.6	2.2	13.0

Chapter 6: Conclusions

The main objective of this project was to develop a CO screening model for intersection analysis in Illinois for use by the Illinois Department of Transportation. Development of the model was divided into several smaller tasks. First a comprehensive literature review was conducted on CO air quality issues as related to modeling CO concentrations. Journal publications, regulatory documentation, and reports were the main sources for the literature survey. The next task was to write and distribute a questionnaire to the Departments of Transportation in all 50 States, Puerto Rico, and Washington DC. The purpose of the survey was to document the practices of other states in modeling CO and other pollutants for roadway projects. The survey also asked for suggestions to make a new screening tool as useful as possible.

In another part of the project, researchers conducted an evaluation of CO levels predicted by computer modeling using CAL3QHC on Illinois intersections. Three different sites located in Illinois were evaluated using MOBILE5b and CAL3QHC. The first site was located in Schiller Park, Cook County, the second in downtown Springfield, Sangamon County, and the third in Peoria, Peoria County. After completing each intersection analysis the data was analyzed by calculating the residuals and percent error between the modeled and measured concentrations. This gave information on how three different methods of estimating CO concentrations compared to the measured concentrations. The first method (using airport wind speed and direction) of modeling generally under-predicted concentrations. The second method (using airport wind speed plus angle search) both over-predicted and under-predicted. However, it produced modeled values closest to the measured concentrations. Plots of the frequency of residuals for method 2 showed modeled concentrations generally within ±1 ppm from the measured concentrations. The third method (using 1 m/s wind speed plus angle search) always over-predicted concentrations.

Finally, the researchers have created a computer model called "Illinois COSIM," CO Screen for Intersection Modeling, for use in Illinois. The model was designed to estimate one-hour and eight-hour worst-case CO concentrations at the signalized intersections typically found in Illinois. The model allows 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. Two training sessions introduced IDOT personnel to COSIM. The first session was August 23, 1999, the second was August 30, 1999. COSIM and the user's manual have been distributed to IDOT personnel in each district for use in project-level CO air quality analysis. Throughout the duration of the project, periodic meetings with project committee members were held at the IDOT Springfield office to discuss project-related issues. Additional conference calls and meetings with other regulatory personnel were held as needed throughout the project.

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Appendix A: Questionnaire Sent To The DOTs In All 50 States

Survey on Screening Programs for Roadway Air Quality

By March 1, return the completed survey, using the enclosed stamped and addressed envelope to:

Susan Larson
University of Illinois, Department of Civil and Environmental Engineering
3230 Newmark Laboratory, MC-250
205 N. Mathews Avenue
Urbana, IL 61801 (Surveys can also be returned by fax to 217-333-6968)

1. What state do you represent? ______________________
2. What types of air pollution screening tools are currently in use at your facility? Check answer(s).

   ___ Computer ___ Manual (e.g., graphical, hand calculations)
   ___ None (if none, please skip to question 6.)

3. What pollutants are **screened**? Check appropriate answer(s).

   ___ CO ___ PM-10 ___ PM2.5 ___ NOx
   ___ Hydrocarbons Other: ______________

4. Please provide the names or a brief description of the **screening** programs or the approaches used:

Screening model name or brief approach description	Pollutant(s)
______________________	__________
______________________	
______________________	__________
______________________	
______________________	__________

5. What criteria must be fulfilled before **screening** tools are applied? (E.g., "average daily traffic above a certain threshold (please specify) for CO", or "within a non-attainment area for CO", or "screening applied to all projects".)

Level	Pollutant(s)
______________________	__________
______________________	
______________________	__________
______________________	
______________________	__________

6. What **refined** modeling tools are currently acceptable for use in your state? Check all that apply.

_____ MOBILE 5a	_____ Highway Capacity Model	_____ TRAF-NETSIM
_____ MOBILE 5b	_____ HIWAY	_____ EMFAC7F
_____ CALINE 4	_____ TEXIN	_____ Other (__________
_____ CAL3QHC	_____ PAL	__________)

7. What criteria must be fulfilled before refined modeling tools are applied in your state? (E.g., "average daily traffic above a certain threshold (please specify) for CO", or "within a non-attainment area for CO")

Level	Pollutant
______________________________	__________
______________________________	
______________________________	__________
______________________________	
______________________________	__________
______________________________	
______________________________	__________
______________________________	

8. What would be the most important features to be incorporated into a new computerized screening tool for CO concentrations? (Check all that apply.)

_____ Choice of intersection type	_____ Other (____________________
_____ Choice of intersection angle	____________________
_____ Directionally dependent traffic volumes	____________________
_____ Directionally dependent traffic speeds	____________________
_____ Graphical output	____________________
Table output	____________________)

Appendix B: CAL3QHC Case Studies Of Illinois Intersections

Appendix B: CAL3QHC Case Studies Of Illinois Intersections

B.1 Sixth and Monroe

The intersection of Sixth Street and Monroe Avenue is located in downtown Springfield, Illinois. Both streets are three lane, one-way streets with parking on both sides. Sixth street carries north bound traffic, while Monroe carries east bound traffic. Most of the surrounding buildings are two to four stories high.

B.1.1 Setup

The intersection was modeled with CAL3QHC v 2.0 using 14 links, 10 free flow, and 4 queue links. Table B1 shows the start and stop coordinates for each link. Figure B1 gives a graphical interpretation of the intersection. Table B2 lists the base conditions used in each CAL3QHC input file.

Table B1 *CAL3QHC link coordinates for Sixth and Monroe.*

	Coordinates in feet				Mix Zone
Link Name	X1	Y1	X2	Y2	Width (ft)
NB 6th St App 1	0	-105.7	0	-1000	56
NB 6th St App 2	0	-105.7	0	0	56
NB 6th St Depart	0	0	0	1000	56
NB 6th St Rt App	23	-11	23	-105.7	14
NB 6th St Rt Dep	23	-11	1000	-11	31
NB 6th St Queue	0	-44	0	-1000	36
NB 6th St Rt Queue	23	-44	23	-105.7	10
EB Monroe App 1	-111	0	-1000	0	53
EB Monroe App 2	-111	0	0	0	53
EB Monroe Dep	0	0	1000	0	53
EB Monroe Lt App	-12	20.3	-111	20.3	14
EB Monroe Lt Dep	-12	20.3	-12	1000	32
EB Monroe Queue	-46.5	0	1000	0	33
EB Monroe Lt Queue	-46.5	20.3	-111	20.3	7.5

Table B2 *CAL3QHC v 2.0 base conditions for each input file.*

Cycle Length (s)	80
Sixth St. Red Time (s)	36
Monroe Ave. Red Time (s)	44
Clearance Lost Time (s)	4
Saturation Flowrate (vphpl)	1900
Signal Type	1 (pretimed)
Arrival Rate	3 (average)
Atmospheric Stability Class	D (4)
Averaging Time (min)	60
Surface Roughness (cm)	175
Settling Velocity (cm/s)	0
Deposition Velocity (cm/s)	0
Source Height (ft)	0
Mixing Height (m)	1000
Background Conc. (ppm)	0

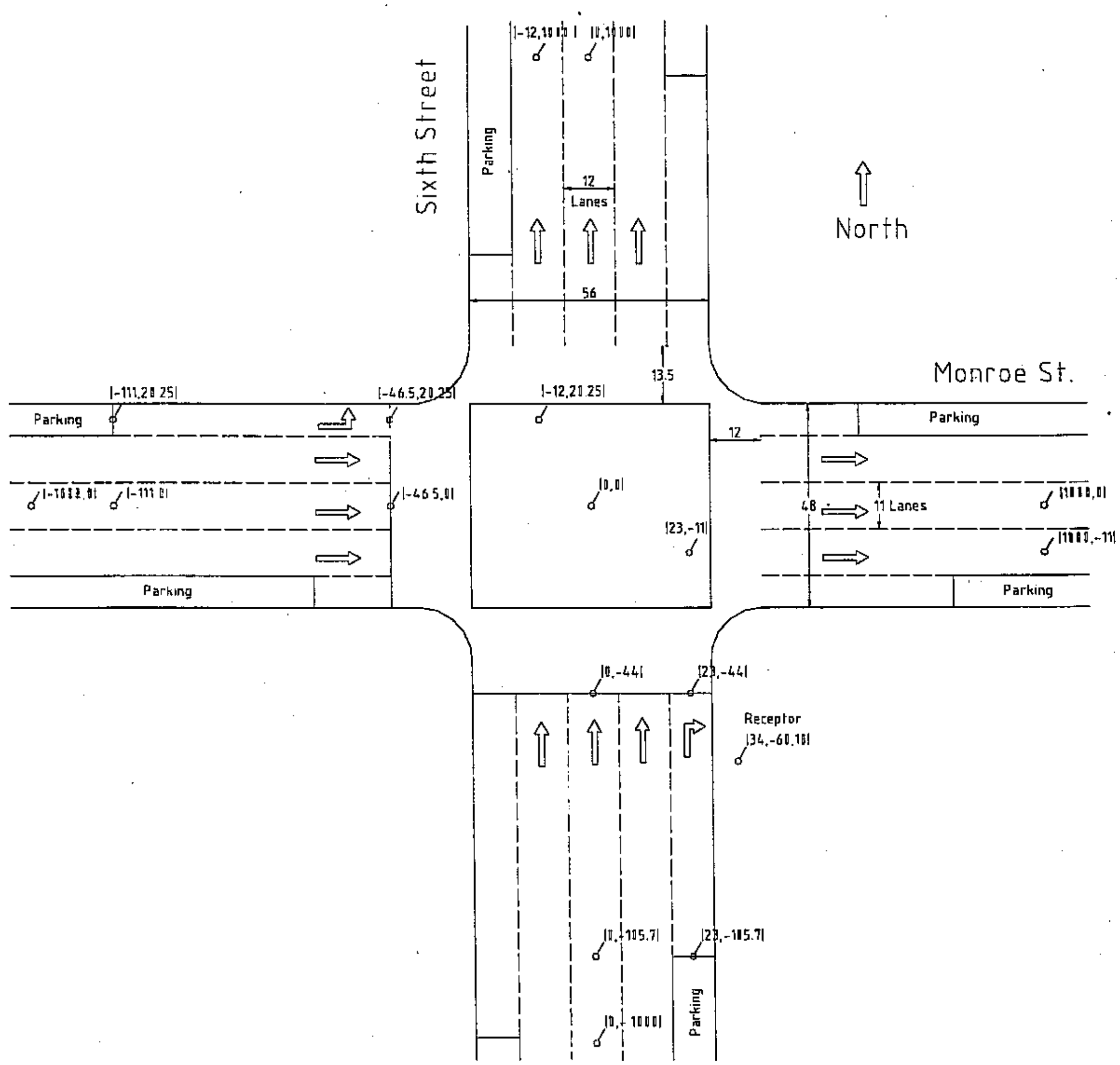

Figure B1. *CAL3QHC intersection geometry for Sixth and Monroe.*

B.1.2 Meteorology

Wind speeds, wind directions, and ambient temperatures were acquired for the Springfield airport, from the National Climatic Data Center at www.ncdc.gov. The data are summarized in Table B3.

B.1.3 Signal Timing

The signal timing at Sixth and Monroe was provided by IDOT District 6. Signal timing is given in Table B2.

B.1.4 Emission Factors

Approach speeds used were 25 mph for through and departing links and 15 mph for right and left turn links. These speeds were representative of values measured at the traffic counts. Temperature data, maximum and minimum daily temperatures and hourly temperatures, used for the emission factor calculation were taken at Springfield airport, see Table B3. VMT mix was taken from 1996 IDOT data for Urban Local Streets. The fleet mix is as follows: LDGV 0.663, LDGT1 0.199, LDGT2 0.080, HDGV 0.016, LDDV 0.008, LDDT 0.002, HDDV 0.068, and MC 0.010. Fuel RVP values were set at 9.0 psi. The EFs are summarized in Table B3.

B.1.5 Receptor

Due to the low CO concentrations observed at the intersection, background concentration was assumed to be zero. The measured concentrations were from the IEPA CO monitor located in the southeast corner of the intersection. The CO data dates, times, and averaging periods corresponded to the traffic data dates, times, and averaging periods.

B.1.6 Traffic

Traffic data were obtained from IDOT District 6 for July 7, 1997, August 24-26, 1998, and May 24-26, 1999. To further condense the traffic data, we only looked at periods of high flow (6 am to 7 pm). The volumes are summarized in Table B4.

B.1.7 Results

The results of the Sixth and Monroe intersection study are presented in Table B5. The first two columns contain the date and averaging hour being modeled. The Measured Conc. column gives the concentrations measured at the IEPA monitor. The Modeled Conc. column gives the modeled concentration using the wind speed and direction as reported at the Springfield airport. (Note: measured wind speeds less than 1 m/s were assumed to be 1 m/s. If the direction of wind was reported as variable or no wind direction was reported the 10 degree incremental wind search was used.) The maximum and minimum concentration columns report the maximum and minimum modeled concentration using the airport wind speed but neglecting the wind direction. A 10 degree increment search was used to determine the directions at which the maximum and minimum concentrations occurred. The "Max Conc Wind speed of 1 m/s" column gives the maximum modeled concentration assuming the worst-case wind speed of 1 m/s and using a 10 degree increment wind direction search.

Table B3. *Meteorological and emission factor data for Sixth and Monroe.*

Date	Time of Measurement	Model Averaging Hour	Temp (F)	Wind Direction (degrees)	Wind Speed (m/s)	Idle EF (gm/hr)	15 mph EF (gm/mile)	25 mph EF (gm/mile)
7/7/97	7:54	8	72	80	2.1	305.61	26.6	17.6
	8:54	9	76	50	2.6	296.40	25.8	17.0
	9:54	10	78	40	1.5	302.47	26.3	17.4
	10:54	11	80	110	2.1	308.58	26.8	17.7
	11:54	12	82	Var.	3.1	314.74	27.3	18.1
	12:54	13	82	-	0.0	314.74	27.3	18.1
	13:54	14	83	-	0.0	317.84	27.6	18.2
	14:54	15	84	250	3.1	320.95	27.9	18.4
	15:54	16	86	260	3.1	327.29	28.4	18.7
	16:54	17	84	-	0.0	320.95	27.9	18.4
	17:54	18	83	-	0.0	317.84	27.6	18.2
8/24/98	10:54	11	89	230	4.1	313.35	28.0	18.5
	11:54	12	88	230	4.6	310.51	27.8	18.4
	12:54	13	91	250	4.6	319.06	28.5	18.8
	13:54	14	91	230	4.1	319.06	28.5	18.8
	14:54	15	92	220	4.6	321.94	28.7	19.0
	15:54	16	92	230	3.6	321.94	28.7	19.0
	16:54	17	91	220	2.6	319.06	28.5	18.8
	17:54	18	88	210	3.6	310.51	27.8	18.4
8/25/98	5:54	6	73	200	2.1	282.11	25.4	16.8
	6:54	7	77	220	3.1	279.88	25.2	16.6
	7:54	8	80	260	3.6	288.20	25.9	17.1
	8:54	9	82	310	3.6	293.74	26.4	17.4
	9:54	10	82	350	4.6	293.74	26.4	17.4
	10:54	11	84	350	4.6	299.27	26.9	17.7
	11:54	12	84	360	3.6	299.27	26.9	17.7
	12:54	13	85	360	4.1	302.05	27.1	17.9
	13:54	14	86	350	5.1	304.86	27.3	18.0
	14:54	15	85	360	4.6	302.05	27.1	17.9
	15:54	16	84	350	3.1	299.27	26.9	17.7
	16:54	17	82	360	2.6	293.74	26.4	17.4
	17:54	18	80	350	2.1	288.20	25.9	17.1
8/26/98	5:54	6	63	30	2.1	319.91	28.9	19.1
	6:54	7	67	-	0.0	304.46	27.4	18.2
	7:54	8	73	90	1.5	282.11	25.4	16.8
	8:54	9	77	-	0.0	279.88	25.2	16.6
	9:54	10	80	70	2.1	288.20	25.9	17.1
5/24/99	11:54	12	67	320	8.2	285.46	26.8	17.7
	12:54	13	68	310	8.2	281.93	26.5	17.5
	13:54	14	69	290	10.3	278.42	26.1	17.3
	14:54	15	69	280	8.7	278.42	26.1	17.3
	15:54	16	68	280	8.7	281.93	26.5	17.5
	16:54	17	69	300	5.7	278.42	26.1	17.3
	17:54	18	67	310	8.2	285.46	26.8	17.7
	18:54	19	64	300	5.7	296.22	27.8	18.4
5/25/99	5:54	6	54	240	3.1	333.90	31.4	20.8
	6:54	7	58	250	3.6	318.48	29.9	19.8
	7:54	8	61	280	4.1	307.23	28.9	19.1
	8:54	9	65	290	6.7	292.61	27.5	18.2
	9:54	10	68	300	6.2	281.93	26.5	17.5
	10:54	11	69	320	6.7	278.42	26.1	17.3
	11:54	12	71	300	6.7	271.48	25.5	16.8
	12:54	13	70	300	6.2	274.93	25.8	17.1
	13:54	14	73	280	8.2	264.63	24.8	16.4
	14:54	15	72	300	7.2	268.04	25.1	16.6
	15:54	16	72	270	7.2	268.04	25.1	16.6
	16:54	17	72	290	6.7	268.04	25.1	16.6
	17:54	18	70	280	4.6	274.93	25.8	17.1
	18:54	19	67	300	4.6	285.46	26.8	17.7
5/26/99	5:54	6	53	360	1.5	337.83	31.8	21.0
	6:54	7	57	60	3.1	322.29	30.3	20.0
	7:54	8	59	60	2.1	314.70	29.6	19.6
	8:54	9	60	50	3.6	310.95	29.2	19.3
	9:54	10	60	360	2.6	310.95	29.2	19.3
	10:54	11	59	290	3.6	314.70	29.6	19.6

Table B4 *Hourly traffic volumes at Sixth and Monroe.*

Date	Model Averaging Hour	NB App 1 (vph)	NB App 2 NB Queue NB Dep (vph)	NB Rt App NB RT Dep NB Rt Queue (vph)	EB App 1 (vph)	EB App 2 EB Queue EB Dep (vph)	EB Lt App EB Lt Dep EB Lt Queue (vph)
7/7/97	8	1022	964	58	384	260	124
	9	1115	984	131	566	395	171
	10	774	670	104	373	261	112
	11	854	732	122	417	269	148
	12	904	749	155	487	340	147
	13	1121	952	169	643	429	214
	14	1082	939	143	611	420	191
	15	971	846	125	497	363	134
	16	900	783	117	446	328	118
	17	1032	896	136	560	422	138
	18	946	869	77	505	387	118
8/24/98	11	941	819	122	409	291	119
	12	1137	1005	132	471	344	128
	13	1082	960	122	518	385	133
	14	936	812	124	398	305	93
	15	855	750	105	365	280	86
	16	965	833	132	481	370	112
	17	828	746	82	413	320	94
	18	515	456	59	185	132	54
8/25/98	6	532	488	44	618	340	278
	7	1166	1083	83	801	499	303
	8	1218	1060	158	548	377	171
	9	828	709	119	358	313	45
	10	795	678	117	351	259	93
	11	935	800	135	390	281	109
	12	1121	992	129	613	447	167
	13	1135	963	172	478	361	117
	14	931	792	139	384	317	67
	15	886	766	120	456	323	133
	16	977	879	98	616	434	182
	17	867	792	75	467	365	103
	18	538	480	58	1429	774	656
8/26/98	6	547	492	55	419	247	173
	7	1215	1113	102	406	298	108
	8	1230	1076	154	501	381	121
	9	734	639	95	341	275	67
	10	791	664	127	313	239	75
5/24/99	12	1024	945	79	540	421	120
	13	984	917	67	402	326	77
	14	944	872	72	372	297	76
	15	903	812	91	418	341	77
	16	1094	1031	63	546	452	94
	17	730	687	43	328	274	54
	18	430	398	32	172	146	27
	19	367	344	23	115	94	21
5/25/99	6	612	585	27	106	85	22
	7	1270	1205	65	318	266	53
	8	994	929	65	398	305	93
	9	795	731	64	302	266	37
	10	722	650	72	299	244	55
	11	933	873	60	485	390	96
	12	1063	986	77	441	358	84
	13	967	861	106	400	329	71
	14	916	843	73	340	276	64
	15	847	774	73	363	293	70
	16	952	897	55	554	449	106
	17	720	672	48	298	248	50
	18	528	474	54	220	177	43
	19	362	312	50	165	134	32
5/26/99	6	483	447	36	117	91	27
	7	1196	1131	65	320	271	49
	8	884	801	83	345	301	44
	9	633	567	66	228	190	39
	10	742	684	58	297	231	67
	11	853	795	58	512	405	108

Table B5 *Results from Sixth and Monroe.*

Date	Model Averaging Hour	Measured Conc. (ppm)	Modeled Conc. (ppm)	Maximum Conc. (ppm)	Angle of Wind (deg off N.)	Minimum Conc. (ppm)	Angle of Wind (deg off N.)	Max Conc Wind speed 1 m/s (ppm)	Angle of Wind (deg off N.)
7/7/97	8	1.0	0.1	1.5	270-280	0	90-160	2.9	240,270
	9	1.2	0.1	1.5	270	0	90-160	3.7	260,270
	10	0.8	0.1	2.3	270	0	100-160	3.4	270
	11	0.9	0.0	1.7	260-280	0	90-160	3.6	270,280
	12	0.9	-	1.3	280	0	90-160	3.8	260,270
	13	0.7	-	4.0	240,270,280	0	100-150	4.0	240,270,280
	14	0.7	-	4.0	270-280	0	100-150	4.0	270,280,270
	15	0.8	1.2	1.3	280	0	90-160	4.0	270
	16	0.7	1.3	1.3	260,280	0	90-160	3.9	270
	17	0.5	-	4.1	280	0	100-150	4.1	280
	18	0.5	-	3.4	270,280	0	100-150	3.4	270,280
8/24/98	11	0.7	0.7	0.9	250-270	0	20-160	3.8	270
	12	0.8	0.8	0.9	250-260	0	20-160	3.9	270
	13	0.8	0.9	0.9	250-280	0	20-60,80-160	4.0	270
	14	0.7	0.7	0.9	250-280	0	20-160	4.0	270
	15	0.9	0.5	0.9	270	0	20-40,90-160	3.7	270-280
	16	0.7	0.9	1.2	280	0	90-160	4.0	260-270
	17	0.7	0.7	1.3	270-280	0	90-160	3.5	270
	18	0.7	0.1	0.8	280-290	0	10-160	2.6	280
8/25/98	6	1.0	0.1	1.3	290	0	90-160	2.5	280
	7	1.0	0.9	1.1	280-290	0	100-160	3.5	280-290
	8	0.8	1.0	1.1	230	0	20-50,90-160	3.8	240
	9	0.7	0.6	1.0	260, 280	0	20-160	3.5	270
	10	0.9	0.1	0.8	260-270	0	10-160	3.5	270
	11	0.8	0.1	0.8	250-270	0	20-160	3.5	260-270
	12	0.8	0.2	1.1	270-280	0	20, 90-160	3.8	270-280
	13	0.8	0.1	0.9	220-280	0	20-60,80-160	3.9	240
	14	0.9	0.1	0.8	250-270	0	10-160	3.8	270
	15	0.8	0.1	0.8	260-280	0	20-160	3.6	270
	16	0.8	0.3	1.2	270-290	0	90-160	3.8	280
	17	0.6	0.3	1.3	280	0	90-160	3.1	280
	18	0.7	0.5	1.9	290	0	100-160	3.8	290
8/26/98	6	1.4	0.1	1.4	280-290	0	20, 90-160	2.8	290
	7	1.7	-	3.6	270-280	0	100-150	3.6	270,280
	8	0.9	0.1	2.6	230-240	0	100-150	3.7	230,240
	9	1.1	-	3.1	270	0	100-150	3.1	270
	10	1.0	0.1	1.6	260-280	0	20-50,90-160	3.4	270
5/24/99	12	0.7	0.1	0.4	290-310	0	10-170	3.2	270-290
	13	0.7	0.4	0.4	290,310	0	10-170	2.9	290
	14	?	0.2	0.3	300	0	10-170,330-340	2.9	270
	15	0.8	0.3	0.4	270,290	0	10-170	3.2	270
	16	0.6	0.2	0.4	290-310	0	10-170	3.1	280
	17	0.4	0.5	0.5	300	0	10-170	2.5	270
	18	0.4	0.1	0.2	260-290	0	0-230,320-360	2.1	280
	19	0.5	0.2	0.3	270-290	0	0-180,200-230,330-360	1.7	270-290
5/25/99	6	1.0	0.7	0.9	260-270	0	20-160	2.7	260-270
	7	0.9	1.0	1.0	220-250,270-280	0	20-160	3.5	230
	8	0.8	0.8	0.8	280	0	20-160	3.0	270-290
	9	0.9	0.4	0.4	260,290-310	0	10-170	2.8	270
	10	0.8	0.4	0.4	260-300	0	10-170	2.8	270,290
	11	0.9	0.3	0.5	250,290	0	10-170	2.8	270
	12	0.9	0.4	0.5	240,280-290	0	10-170	2.9	270-300
	13	1.0	0.5	0.6	250-270	0	10-170	3.2	270-280
	14	0.9	0.2	0.3	240-270,290-310	0	10-170	2.7	270
	15	0.9	0.3	0.4	280	0	10-170	2.7	270-280
	16	0.8	0.3	0.4	300-310	0	10-170	2.6	270-290
	17	0.7	0.2	0.3	240-280,300-310	0	10-170	2.4	270
	18	0.5	0.4	0.4	260-300	0	10-170,210	2.3	270-280
	19	0.7	0.4	0.4	290-300	0	0-180,200-230,350-360	1.9	280
5/26/99	6	1.2	0.2	1.6	270	0	20-160	2.5	280
	7	1.3	0.1	1.2	230	0	20-50,90-160	3.5	230
	8	1.1	0.1	1.7	270-290	0	100-160	3.4	270-280
	9	1.0	0.0	0.9	270	0	20-160	2.8	270-280
	10	1.0	0.2	1.1	260,280	0	20-60,80-160	2.8	270-280
	11	1.2	0.8	1.0	280	0	90-160	3.3	280

B.2 University and Main

The intersection of Main Street and University Street is located in Peoria, Illinois. Both streets are two lane, two-way streets with designated left turn lanes. University Street carries north/south bound traffic, while Main Street carries east/west bound traffic. South bound University has an additional right-turn-only lane. The surrounding buildings are one to three stories high.

B.2.1 Setup

The intersection was modeled with CAL3QHC v 2.0 using 38 links, 29 free flow, and 9 queue links. Table B6 lists the base conditions used in each CAL3QHC input file.

Table B7 shows the start and stop coordinates for each link. Figure B2 gives a graphical interpretation of the intersection.

Table B6 *CAL3QHC base conditions for each University and Main input file.*

Clearance Lost Time (s)	3
Saturation Flowrate (vphpl)	1900
Signal Type	1 (pretimed)
Arrival Rate	3 (average)
Atmospheric Stability Class	D (4)
Averaging Time (min)	60
Surface Roughness (cm)	175
Settling Velocity (cm/s)	0
Deposition Velocity (cm/s)	0
Source Height (ft)	0
Mixing Height (m)	1000
Background Conc. (ppm)	0

B.2.2 Meteorology

Wind speeds, wind directions, and ambient temperatures were acquired for Peoria Greater Peoria Airport from the National Climatic Data Center. Weather data are summarized in Table B8.

B.2.3 Signal Timing

The signal timing at University and Main, provided by IDOT District 4, changed throughout the day. Signal timing is summarized in Table B9.

B.2.4 Emission Factors

EFs were determined using the IDOT default MOBILE5b input file for attainment counties in Illinois north of 40° latitude. Other temperature data used for the EF calculation were the maximum and minimum daily temperatures, speeds measured at the intersection (September 1998, data), and the hourly temperatures. VMT mix was taken from 1996 IDOT data for Urban Local Streets, and is as follows: LDGV 0.663, LDGT1 0.199, LDGT2 0.080, HDGV 0.016, LDDV 0.008, LDDT 0.002, HDDV 0.068, and MC 0.010. Fuel RVP values were set at 9.0 psi.

Approach and departure vehicle speeds were representative of the speeds measured at the traffic count. Left turn movements were all assumed to be 15 mph. EFs are summarized in Tables B10 and B11.

B.2.5 Receptor

Due to the low CO concentrations observed at the intersection, background concentration was modeled as zero. The measured concentrations were from the IEPA CO monitor located in the northwest corner of the intersection. The CO data dates, times, and averaging periods corresponded to the traffic data dates, times, and averaging periods.

B.2.6 Traffic

IDOT District 4 provided traffic data for September 22-23, 1998, and March 16-17, 1999. To further condense the traffic data, we only looked at periods of high flow (6 am to 5 pm). Hourly traffic volumes are summarized in Tables B12 and B13.

B.2.7 Results

The results of the University and Main intersection study are presented in Table B14. The first two columns contain the date and averaging hour being modeled. The Measured Conc. column gives the concentrations measured at the IEPA monitor. The Modeled Conc. column gives the modeled concentration using the wind speed and direction as reported at the Peoria airport. (Note: measured wind speeds less than 1 m/s were assumed to be 1 m/s. If the direction of wind was reported as variable or no wind direction was reported the 10 degree incremental wind search was used.) The maximum and minimum concentration columns report the maximum and minimum modeled concentration using the airport wind speed but neglecting the wind direction. A 10 degree increment search was used to determine the directions at which the maximum and minimum concentrations occurred. The "Max Conc Wind speed of 1 m/s" column gives the maximum modeled concentration assuming the worst-case wind speed of 1 m/s and using a 10 degree increment wind direction search.

Table B7 *CAL3QHC link coordinates for University and Main.*

	Coordinates in feet				Mix Zone
Link Name	X1	Y1	X2	Y2	Width (ft)
NB App 1	16.5	-1000	16.5	-178.5	42
NB App 2	16.5	-178.5	16.5	-16.5	42
NB Depart	16.5	-16.5	16.5	1000	42
NB Rt Turn Depart	16.5	-16.5	1000	-16.5	42
NB Main Queue	16.5	-53.5	16.5	-1000	22
NB Lt Turn Queue	0	-53.5	0	-178.5	11
NB Lt Turn App	0	-53.5	0	-178.5	31
NB Lt Turn Depart 1	0	-53.5	-33	16.5	31
NB Lt Turn Depart 2	-33	16.5	-1000	16.5	42
SB App 1	-16.5	1000	-16.5	149.5	42
SB App 2	-16.5	149.5	-16.5	-16.5	42
SB Depart	-16.5	-16.5	-16.5	-1000	42
SB Rt Turn App	-33	1000	-33	16.5	31
SB Rt Turn Depart	-33	16	-1000	16.5	42
SB Rt Turn Queue	-33	49.5	-33	1000	11
SB Main Queue	-16.5	49.5	-16.5	1000	22
SB Lt Turn Queue	0	49.5	0	149.5	11
SB Lt Turn App	0	49.5	0	149.5	31
SB Lt Turn Depart 1	0	49.5	16.5	-16.5	31
SB Lt Turn Depart 2	16.5	-16.5	1000	-16.5	42
WB App 1	1000	16.5	155.5	16.5	42
WB App 2	155	16.5	16.5	16.5	42
WB Depart	16.5	16.5	-1000	16.5	42
WB Rt Turn Depart	16.5	16.5	16.5	1000	42
WB Main Queue	49.5	16.5	1000	16.5	22
WB Lt Turn Queue	52.5	0	155.5	0	11
WB Lt Turn App	52.5	0	155.5	0	31
WB Lt Turn Depart 1	52.5	0	-16.5	-16.5	31
WB Lt Turn Depart 2	-16.5	-16.5	-16.5	-1000	42
EB App 1	-1000	-16.5	-263.5	-16.5	42
EB App 2	-263.5	-16.5	-16.5	-16.5	42
EB Depart	-16.5	-16.5	1000	-16.5	42
EB Rt Turn Depart	-16.5	-16.5	-16.5	-1000	42
EB Main Queue	-61.5	-16.5	-1000	-16.5	22
EB Lt Turn Queue	-66.5	0	-263.5	0	11
EB Lt Turn App	-66.5	0	-263.5	0	31
EB Lt Turn Depart 1	-66.5	0	16.5	16.5	31
EB Lt Turn Depart 2	16.5	16.5	16.5	1000	42

Table B8 *Meteorological data for University and Main.*

Date	Time of Measurement	Model Averaging Hour	Temp (F)	Wind Direction (degrees)	Wind Speed (m/s)
9/23/98	5:54	6	46	70	2.1
	6:54	7	51	90	1.5
	7:54	8	56	120	2.6
	8:54	9	60	Var.	2.6
	9:54	10	62	Var.	2.1
	10:54	11	64	0	0.0
9/22/98	11:54	12	70	Var.	2.6
	12:54	13	70	330	4.6
	13:54	14	71	10	4.1
	14:54	15	71	340	4.1
	15:54	16	70	330	4.1
	16:54	17	69	10	2.6
3/17/99	5:54	6	45	200	6.2
	6:54	7	46	200	5.1
	7:54	8	50	200	6.2
	8:54	9	55.9	230	8.7
	9:54	10	61	250	8.7
	10:54	11	62.1	260	9.3
3/16/99	11:54	12	55.9	220	6.7
	12:54	13	57.9	210	5.1
	13:54	14	60.1	240	6.2
	14:54	15	63	220	6.2
	15:54	16	64	210	5.7
	16:54	17	64	210	6.2

Table B9 *Signal timing for University and Main.*

			Red time in seconds.							
Start Hour	Pattern*	Cycle Length (s)	NB	NB Lt**	SB	SB Lt**	WB	WB Lt**	EB	EB Lt**
6	2	90	63	76.5	63	76.5	63	67.5	63	67.5
7	2	90	63	76.5	63	76.5	63	67.5	63	67.5
8	2	90	63	76.5	63	76.5	63	67.5	63	67.5
9	1	80	56	68	56	68	56	60	56	60
10	1	80	56	68	56	68	56	60	56	60
11	3	100	75	85	75	85	70	70	70	70
12	3	100	75	85	75	85	70	70	70	70
13	3	100	75	85	75	85	70	70	70	70
14	1	80	56	68	56	68	56	60	56	60
15	3	100	75	85	75	85	70	70	70	70
16	3	100	75	85	75	85	70	70	70	70
17	3	100	75	85	75	85	70	70	70	70

** Pattern 3 actually starts at 11:30 to 13:30 & 15:30 to 18:30*
*** Round NB Lt & SB Lt Down, WB Lt & EB Lt Up*

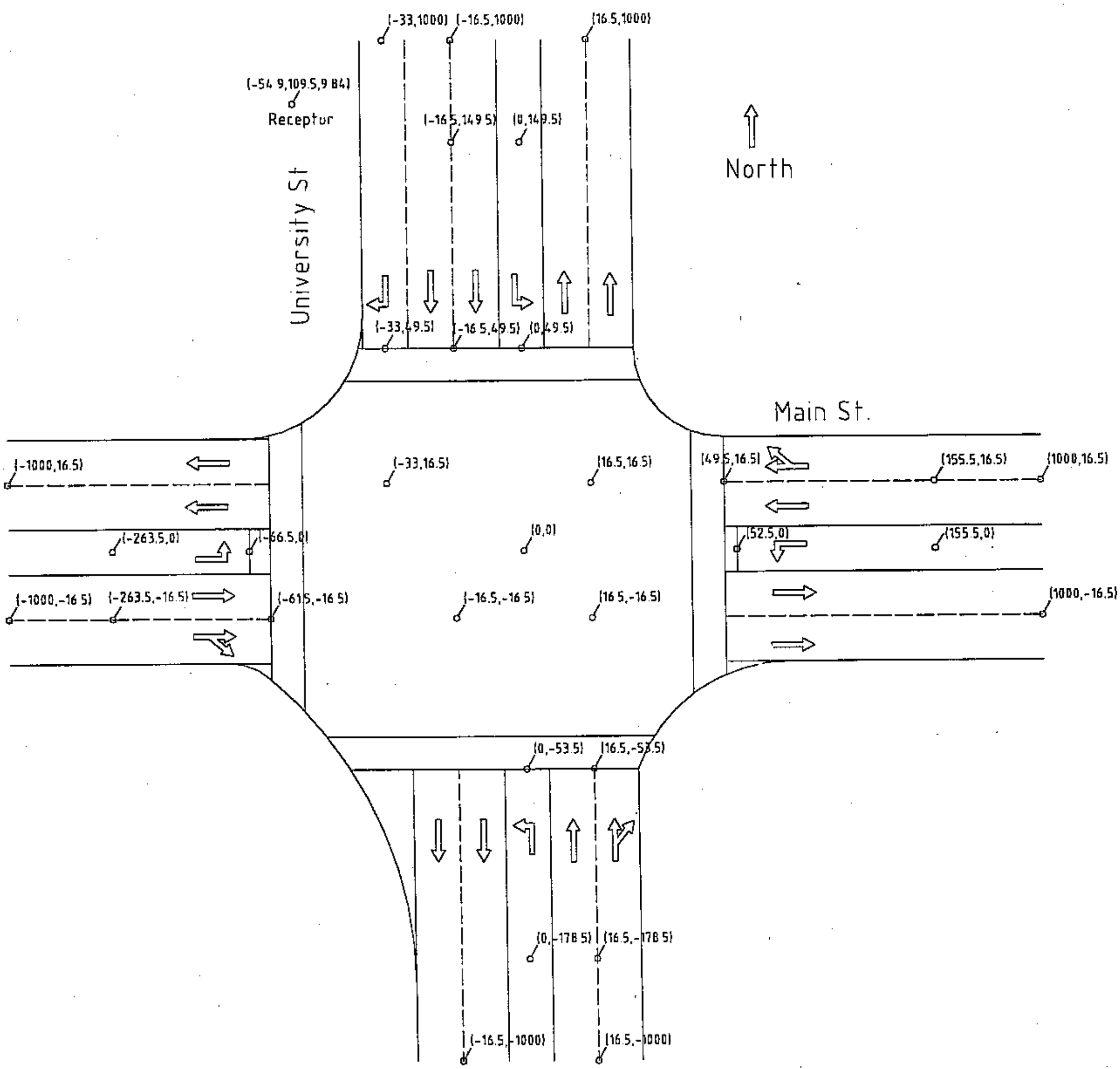

Figure B2 *CAL3QHC intersection geometry for University and Main.*

Table B10 *Emission factors for University and Main, September 22 & 23, 1998.*

Link Name	Ave Speed (mph)	Emission Factors in g/mile (g/hr for idle emissions) 9/23/98						9/22/98					
		6	7	8	9	10	11	12	13	14	15	16	17
NB App 1	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
NB App 2	26	22.6	21.3	20.1	19.1	18.6	18.2	16.8	16.8	16.6	16.6	16.8	17.1
NB Depart	33	18.0	17.0	16.0	15.2	14.9	14.5	13.4	13.4	13.3	13.3	13.4	13.6
NB Rt Turn Depart	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
NB Main Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
NB Lt Turn Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
NB Lt Turn App	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
NB Lt Turn Depart 1	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
NB Lt Turn Depart 2	31	19.1	18.0	17.0	16.2	15.8	15.4	14.3	14.3	14.1	14.1	14.3	14.4
SB App 1	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
SB App 2	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
SB Depart	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
SB Rt Turn App	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
SB Rt Turn Depart	31	19.1	18.0	17.0	16.2	15.8	15.4	14.3	14.3	14.1	14.1	14.3	14.4
SB Rt Turn Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
SB Main Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
SB Lt Turn Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
SB Lt Turn App	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
SB Lt Turn Depart 1	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
SB Lt Turn Depart 2	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
WB App 1	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
WB App 2	25	23.4	22.1	20.8	19.8	19.3	18.9	17.5	17.5	17.2	17.2	17.5	17.7
WB Depart	31	19.1	18.0	17.0	16.2	15.8	15.4	14.3	14.3	14.1	14.1	14.3	14.4
WB Rt Turn Depart	33	18.0	17.0	16.0	15.2	14.9	14.5	13.4	13.4	13.3	13.3	13.4	13.6
WB Main Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
WB Lt Turn Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
WB Lt Turn App	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
WB Lt Turn Depart 1	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
WB Lt Turn Depart 2	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
EB App 1	30	19.7	18.6	17.5	16.7	16.3	15.9	14.7	14.7	14.5	14.5	14.7	14.9
EB App 2	28	21.0	19.8	18.7	17.8	17.4	16.9	15.7	15.7	15.5	15.5	15.7	15.9
EB Depart	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
EB Rt Turn Depart	29	20.3	19.2	18.1	17.2	16.8	16.4	15.2	15.2	15.0	15.0	15.2	15.4
EB Main Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
EB Lt Turn Queue	idle	391.15	369.19	348.09	331.80	323.84	316.00	293.16	293.16	289.45	289.45	293.16	296.90
EB Lt Turn App	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
EB Lt Turn Depart 1	15	35.4	34.0	31.4	29.9	29.2	28.5	26.4	26.4	26.1	26.1	26.4	26.8
EB Lt Turn Depart 2	33	18.0	17.0	16.0	15.2	14.9	14.5	13.4	13.4	13.3	13.3	13.4	13.6

Table B11 *Emission factors for University and Main, March 16 & 17, 1999.*

Link Name	Ave Speed (mph)	Emission Factors in g/mile (g/hr for idle emissions) 3/17/99						3/16/99					
		6	7	8	9	10	11	12	13	14	15	16	17
NB App 1	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
NB App 2	26	22.5	22.6	23.1	23.6	23.8	23.8	23.6	23.7	23.8	23.8	23.9	23.9
NB Depart	33	17.8	17.9	18.3	18.7	18.8	18.9	18.7	18.7	18.8	18.9	18.9	18.9
NB Rt Turn Depart	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
NB Main Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
NB Lt Turn Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
NB Lt Turn App	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
NB Lt Turn Depart 1	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
NB Lt Turn Depart 2	31	18.9	19.0	19.4	19.8	20.0	20.1	19.8	19.9	20.0	20.1	20.1	20.1
SB App 1	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
SB App 2	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
SB Depart	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
SB Rt Turn App	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
SB Rt Turn Depart	31	18.9	19.0	19.4	19.8	20.0	20.1	19.8	19.9	20.0	20.1	20.1	20.1
SB Rt Turn Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
SB Main Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
SB Lt Turn Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
SB Lt Turn App	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
SB Lt Turn Depart 1	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
SB Lt Turn Depart 2	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
WB App 1	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
WB App 2	25	23.3	23.5	24.0	24.5	24.7	24.8	24.5	24.6	24.7	24.8	24.8	24.8
WB Depart	31	18.9	19.0	19.4	19.8	20.0	20.1	19.8	19.9	20.0	20.1	20.1	20.1
WB Rt Turn Depart	33	17.8	17.9	18.3	18.7	18.8	18.9	18.7	18.7	18.8	18.9	18.9	18.9
WB Main Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
WB Lt Turn Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
WB Lt Turn App	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
WB Lt Turn Depart 1	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
WB Lt Turn Depart 2	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
EB App 1	30	19.5	19.6	20.1	20.5	20.7	20.7	20.5	20.6	20.7	20.7	20.7	20.7
EB App 2	28	20.9	21.0	21.5	21.9	22.1	22.2	21.9	22.0	22.1	22.2	22.2	22.2
EB Depart	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
EB Rt Turn Depart	29	20.2	20.3	20.7	21.2	21.4	21.4	21.2	21.3	21.4	21.4	21.4	21.4
EB Main Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
EB Lt Turn Queue	idle	373.62	375.74	382.92	390.09	393.39	393.79	390.09	391.69	392.99	394.03	394.22	394.22
EB Lt Turn App	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
EB Lt Turn Depart 1	15	35.2	35.5	36.2	36.9	37.3	37.3	36.9	37.1	37.2	37.4	37.4	37.4
EB Lt Turn Depart 2	33	17.8	17.9	18.3	18.7	18.8	18.9	18.7	18.7	18.8	18.9	18.9	18.9

Assume Speeds are the same as the Sept 1998 Analysis (data was not provided).

Table B12 *Hourly volumes for University and Main, September 22 & 23, 1998.*

Link Name	Hourly Volumes in vph.											
	9/23/98						9/22/98					
	6	7	8	9	10	11	12	13	14	15	16	17
NB App 1	147	355	312	300	309	437	502	454	566	662	816	878
NB App 2	132	299	257	233	256	366	415	385	449	515	658	733
NB Depart	123	279	243	208	236	332	364	341	423	483	622	679
NB Rt Turn Depart	9	20	14	25	20	34	51	44	26	32	36	54
NB Main Queue	132	299	257	233	256	366	415	385	449	515	658	733
NB Lt Turn Queue	15	56	55	67	53	71	87	69	117	147	158	145
NB Lt Turn App	15	56	55	67	53	71	87	69	117	147	158	145
NB Lt Turn Depart 1	15	56	55	67	53	71	87	69	117	147	158	145
NB Lt Turn Depart 2	15	56	55	67	53	71	87	69	117	147	158	145
SB App 1	414	1046	1069	879	844	751	871	873	953	972	1127	1048
SB App 2	199	479	421	329	305	265	277	289	372	343	428	386
SB Depart	199	479	421	329	305	265	277	289	372	343	428	386
SB Rt Turn App	154	424	476	395	396	315	395	406	407	468	527	514
SB Rt Turn Depart	154	424	476	395	396	315	395	406	407	468	527	514
SB Rt Turn Queue	154	424	476	395	396	315	395	406	407	468	527	514
SB Main Queue	199	479	421	329	305	265	277	289	372	343	428	386
SB Lt Turn Queue	61	143	172	155	143	171	199	178	174	161	172	148
SB Lt Turn App	61	143	172	155	143	171	199	178	174	161	172	148
SB Lt Turn Depart 1	61	143	172	155	143	171	199	178	174	161	172	148
SB Lt Turn Depart 2	61	143	172	155	143	171	199	178	174	161	172	148
WB App 1	116	305	301	423	584	671	497	453	567	630	826	897
WB App 2	108	276	275	395	541	633	457	405	535	586	764	830
WB Depart	68	198	195	276	371	392	240	325	348	390	522	572
WB Rt Turn Depart	40	78	80	119	170	241	217	80	187	196	242	258
WB Main Queue	108	276	275	395	541	633	457	405	535	586	764	830
WB Lt Turn Queue	8	29	26	28	43	38	40	48	32	44	62	67
WB Lt Turn App	8	29	26	28	43	38	40	48	32	44	62	67
WB Lt Turn Depart 1	8	29	26	28	43	38	40	48	32	44	62	67
WB Lt Turn Depart 2	8	29	26	28	43	38	40	48	32	44	62	67
EB App 1	724	1049	963	783	709	858	1000	916	938	944	1146	1018
EB App 2	422	609	554	439	401	469	565	493	544	540	644	528
EB Depart	354	514	495	391	339	435	501	440	460	467	577	452
EB Rt Turn Depart	68	95	59	48	62	34	64	53	84	73	67	76
EB Main Queue	422	609	554	439	401	469	565	493	544	540	644	528
EB Lt Turn Queue	302	440	409	344	308	389	435	423	394	404	502	490
EB Lt Turn App	302	440	409	344	308	389	435	423	394	404	502	490
EB Lt Turn Depart 1	302	440	409	344	308	389	435	423	394	404	502	490
EB Lt Turn Depart 2	302	440	409	344	308	389	435	423	394	404	502	490

Table B13 *Hourly volumes for University and Main, March 16 & 17, 1999.*

Link Name	Hourly Volumes in vph.											
	3/17/99						3/16/99					
	6	7	8	9	10	11	12	13	14	15	16	17
NB App 1	122	302	309	274	338	421	504	423	480	635	702	642
NB App 2	104	263	258	224	283	343	421	350	400	507	558	507
NB Depart	100	247	241	200	252	306	384	305	368	464	526	477
NB Rt Turn Depart	4	16	17	24	31	37	37	45	32	43	32	30
NB Main Queue	104	263	258	224	283	343	421	350	400	507	558	507
NB Lt Turn Queue	18	39	51	50	55	78	83	73	80	128	144	135
NB Lt Turn App	18	39	51	50	55	78	83	73	80	128	144	135
NB Lt Turn Depart 1	18	39	51	50	55	78	83	73	80	128	144	135
NB Lt Turn Depart 2	18	39	51	50	55	78	83	73	80	128	144	135
SB App 1	409	864	872	718	732	793	923	832	893	944	1094	935
SB App 2	162	313	324	235	200	247	301	307	300	346	367	303
SB Depart	162	313	324	235	200	247	301	307	300	346	367	303
SB Rt Turn App	187	404	372	332	337	363	406	339	424	434	557	476
SB Rt Turn Depart	187	404	372	332	337	363	406	339	424	434	557	476
SB Rt Turn Queue	187	404	372	332	337	363	406	339	424	434	557	476
SB Main Queue	162	313	324	235	200	247	301	307	300	346	367	303
SB Lt Turn Queue	60	147	176	151	195	183	216	186	169	164	170	156
SB Lt Turn App	60	147	176	151	195	183	216	186	169	164	170	156
SB Lt Turn Depart 1	60	147	176	151	195	183	216	186	169	164	170	156
SB Lt Turn Depart 2	60	147	176	151	195	183	216	186	169	164	170	156
WB App 1	103	317	378	453	429	537	653	544	595	724	779	667
WB App 2	99	288	337	420	391	507	601	512	549	673	736	631
WB Depart	61	218	217	274	241	304	344	292	339	470	498	430
WB Rt Turn Depart	38	70	120	146	150	203	257	220	210	203	238	201
WB Main Queue	99	288	337	420	391	507	601	512	549	673	736	631
WB Lt Turn Queue	4	29	41	33	38	30	52	32	46	51	43	36
WB Lt Turn App	4	29	41	33	38	30	52	32	46	51	43	36
WB Lt Turn Depart 1	4	29	41	33	38	30	52	32	46	51	43	36
WB Lt Turn Depart 2	4	29	41	33	38	30	52	32	46	51	43	36
EB App 1	713	1132	932	781	876	778	956	922	923	999	1047	1061
EB App 2	431	653	571	479	527	437	551	521	531	589	571	540
EB Depart	373	554	516	433	488	392	498	471	471	532	507	486
EB Rt Turn Depart	58	99	55	46	39	45	53	50	60	57	64	54
EB Main Queue	431	653	571	479	527	437	551	521	531	589	571	540
EB Lt Turn Queue	282	479	361	302	349	341	405	401	392	410	476	521
EB Lt Turn App	282	479	361	302	349	341	405	401	392	410	476	521
EB Lt Turn Depart 1	282	479	361	302	349	341	405	401	392	410	476	521
EB Lt Turn Depart 2	282	479	361	302	349	341	405	401	392	410	476	521

Table B14 *Results from University and Main.*

Date	Model Averaging Hour	Measured Conc. (ppm)	Modeled Conc. (ppm)	Max Modeled Conc. (ppm)	Angle of Wind (deg off N)	Min Modeled Conc. (ppm)	Angle of Wind (deg off N)	Max Conc with Wind speed of 1 m/s (ppm)	Angle of Wind (deg off N)
9/23/98	6	2.8	0	1.9	140	0	60-80, 270-350	4.3	140
	7	2.1	3.6	4.3	120-130	0	290-340	6.3	120
	8	1.9	2.4	2.4	120	0	280-330	6.0	120
	9	1.3	-	2.0	120-130	0	270-340	5.3	120
	10	1.3	-	5.3	130	0	270-340	5.3	130
	11	?	-	6.0	120	0	280-340	6.0	120
9/22/98	12	1.4	-	2.0	120	0	270-330	5.4	120
	13	1.3	0	1.1	110-120	0	250-340	5.4	120
	14	1.8	0.5	1.2	120	0	270-350	5.1	120
	15	2.2	0	1.3	110-120	0	250-340	5.8	120
	16	2.2	0	1.4	120	0	270-330	6.1	120
	17	1.9	1.3	2.5	110, 120	0	270-330	6.5	120
3/17/99	6	0.5	0.3	0.6	130-140	0	0-60,240-360	3.9	140
	7	1.4	0.3	1.1	120-140	0	280-350	6.1	120
	8	1.1	0.3	0.9	110-140	0	260-350	6.7	120
	9	1.3	0.0	0.6	130-140	0	230-360	5.4	130-140
	10	1.3	0.0	0.6	130-140	0	250-350	5.3	130-140
	11	1.0	0.0	0.7	120-140	0	230-350	7.0	120
3/16/99	12	1.9	0.2	1.1	120	0	250-340	7.8	120
	13	1.5	0.4	1.5	120-130	0	260-340	7.6	120
	14	2.3	0.1	1.0	120	0	270-350	6.5	120-130
	15	2.7	0.3	1.2	110-120	0	250-340	8	120
	16	5.2	0.3	1.4	120	0	260-330	8.4	120
	17	4.3	0.3	1.2	110-120	0	270-340	7.9	120

B.3 Irving Park Road And Mannheim Road

The intersection of Irving Park Road and Mannheim Road is located in Schiller Park, Illinois. Irving Park is a two-way, three-lane freeway running east and west. There are two designated left turn lanes, and one designated right turn lane in each direction. Mannheim is a two-way, three-lane freeway running north and south. There are two designated left and right turn lanes in each direction. The area surrounding the intersection is mixture of short grass, and deciduous trees. O'Hare International Airport is located just west of the intersection.

B.3.1 Setup

Due to the complexity of the intersection, several simplifications were made to the analysis. Curvature in each approach was removed from the analysis, traffic lanes approaching the intersection were modeled as straight lines. Each approach was modeled from the center of the intersection to where the approach began to significantly curve. We set up the intersection geometry in AutoCad using an aerial photograph and a pavement marking plan of the intersection provided by IDOT District 1. Volume link coordinates were then established from the AutoCad drawing. The intersection was modeled with CAL3QHC v 2.0 using 48 links, 36 free flow, and 12 queue links. Table B15 lists the base conditions used in each CAL3QHC input file. Table B16 contains the start and end coordinates for each link. Figure B3 gives a graphical interpretation of the intersection.

Table B15 *CAL3QHC base conditions for each Irving and Mannheim input file.*

Clearance Lost Time (s)	3
Saturation Flowrate (vphpl)	1900
Signal Type	1 (pretimed)
Arrival Rate	3 (average)
Atmospheric Stability Class	D (4), E (5)
Averaging Time (min)	60
Surface Roughness (cm)	1
Settling Velocity (cm/s)	0
Deposition Velocity (cm/s)	0
Source Height (ft)	0
Mixing Height (m)	1000
Background Conc. (ppm)	0

B.3.2 Meteorology

Wind speeds, wind directions, and ambient temperatures were acquired for Chicago O'Hare International Airport from the National Climatic Data Center. Weather data are summarized in Table B17.

B.3.3 Signal Timing

The signal timing at University and Main, provided by IDOT District 1, changed throughout the day. Signal timing is summarized in Table B18.

B.3.4 Emission Factors

A free flow speed of 20 mph was used on the left and right turn links closest to the center of the intersection, while 45 mph was used on all other free flow links. This is consistent with the average speeds given on the EPA monitoring data (From IEPA report APAQ0105, 1994 the average speed on Mannheim is 45 mph). EFs are summarized in Tables B19 and B20.

B.3.5 Receptor

Due to the low CO concentrations observed at the intersection, background concentration was modeled as zero. The measured concentrations were taken from an IEPA CO monitor positioned on the west edge of a trailer roof, located southeast of the intersection (the monitor was relocated in 1997). The location was estimated. The location of the receptor was estimated using the aerial photograph and IEPA documentation to be 31 feet from the edge of Mannheim road, 410 feet from the edge of Irving Park road, and 9.8 feet high. The CO data dates, times, and averaging periods correspond to the traffic data.

B.3.6 Traffic

IDOT District 1 provided traffic data for December 16 and 21, 1994, and December 7 and 8, 1995. Hourly volumes are summarized in Tables B21 and B22.

B.3.7 Results

The results of the Irving and Mannheim intersection study are presented in Table B23. The first two columns contain the date and averaging hour being modeled. The "Measured Conc." column gives the concentrations measured at the IEPA monitor. The "Modeled Conc." column gives the modeled concentration using the wind speed and direction as reported at O'Hare Airport. (Note: measured wind speeds less than 1 m/s were assumed to be 1 m/s. If the direction of wind was reported as variable or no wind direction was reported the 10 degree incremental wind search was used.) The maximum and minimum concentration columns report the maximum and minimum modeled concentration using the airport wind speed but neglecting the wind direction. A 10 degree increment search was used to determine the directions at which the maximum and minimum concentrations occurred. The "Max Conc Wind speed of 1 m/s" column gives the maximum modeled concentration assuming the worst-case wind speed of 1 m/s and using a 10 degree increment wind direction search. Also, due to the relatively flat, open surroundings near the intersection, stability class was changed from D (4) to E (5) to better represent worst-case conditions for these concentrations.

Table B16 *CAL3QHC link coordinates for Irving and Mannheim.*

Link Name	Coordinates in feet. X1	Y1	X2	Y2	Mix Zone Width (ft)
NB Approach 1	-105.5	-700.0	-73.7	-536.5	56
NB Approach 2	-73.7	-536.5	-59.0	-460.9	56
NB Approach 3	-59.0	-460.9	44.5	55.0	56
NB Depart	44.5	55.0	170.7	700.0	56
NB Queue	11.5	-98.0	-105.5	-700.0	36
NB Left 1	-89.5	-460.9	-19.0	-98.0	44
NB Left 2	-19.0	-98.0	-43.1	37.0	44
NB Left Depart	-43.1	37.0	-700.0	37.0	44
NB Left Queue	-19.0	-98.0	-89.5	-460.9	24
NB Right 1	-43.1	-536.5	34.8	-135.7	44
NB Right 2	34.8	-135.7	81.0	-69.0	44
NB Right 3	81.0	-69.0	174.5	-36.0	44
NB Right 4	174.5	-36.0	600.0	-30.0	44
NB Right Queue	81.0	-69.0	34.8	-135.7	24
SB Approach 1	105.5	700.0	65.2	492.8	56
SB Approach 2	65.2	492.8	34.4	334.7	56
SB Approach 3	34.4	334.7	-43.0	-48.0	56
SB Depart	-43.0	-48.0	-170.7	-700.0	56
SB Queue	-11.6	98.0	105.5	700.0	36
SB Left 1	65.0	334.7	19.0	98.0	44
SB Left 2	19.0	98.0	44.6	-30.0	44
SB Left Depart	44.6	-30.0	600.0	-30.0	44
SB Left Queue	19.0	98.0	65.0	334.7	24
SB Right 1	34.6	492.8	-29.7	161.8	44
SB Right 2	-29.7	161.8	-80.8	81.3	44
SB Right 3	-80.8	81.3	-147.9	43.0	44
SB Right 4	-147.9	43.0	-700.0	37.0	44
SB Right Queue	-80.8	81.3	-29.7	161.8	24
WB Approach 1	600.0	37.0	394.0	37.0	56
WB Approach 2	394.0	37.0	314.9	37.0	56
WB Approach 3	314.9	37.0	-43.1	37.0	56
WB Depart	-43.1	37.0	-700.0	37.0	56
WB Queue	103.0	37.0	600.0	37.0	36
WB Left 1	314.9	7.5	103.0	0.0	44
WB Left 2	103.0	0.0	-43.0	-48.0	44
WB Left Depart	-43.0	-48.0	-170.7	-700.0	44
WB Left Queue	103.0	0.0	314.9	7.5	24
WB Right 1	394.0	61.0	135.5	63.5	32
WB Right 2	135.5	63.5	90.5	90.0	32
WB Right 3	90.5	90.0	89.3	199.0	32
WB Right 4	89.3	199.0	170.7	700.0	32
WB Right Queue	90.5	90.0	135.5	63.5	12
EB Approach 1	-700.0	-30.0	-501.0	-30.0	56
EB Approach 2	-501.0	-30.0	-408.0	-30.0	56
EB Approach 3	-408.0	-30.0	44.6	-30.0	56
EB Depart	44.6	-30.0	600.0	-30.0	56
EB Queue	-103.0	-30.0	-700.0	-30.0	36
EB Left 1	-501.0	-0.4	-103.0	7.0	44
EB Left 2	-103.0	7.0	44.5	55.0	44
EB Left Depart	44.5	55.0	170.7	700.0	44
EB Left Queue	-103.0	7.0	-501.0	-0.4	24
EB Right 1	-408.0	-54.0	-134.4	-54.0	32
EB Right 2	-134.4	-54.0	-88.5	-89.1	32
EB Right 3	-88.5	-89.1	-73.0	-123.8	32
EB Right 4	-73.0	-123.8	-170.7	-700.0	32
EB Right Queue	-88.5	-89.1	-134.4	-54.0	12

Table B17 *Meteorological data for Irving and Mannheim.*

Date	Time of Measurement	Model Averaging Hour	Temp (F)	Wind Dir. From (degrees)	Wind Speed (m/s)
12/16/94	5:50	6	36	180	2.6
	6:50	7	36	190	5.1
	7:50	8	37	190	4.6
	8:50	9	37	190	5.1
	9:50	10	37	180	4.1
	10:50	11	38	180	4.1
12/21/94	11:50	12	47	190	2.6
	12:50	13	51	180	2.6
	13:50	14	50	190	4.1
	14:50	15	49	190	4.6
	15:50	16	47	190	3.6
	16:50	17	44	190	3.1
12/8/95	5:50	6	21	20	2.6
	6:50	7	24	30	2.6
	7:50	8	26	130	2.1
	8:52	9	28	140	2.6
	9:52	10	29	140	4.1
	10:50	11	30	140	5.1
12/7/95	11:50	12	29	290	5.7
	12:50	13	30	300	6.2
	13:50	14	31	290	6.2
	14:50	15	31	290	6.2
	15:50	16	29	290	4.6
	16:50	17	25	290	3.6

Table B18 ***Signal timing for Irving and Mannheim.***

Start Hour	Pattern*	Cycle Length (s)	Red Time (s)							
			NB	NB Lt	SB	SB Lt	WB	WB Lt	EB	EB Lt
6	pk morn	120	80	103	80	103	92	85	92	85
7	pk morn	120	80	103	80	103	92	85	92	85
8	pk morn	120	80	103	80	103	92	85	92	85
9	pk morn	120	80	103	80	103	92	85	92	85
10	pk morn	120	80	103	80	103	92	85	92	85
11	noon	100	67	83	67	83	77	73	77	73
12	noon	100	67	83	67	83	77	73	77	73
13	noon	100	67	83	67	83	77	73	77	73
14	pk eve	125	82	108	82	108	91	94	91	94
15	pk eve	125	82	108	82	108	91	94	91	94
16	pk eve	125	82	108	82	108	91	94	91	94
17	pk eve	125	82	108	82	108	91	94	91	94

Only 3 patterns were given, peak morning, peak evening, and Noon-Night (after 9pm). No time/pattern data given, therefore start hours were assumed.

Table B19 *Emission factors for Irving and Mannheim, December 16 & 21, 1994.*

Link Name	Ave Speed	Emission Factors in g/mile (g/hr for idle emissions)											
	(mph)	12/16/94						12/21/94					
		6	7	8	9	10	11	12	13	14	15	16	17
NB Approach 1, 2, & 3	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
NB Left 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Left 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
NB Left Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Left Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
NB Right 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Right 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
NB Right 3	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
NB Right 4	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
NB Right Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
SB Approach 1, 2, & 3	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
SB Left 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Left 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
SB Left Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Left Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
SB Right 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Right 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
SB Right 3	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
SB Right 4	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
SB Right Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
WB Approach 1, 2, & 3	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
WB Left 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Left 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
WB Left Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Left Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
WB Right 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Right 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
WB Right 3	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
WB Right 4	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
WB Right Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
EB Approach 1, 2, & 3	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
EB Left 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Left 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
EB Left Depart	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Left Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15
EB Right 1	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Right 2	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
EB Right 3	20	23.5	23.5	23.2	23.2	23.2	22.9	20.8	20.8	20.8	20.8	20.8	21.0
EB Right 4	45	11.4	11.4	11.2	11.2	11.2	11.0	10.1	10.1	10.1	10.1	10.1	10.2
EB Right Queue	idle	317.93	317.93	313.57	313.57	313.57	309.25	280.91	281.64	281.56	281.42	280.91	284.15

Measurements for the hourly data were made at 10 to the hour. See weather data for exact times.

Table B20 *Emission factors for Irving and Mannheim, December 7 & 8, 1995.*

Link Name	Ave Speed (mph)	Emission Factors in g/mile (g/hr for idle emissions)											
		12/8/95						12/7/95					
		6	7	8	9	10	11	12	13	14	15	16	17
NB Approach 1, 2, & 3	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
NB Left 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Left 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
NB Left Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Left Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
NB Right 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Right 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
NB Right 3	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
NB Right 4	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
NB Right Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
SB Approach 1, 2, & 3	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
SB Left 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Left 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
SB Left Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Left Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
SB Right 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Right 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
SB Right 3	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
SB Right 4	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
SB Right Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
WB Approach 1, 2, & 3	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
WB Left 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Left 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
WB Left Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Left Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
WB Right 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Right 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
WB Right 3	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
WB Right 4	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
WB Right Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
EB Approach 1, 2, & 3	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
EB Left 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Left 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
EB Left Depart	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Left Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76
EB Right 1	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Right 2	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
EB Right 3	20	28.7	27.6	26.9	26.2	25.8	25.5	25.8	25.5	25.1	25.1	25.8	27.2
EB Right 4	45	13.8	13.3	13.0	12.6	12.5	12.3	12.5	12.3	12.1	12.1	12.5	13.1
EB Right Queue	idle	388.67	373.66	363.90	354.35	349.64	344.97	349.64	344.97	340.36	340.36	349.64	368.76

Measurements for the hourly data were made at 10 or 8 to the hour. See weather data for exact times.

Table B21 *Hourly volumes for Irving and Mannheim, December 16 & 21, 1994.*

Link Names	Hourly Volumes in vph											
	12/16/94						12/21/94					
	6	7	8	9	10	11	12	13	14	15	16	17
NB Approach 1	1942	1694	1523	1428	1349	1713	1698	2093	2079	2140	1936	2113
NB Approach 2	1351	1151	1039	986	949	1260	1324	1654	1570	1568	1448	1577
NB Approach 3, Depart, & Queue	1123	1014	914	822	734	1092	1101	1390	1339	1392	1295	1410
NB Left 1, 2, Depart, & Queue	228	137	125	164	215	168	223	264	231	176	153	167
NB Right 1,2, 3, 4, & Queue	591	543	484	442	400	453	374	439	509	572	488	536
SB Approach 1	1244	1197	1459	1348	1385	1083	1243	1562	1685	1917	1869	1994
SB Approach 2	832	819	1139	991	911	761	788	1059	1188	1398	1217	1288
SB Approach 3, Depart & Queue	815	720	1043	926	869	703	754	922	1034	1181	1143	1206
SB Left 1, 2, Depart, & Queue	17	99	96	65	42	58	34	137	154	217	74	82
SB Right 1, 2, 3, 4, & Queue	412	378	320	357	474	322	455	503	497	519	652	706
WB Approach 1	1737	1464	1240	1146	1087	2831	960	1081	997	1078	1050	1126
WB Approach 2	1554	1345	1134	1069	1029	2734	828	930	899	1001	966	996
WB Approach 3, Depart, & Queue	958	849	683	617	560	2228	551	593	562	578	594	687
WB Left 1, 2, Depart, & Queue	596	496	451	452	469	506	277	337	337	423	372	309
WB Right 1, 2, 3, 4, & Queue	183	119	106	77	58	97	132	151	98	77	84	130
EB Approach 1	2054	1748	1719	1335	967	726	1176	1228	1704	2110	2034	2207
EB Approach 2	1339	974	1030	738	463	414	706	814	1181	1389	1346	1465
EB Approach, Depart, & Queue	1079	794	845	601	353	269	566	656	956	1125	1118	1197
EB Left 1, 2, Depart, & Queue	715	774	689	597	484	312	470	414	523	721	688	742
EB Right 1, 2, 3, 4, & Queue	260	180	185	137	130	145	140	158	225	264	228	268

Table B22 *Hourly volumes for Irving and Mannheim, December 7 & 8, 1995.*

Link Names	Hourly Volumes in vph											
	12/6/95						12/7/95					
	6	7	8	9	10	11	12	13	14	15	16	17
NB Approach 1	1450	1446	1955	1710	1639	1473	1407	1266	1475	1710	2219	2271
NB Approach 2	767	1209	1191	1122	1058	983	935	842	932	1014	1386	1451
NB Approach 3, Depart, & Queue	605	1035	1014	950	891	826	793	718	810	901	1256	1238
NB Left 1, 2, Depart, & Queue	162	174	177	172	167	157	142	124	122	113	130	213
NB Right 1,2, 3, 4, & Queue	683	237	764	588	581	490	472	424	543	696	833	820
SB Approach 1	1460	1954	1695	910	977	1171	1347	1218	1322	2196	2253	1961
SB Approach 2	1179	1552	1342	665	736	853	962	777	905	1738	1896	1443
SB Approach 3, Depart & Queue	1112	1252	1167	599	591	749	882	682	792	1591	1747	1325
SB Left 1, 2, Depart, & Queue	67	300	175	66	145	104	80	95	113	147	149	118
SB Right 1, 2, 3, 4, & Queue	281	402	353	245	241	318	385	441	417	458	357	518
WB Approach 1	1744	1950	1684	887	1201	1083	925	1202	1240	1238	1251	1397
WB Approach 2	1664	1846	1576	782	1034	906	762	998	1077	1086	1110	1224
WB Approach 3, Depart, & Queue	741	896	830	369	587	484	399	515	672	573	536	722
WB Left 1, 2, Depart, & Queue	923	950	746	413	447	422	363	463	405	513	574	502
WB Right 1, 2, 3, 4, & Queue	80	104	108	105	167	177	163	204	163	152	141	173
EB Approach 1	1939	1878	1451	1297	1148	982	829	906	1181	1604	2102	1831
EB Approach 2	1157	1104	858	799	693	588	511	565	739	1046	1389	1298
EB Approach, Depart, & Queue	856	657	658	580	471	423	381	404	542	819	1136	1084
EB Left 1, 2, Depart, & Queue	782	774	593	498	455	394	318	341	442	558	713	533
EB Right 1, 2, 3, 4, & Queue	301	247	200	219	222	165	130	161	197	227	253	214

Table B23 *Results from Irving and Mannheim.*

Hour of Measurements	Measured Conc. (ppm)	Modeled Conc. (ppm)	Max Modeled Conc. (ppm)	Angle of Wind (deg off N)	Min Modeled Conc. (ppm)	Angle of Wind (deg off N)	Max Conc with Wind speed of 1 m/s (ppm) and Stability E	Angle of Wind (deg off N)
6	2.9	0.6	1.5	10	0	60-200	5.8	10
7	2.9	0.7	2.0	10	0	60-200	7.3	10
8	2.2	0.0	2.4	10	0	50-200	6.8	10
9	1.7	0.0	1.3	10	0	40-200	5.1	10
10	1.1	0.0	1	10	0	40-210	4.9	10
11	0.6	0.0	0.5	10	0	40-210,240,260-330	4.1	10
12	0.3	0.0	0.5	10	0	40-210,240-340	4.3	10
13	0.4	0.0	0.3	10	0	40-210,240-340	3.8	10
14	0.5	0.0	0.4	0, 10	0	40-210,240-330	5.1	10
15	0.8	0.0	0.7	0, 10	0	40-210,260,290-300,320	6.7	10
16	1.1	0.3	1.4	10	0	50-200	8.2	10
17	1.4	0.3	1.6	0, 10	0	50-200	7.6	10

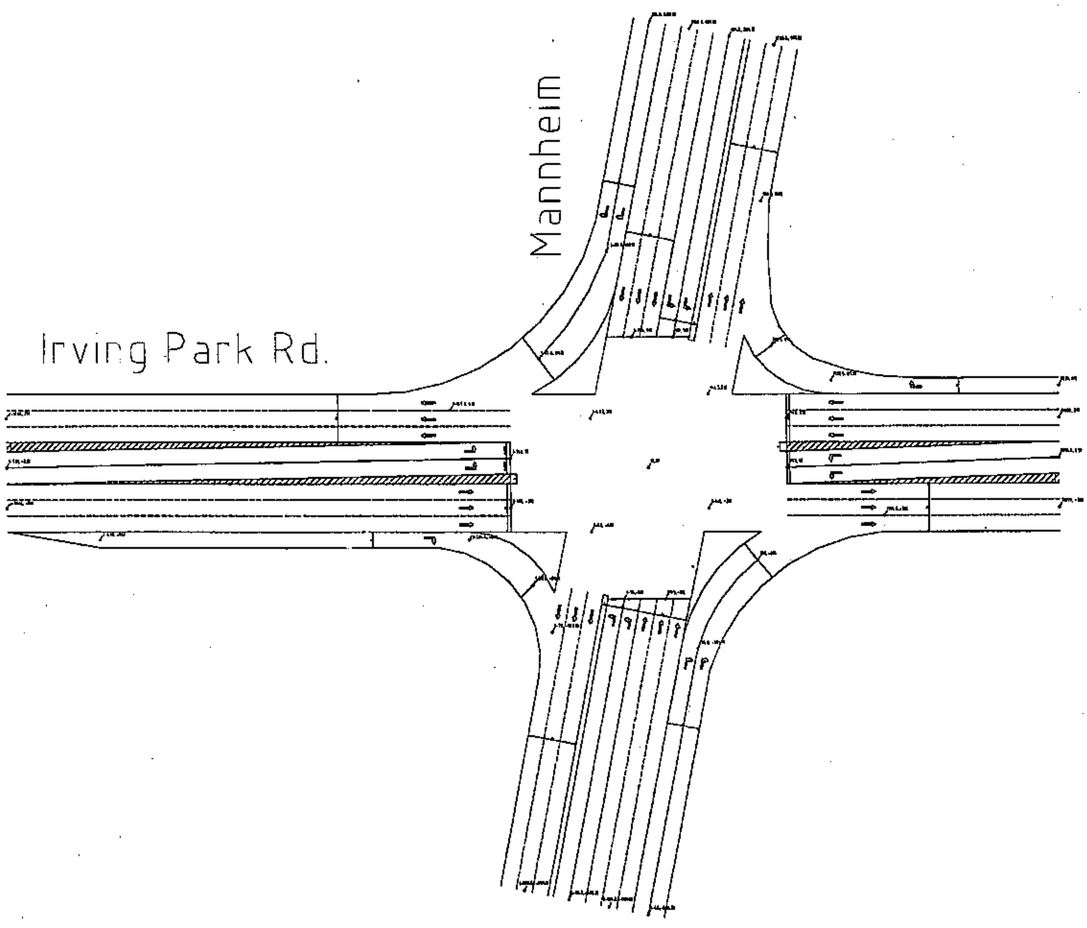

Figure B3 *CAL3QHC intersection geometry for Irving and Mannheim.*

Appendix C: CAL3QHC Intersection Input Files Used in COSIM

Appendix C: CAL3QHC Intersection Input Files Used In COSIM

After numerous meetings between the researchers, members of the technical review panel, and geometric and environmental staff from each IDOT district, fourteen intersection geometries were selected for use in COSIM. The intersections are thought to represent the most common configurations throughout Illinois. Each intersection was defined in CAL3QHC with a series of free-flow and queue links. Figures C1 through C14, show the start and end link coordinates for the given intersection. Several general defining characteristics were used as initial setup guidelines for each intersection. These include:

1. Each lane is 12 feet wide.
2. Traffic in designated left turn lane queue links is assumed to stop 6 feet from the nearest edge of the intersecting roadway (FHWA, 1988).
3. Traffic in the main queue links is assumed to stop 4 feet from the nearest edge of the intersecting roadway (FHWA, 1988)
4. Right turning traffic is assumed to stop with through traffic. No right turn on red.
5. All links extend 1000 feet from the center of the intersection.

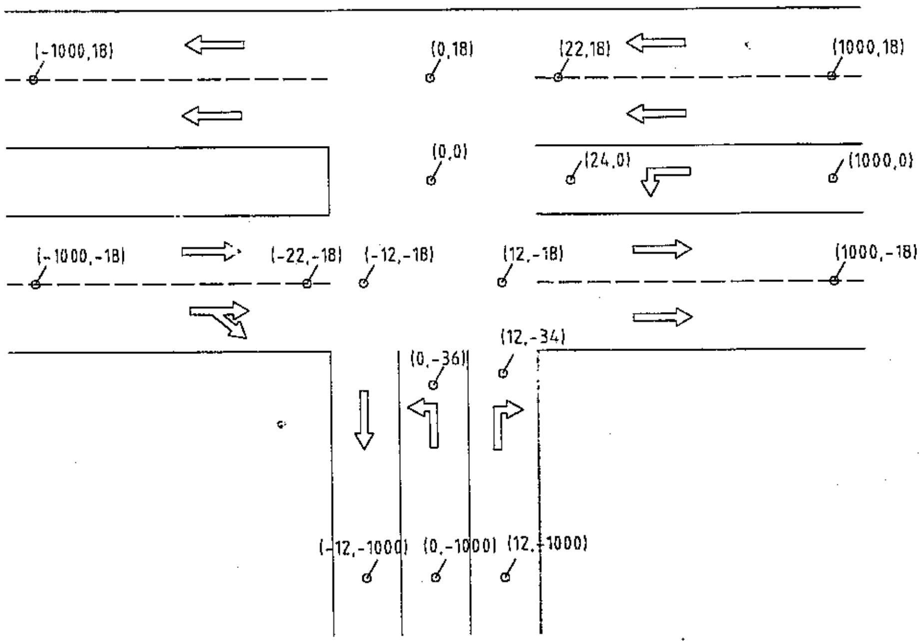

Figure C1 *CAL3QHC link coordinates for T-type intersection, 3 x 4 lanes.*

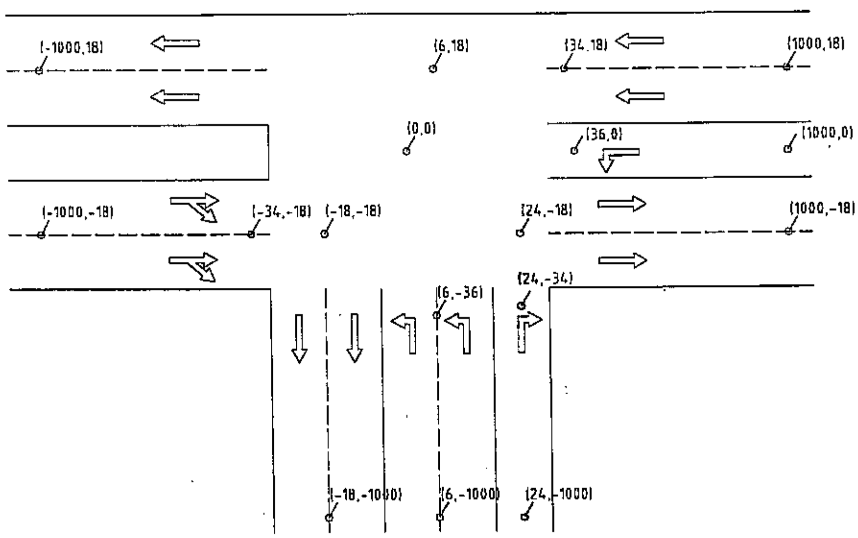

Figure C2 *CAL3QHC link coordinates for T-type intersection, 5 x 4 lanes.*

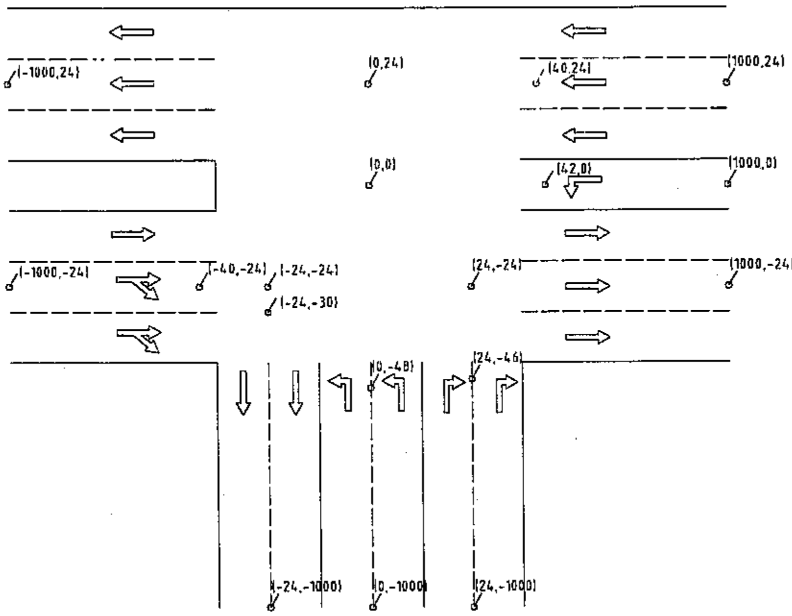

Figure C3 *CAL3QHC link coordinates for T-type intersection, 6 x 6 lanes.*

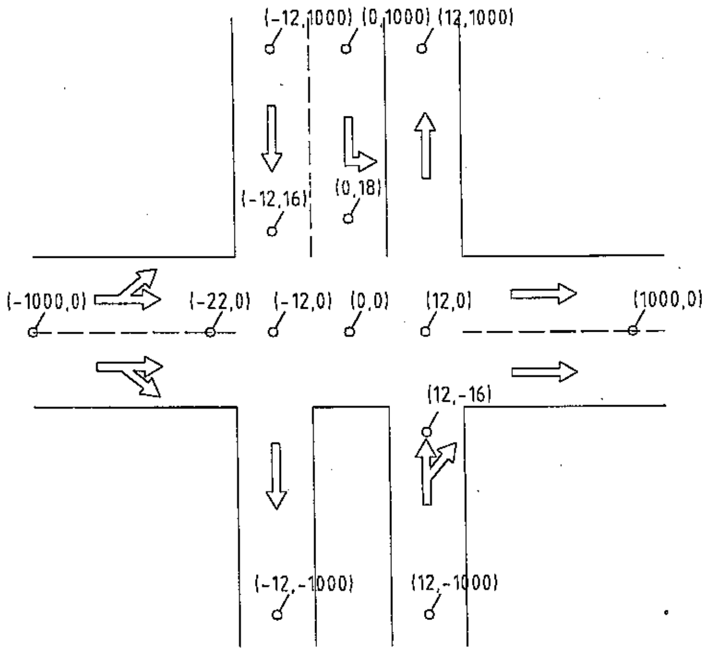

Figure C4 *CAL3QHC link coordinates for One-way street intersection, 2 x 2 w/ 1 Lt turn.*

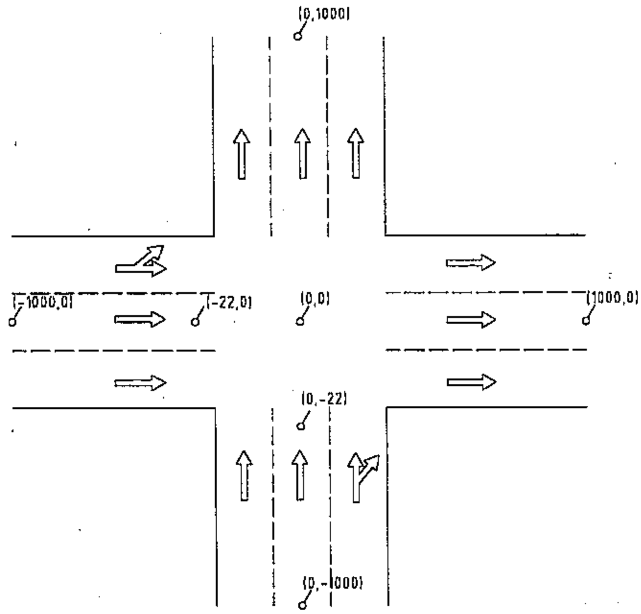

Figure C5 *CAL3QHC link coordinates for One-way street intersection, 3 x 3 lanes.*

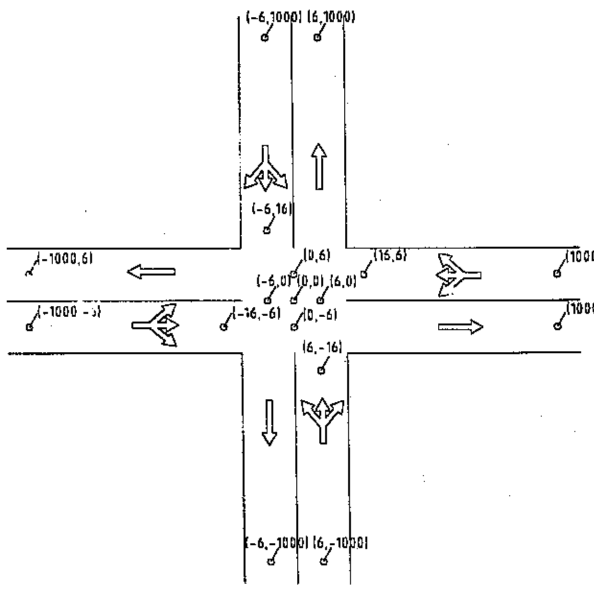

Figure C6 *CAL3QHC link coordinates for Four-way intersection, 2 x 2 w/ no Lt turn.*

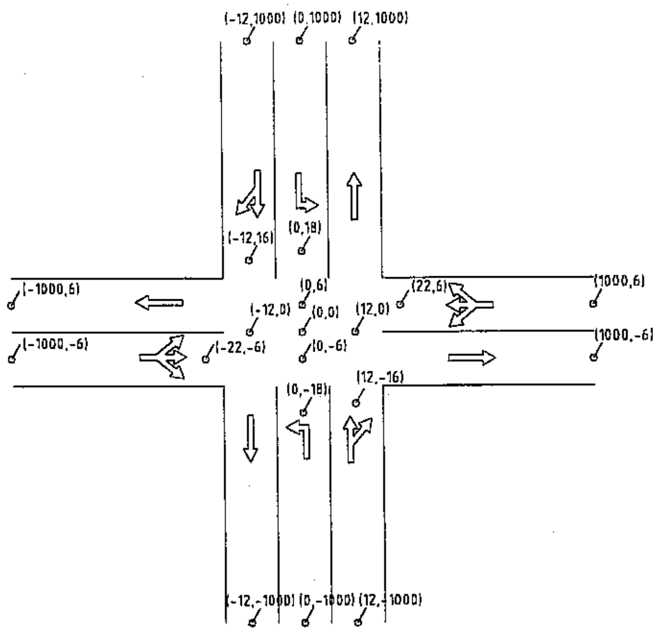

Figure C7 *CAL3QHC link coordinates for Four-way intersection, 2 x 2 w/ 2 Lt turn.*

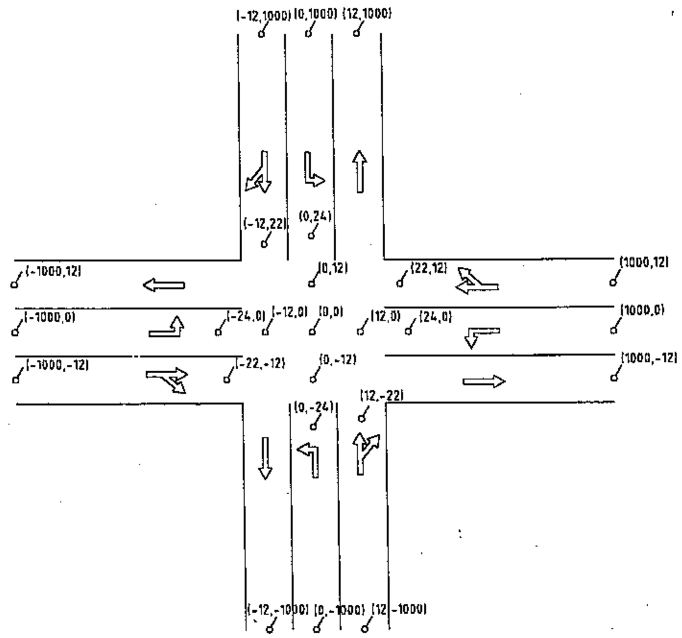

Figure C8 *CAL3QHC link coordinates for Four-way intersection, 2 x 2 w/ 4 Lt turn.*

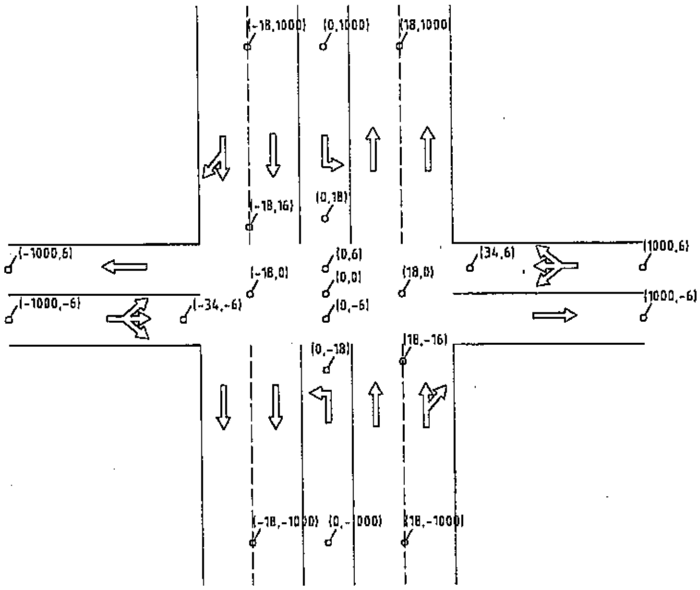

Figure C9 *CAL3QHC link coordinates for Four-way intersection, 4 x 2 w/ 2 Lt turn.*

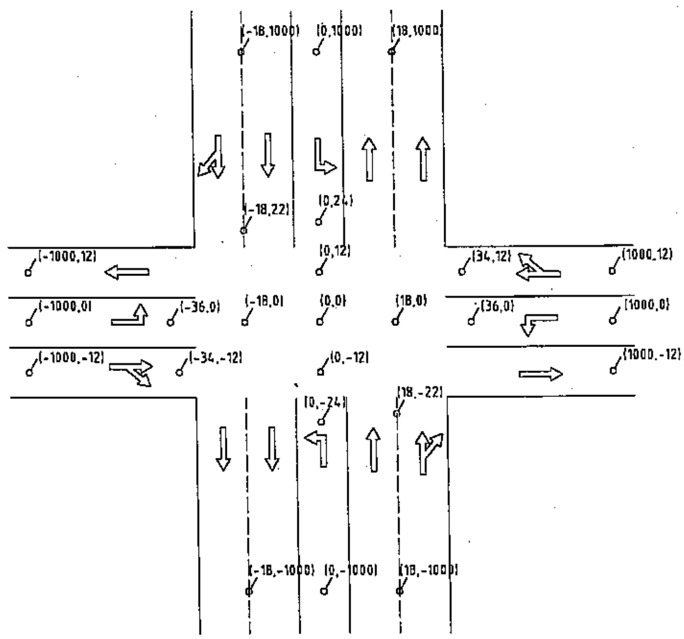

Figure C10 *CAL3QHC link coordinates for Four-way intersection, 4 x 2 w/ 4 Lt turn.*

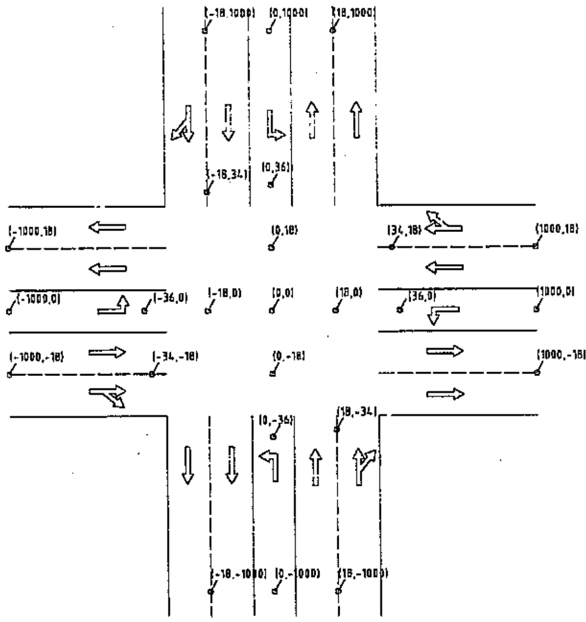

Figure C11 *CAL3QHC link coordinates for Four-way intersection, 4 x 4 w/ 4 Lt turn.*

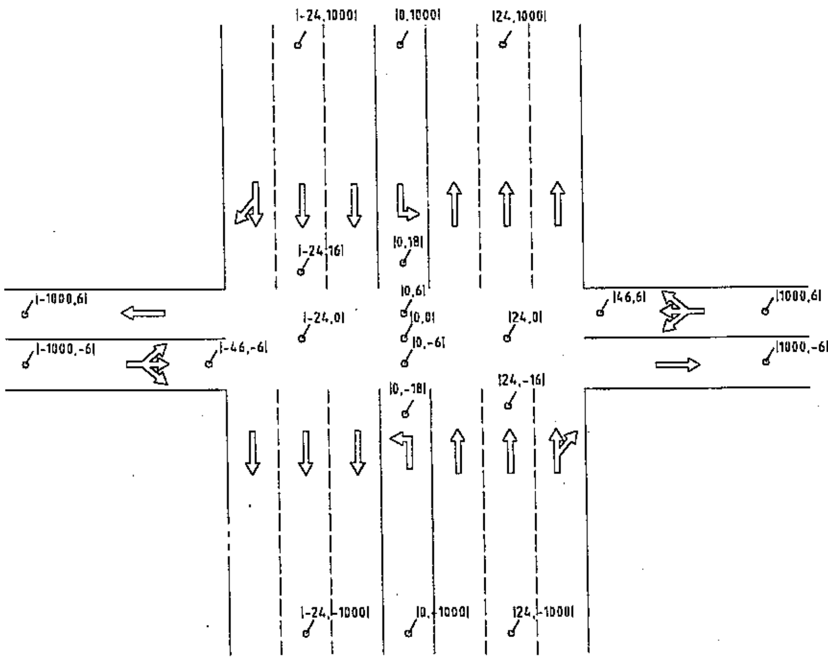

Figure C12 *CAL3QHC link coordinates for Four-way intersection, 6 x 2 w/ 2 Lt turn.*

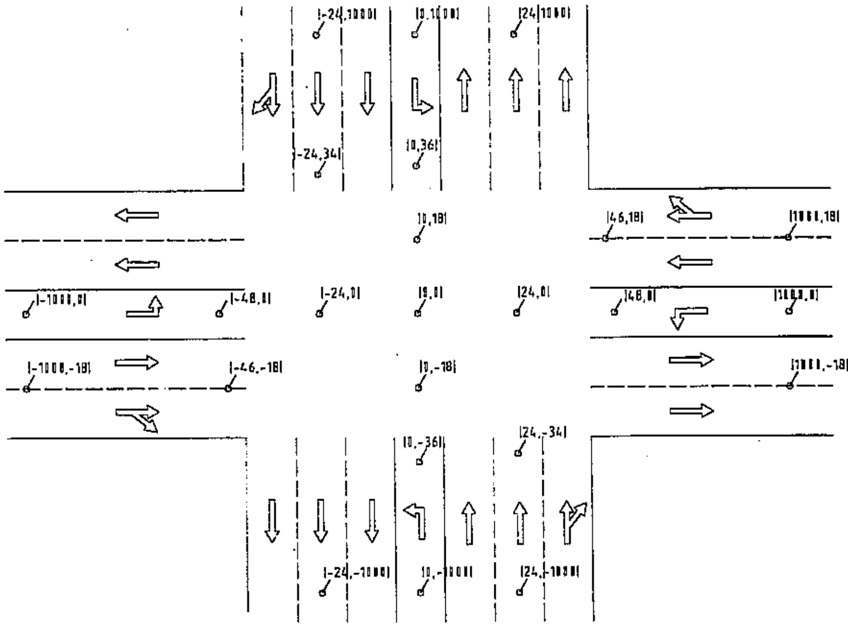

Figure C13 *CAL3QHC link coordinates for Four-way intersection, 6 x 4 w/ 4 Lt turn*

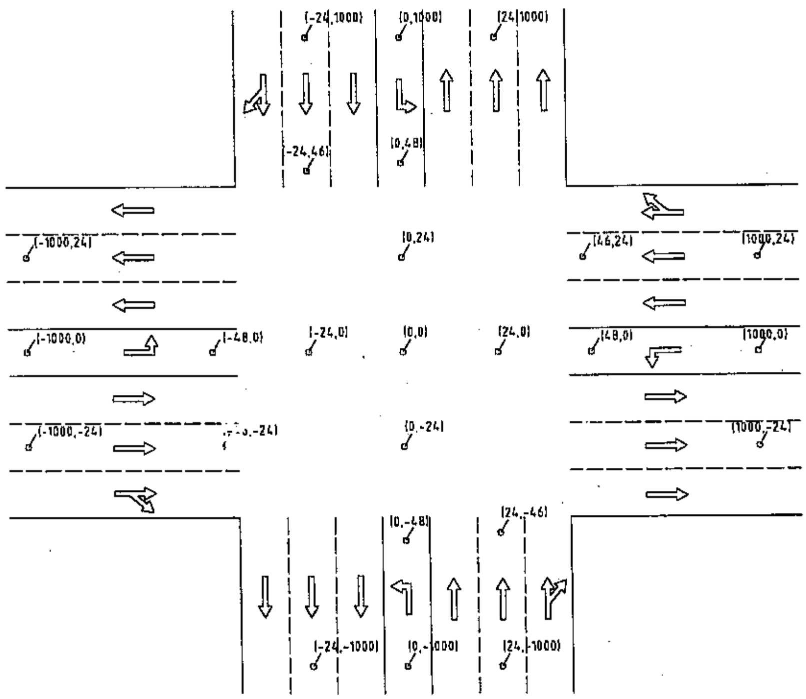

Figure C14 *CAL3QHC link coordinates for Four-way intersection, 6 x 6 w/ 4 Lt turn.*

Appendix D: MOBILE5b Input Files Used For Creating EF Tables In COSIM

Appendix D: MOBILE5b Input Files Used For Creating EF Tables In COSIM

All MOBILE5b input files were recommended by staff from IEPA.

D.1 Illinois Attainment Areas to the North of 40º N Latitude

```
1       PROMPT
Illinois Attainment Areas (north)
1       TAMFLG
1       SPDFLG
1       VMFLAG
1       MYMRFG
1       NEWFLG
1       IMFLAG
1       ALHFLG
1       ATPFLG
5       RLFLAG
2       LOCFLG
2       TEMFLG
4       OUTFMT
2       PRTFLG
2       IDLFLG
3       NMHFLG
1       HCFLAG
Attainment     C  13.  29. 13.5 13.5 95 2 1 1     Local Area Parameter record
.000 .300 .000 .035 2
1 96  5.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 10.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 15.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 20.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 25.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 30.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 35.0 24.0 20.6 27.3 20.6  1          Scenario description record
1 96 40.0 24.0 20.6 27.3 20.6  1          Scenario description record
```

D.2 Illinois Attainment Areas to the South of 40º N Latitude

```
1       PROMPT
Illinois Attainment Areas (south)
1       TAMFLG
1       SPDFLG
1       VMFLAG
1       MYMRFG
1       NEWFLG
1       IMFLAG
1       ALHFLG
1       ATPFLG
5       RLFLAG
2       LOCFLG
2       TEMFLG
```

4 OUTFMT
2 PRTFLG
2 IDLFLG
3 NMHFLG
1 HCFLAG
AttainmentS C 21. 38. 13.5 13.5 96 2 1 1 Local Area Parameter record
.000 .300 .000 .035 2
1 96 5.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 10.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 15.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 20.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 25.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 30.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 35.0 32.0 20.6 27.3 20.6 1 Scenario description record
1 96 40.0 32.0 20.6 27.3 20.6 1 Scenario description record

D.3 Illinois Non-attainment Areas In the Chicago Region with I/M Program for Years 1999-2000

1 PROMPT 1 - No prompting; vertical format.
Chicago Inputs for Winter (I/M; 1999-2000)
1 TAMFLG 1 - Use MOBILE5 default tampering rates.
1 SPDFLG 1 - One speed: all vehicles.
3 VMFLAG 3 - One VMT for all scenarios.
3 MYMRFG 3 - User: regis age, MOBILE5: mileage.
1 NEWFLG 1 - MOBILE5 exhaust rates used.
3 IMFLAG 3 - Supply 2 I/M, MOB5 model emis impact.
1 ALHFLG 1 - No additional correction factors.
8 ATPFLG 8 - Supply ATP & pressure & purge.
5 RLFLAG 5 - Zero-out emissions.
2 LOCFLG 2 - One LAP record for all scenarios.
1 TEMFLG 1 - MOBILE5 provide correction temp.
4 OUTFMT 4 - 80-column descriptive format.
2 PRTFLG 2 - Output CO emission factors.
2 IDLFLG 2 - Output idle emission factors.
3 NMHFLG 3 - Volatile organic compound (VOC).
1 HCFLAG 1 - No component emission output.
.614.184.079.018.008.002.085.010
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070
.0060.0050.0040.0040.0010
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070

.0060.0050.0040.0040.0010
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0339.0669.0669.0669.0669.0729.0608.0399.0409.0508
.0528.0659.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
86 20 68 80 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
86 20 81 20 3. 3. 96. 1 2 2221 4211 1.20 20.0 2.50
86 68 20 2221 12 96.0 11111112
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0
CWin(I/M;99-00) C13.0029.0013.5013.50 95 1 1 2
1 99 5.00 24.0 20.6 27.3 20.6 1
1 99 10.0 24.0 20.6 27.3 20.6 1
1 99 15.0 24.0 20.6 27.3 20.6 1
1 99 20.0 24.0 20.6 27.3 20.6 1
1 99 25.0 24.0 20.6 27.3 20.6 1
1 99 30.0 24.0 20.6 27.3 20.6 1
1 99 35.0 24.0 20.6 27.3 20.6 1
1 99 40.0 24.0 20.6 27.3 20.6 1

D.4 Illinois Non-attainment Areas In the Chicago Region with I/M Program for Years 2001-2030

1 PROMPT 1 - No prompting; vertical format.
Chicago Inputs for Winter (I/M; 2001+)
1 TAMFLG 1 - Use MOBILE5 default tampering rates.
1 SPDFLG 1 - One speed: all vehicles.
3 VMFLAG 3 - One VMT for all scenarios.
3 MYMRFG 3 - User: regis age, MOBILE5: mileage.
1 NEWFLG 1 - MOBILE5 exhaust rates used.
3 IMFLAG 3 - Supply 2 I/M, MOB5 model emis impact.
1 ALHFLG 1 - No additional correction factors.
8 ATPFLG 8 - Supply ATP & pressure & purge.
5 RLFLAG 5 - Zero-out emissions.
2 LOCFLG 2 - One LAP record for all scenarios.
1 TEMFLG 1 - MOBILE5 provide correction temp.
4 OUTFMT 4 - 80-column descriptive format.
2 PRTFLG 2 - Output CO emission factors.
2 IDLFLG 2 - Output idle emission factors.
3 NMHFLG 3 - Volatile organic compound (VOC).
1 HCFLAG 1 - No component emission output.
.614.184.079.018.008.002.085.010
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070
.0060.0050.0040.0040.0010
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.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168

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.0101.0071.0050.0040.0256
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
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.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070
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.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
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.0528.0659.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
86 20 68 20 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
99 20 81 20 3. 3. 96. 1 2 2221 4211 .800 15.0 2.00
86 68 20 1111 12 96.0 11111111
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0
CWin(I/M;2001+)  C13.0029.0013.5013.50 95 1 1 2
1 01 5.00 24.0 20.6 27.3 20.6  1
1 01 10.0 24.0 20.6 27.3 20.6  1
1 01 15.0 24.0 20.6 27.3 20.6  1
1 01 20.0 24.0 20.6 27.3 20.6  1
1 01 25.0 24.0 20.6 27.3 20.6  1
1 01 30.0 24.0 20.6 27.3 20.6  1
1 01 35.0 24.0 20.6 27.3 20.6  1
1 01 40.0 24.0 20.6 27.3 20.6  1
```

D.5 Illinois Non-attainment Areas In the Chicago Region with No I/M Program for All Years

```
1    PROMPT   1 - No prompting; vertical format.
Chicago Inputs for Winter (No I/M)
1    TAMFLG   1 - Use MOBILE5 default tampering rates.
1    SPDFLG   1 - One speed: all vehicles.
3    VMFLAG   3 - One VMT for all scenarios.
3    MYMRFG   3 - User: regis age, MOBILE5: mileage.
1    NEWFLG   1 - MOBILE5 exhaust rates used.
1    IMFLAG   1 - No I/M programs operating.
1    ALHFLG   1 - No additional correction factors.
1    ATPFLG   1 - No ATP assumed.
5    RLFLAG   5 - Zero-out emissions.
2    LOCFLG   2 - One LAP record for all scenarios.
1    TEMFLG   1 - MOBILE5 provide correction temp.
4    OUTFMT   4 - 80-column descriptive format.
2    PRTFLG   2 - Output CO emission factors.
```

```
2    IDLFLG   2  - Output idle emission factors.
3    NMHFLG   3  - Volatile organic compound (VOC).
1    HCFLAG   1  - No component emission output.
.614.184.079.018.008.002.085.010
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070
.0060.0050.0040.0040.0010
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0514.0756.0868.0777.0736.0696.0676.0716.0686.0686
.0635.0524.0423.0282.0181.0141.0151.0181.0090.0070
.0060.0050.0040.0040.0010
.0307.0564.0729.0800.0595.0574.0584.0574.0656.0642
.0553.0656.0522.0420.0348.0256.0183.0317.0023.0168
.0101.0071.0050.0040.0256
.0339.0669.0669.0669.0669.0729.0608.0399.0409.0508
.0528.0659.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
C(No I/M)     C13.0029.0013.5013.50 95 1 1 2
1 99 5.00 24.0 20.6 27.3 20.6  1
1 99 10.0 24.0 20.6 27.3 20.6  1
1 99 15.0 24.0 20.6 27.3 20.6  1
1 99 20.0 24.0 20.6 27.3 20.6  1
1 99 25.0 24.0 20.6 27.3 20.6  1
1 99 30.0 24.0 20.6 27.3 20.6  1
1 99 35.0 24.0 20.6 27.3 20.6  1
1 99 40.0 24.0 20.6 27.3 20.6  1
```

D.6 Illinois Non-attainment Areas In the Metro-East Region with I/M Program for Years 1999-2000

```
1    PROMPT    1  - No prompting; vertical format.
Metro East Inputs for Winter (I/M; 1999-2000)
1    TAMFLG    1  - Use MOBILE5 default tampering rates.
1    SPDFLG    1  - One speed: all vehicles.
3    VMFLAG    3  - One VMT for all scenarios.
3    MYMRFG    3  - User: regis age,  MOBILE5: mileage.
1    NEWFLG    1  - MOBILE5 exhaust rates used.
3    IMFLAG    3  - Supply 2 I/M, MOB5 model emis impact.
1    ALHFLG    1  - No additional correction factors.
8    ATPFLG    8  - Supply ATP & pressure & purge.
5    RLFLAG    5  - Zero-out emissions.
```

```
2    LOCFLG   2  - One LAP record for all scenarios.
1    TEMFLG   1  - MOBILE5 provide correction temp.
4    OUTFMT   4  - 80-column descriptive format.
2    PRTFLG   2  - Output CO emission factors.
2    IDLFLG   2  - Output idle emission factors.
3    NMHFLG   3  - Volatile organic compound (VOC).
1    HCFLAG   1  - No component emission output.
.614.184.079.018.008.002.085.010
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0339.0668.0668.0668.0668.0728.0608.0399.0409.0508
.0528.0658.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
86 20 68 80 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
86 20 81 20 3. 3. 96. 1 2 2221 4211 1.20 20.0 2.50
86 68 20 2221 12 96.0 11111112
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0
MetroEast(I/M)  C21.0038.0013.5013.50 95 2 1 1
.000 .300 .000 .035 2
1 99 5.00 32.0 20.6 27.3 20.6  1
1 99 10.0 32.0 20.6 27.3 20.6  1
1 99 15.0 32.0 20.6 27.3 20.6  1
1 99 20.0 32.0 20.6 27.3 20.6  1
1 99 25.0 32.0 20.6 27.3 20.6  1
1 99 30.0 32.0 20.6 27.3 20.6  1
1 99 35.0 32.0 20.6 27.3 20.6  1
1 99 40.0 32.0 20.6 27.3 20.6  1
```

D.7 Illinois Non-attainment Areas In the Metro-East Region with I/M Program for Years 2001-2030

```
1    PROMPT   1  - No prompting; vertical format.
```

Metro East Inputs for Winter (I/M; 2001+)
1 TAMFLG 1 - Use MOBILE5 default tampering rates.
1 SPDFLG 1 - One speed: all vehicles.
3 VMFLAG 3 - One VMT for all scenarios.
3 MYMRFG 3 - User: regis age, MOBILE5: mileage.
1 NEWFLG 1 - MOBILE5 exhaust rates used.
3 IMFLAG 3 - Supply 2 I/M, MOB5 model emis impact.
1 ALHFLG 1 - No additional correction factors.
8 ATPFLG 8 - Supply ATP & pressure & purge.
5 RLFLAG 5 - Zero-out emissions.
2 LOCFLG 2 - One LAP record for all scenarios.
1 TEMFLG 1 - MOBILE5 provide correction temp.
4 OUTFMT 4 - 80-column descriptive format.
2 PRTFLG 2 - Output CO emission factors.
2 IDLFLG 2 - Output idle emission factors.
3 NMHFLG 3 - Volatile organic compound (VOC).
1 HCFLAG 1 - No component emission output.
.614.184.079.018.008.002.085.010
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0339.0668.0668.0668.0668.0728.0608.0399.0409.0508
.0528.0658.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
86 20 68 20 3. 3. 96. 1 2 2222 1211 220. 1.20 999.
99 20 81 20 3. 3. 96. 1 2 2221 4211 .800 15.0 2.00
86 68 20 1111 12 96.0 11111111
86 68 20 2221 12 50.0
86 81 20 1111 12 96.0
ME(I/M;2001) C21.0038.0013.5013.50 95 2 1 1
.000 .300 .000 .035 2
1 01 5.00 32.0 20.6 27.3 20.6 1
1 01 10.0 32.0 20.6 27.3 20.6 1
1 01 15.0 32.0 20.6 27.3 20.6 1

```
1 01 20.0 32.0 20.6 27.3 20.6 1
1 01 25.0 32.0 20.6 27.3 20.6 1
1 01 30.0 32.0 20.6 27.3 20.6 1
1 01 35.0 32.0 20.6 27.3 20.6 1
1 01 40.0 32.0 20.6 27.3 20.6 1
```

D.8 Illinois Non-attainment Areas In the Metro-East Region with No I/M Program for All Years

```
1    PROMPT    1 - No prompting; vertical format.
Metro East Inputs for Winter (No I/M)
1    TAMFLG    1 - Use MOBILE5 default tampering rates.
1    SPDFLG    1 - One speed: all vehicles.
3    VMFLAG    3 - One VMT for all scenarios.
3    MYMRFG    3 - User: regis age, MOBILE5: mileage.
1    NEWFLG    1 - MOBILE5 exhaust rates used.
1    IMFLAG    1 - No I/M programs operating.
1    ALHFLG    1 - No additional correction factors.
1    ATPFLG    1 - No ATP assumed.
5    RLFLAG    5 - Zero-out emissions.
2    LOCFLG    2 - One LAP record for all scenarios.
1    TEMFLG    1 - MOBILE5 provide correction temp.
4    OUTFMT    4 - 80-column descriptive format.
2    PRTFLG    2 - Output CO emission factors.
2    IDLFLG    2 - Output idle emission factors.
3    NMHFLG    3 - Volatile organic compound (VOC).
1    HCFLAG    1 - No component emission output.
.614.184.079.018.008.002.085.010
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0250.0500.0610.0500.0420.0380.0450.0560.0600.0620
.0550.0540.0450.0350.0270.0210.0230.0430.0390.0300
.0260.0200.0180.0150.0600
.0220.0500.0650.0590.0600.0590.0610.0590.0630.0650
.0610.0640.0610.0510.0340.0300.0270.0310.0240.0170
.0100.0070.0050.0040.0110
.0300.0550.0710.0780.0580.0560.0570.0560.0640.0650
.0540.0640.0510.0410.0340.0250.0180.0310.0240.0170
.0100.0070.0050.0040.0250
.0339.0668.0668.0668.0668.0728.0608.0399.0409.0508
.0528.0658.0548.0568.0449.0189.0229.0279.0239.0159
.0109.0089.0069.0049.0159
.1440.1680.1350.1090.0880.0700.0560.0450.0360.0290
.0230.0970.0000.0000.0000.0000.0000.0000.0000.0000
.0000.0000.0000.0000.0000
```

```
MEast(No I/M)    C21.0038.0013.5013.50 95 2 1 1
.000 .300 .000 .035 2
1 99 5.00 32.0 20.6 27.3 20.6  1
1 99 10.0 32.0 20.6 27.3 20.6  1
1 99 15.0 32.0 20.6 27.3 20.6  1
1 99 20.0 32.0 20.6 27.3 20.6  1
1 99 25.0 32.0 20.6 27.3 20.6  1
1 99 30.0 32.0 20.6 27.3 20.6  1
1 99 35.0 32.0 20.6 27.3 20.6  1
1 99 40.0 32.0 20.6 27.3 20.6  1
```

Appendix E: Sensitivity Analysis For COSIM EFs

Appendix E: Sensitivity Analysis For COSIM EFs

COSIM uses linear interpolation to obtain EFs for speeds between the 5-mph increments of the look-up table. Data analysis was done in order to test the validity of this method.

First, exact EFs for speeds between 5 and 55 mph at 1-mph increments were obtained from MOBILE5b. This was done for the years 1999 to 2010 for 6 regions. The EFs from MOBILE5b were then compared to the COSIM EFs obtained by linear interpolation between the 5-mph increments.

Two methods were use for comparison. First, the percent error was found between the EFs from MOBILE5b and from linear interpolation at each speed. Plots were made of percent error versus speed at each year in order to find the speeds where the largest error occurred.

Figure E1 is a plot of the North Attainment Region. It displays peaks at the speeds with the largest percent errors. Plots from the other 5 regions follow the same trend. For all years and regions tested the maximum percent errors occurred at speeds between 5 and 10 mph. Specifically, for each year and each region the maximum error always occurred at 7 mph. The maximum percent error recorded was 9.5%.

To determine if this error would create a substantial change in CO concentration, CAL3QHC was run using the EFs from MOBILE5b and from the linear interpolation with all other inputs remaining constant. The maximum concentration difference between the MOBILE5b and interpolated EFs was 0.6 ppm. The maximum percent error was slightly over 4 %. The results from each year are presented in Table E1. The interpolated EFs always over predict CO concentrations by less than 4.5%. Therefore, the EF values used in COSIM are considered to be conservative estimates.

The second method used for data comparison was to plot the EFs from MOBILE5b against the EFs from linear interpolation at the same speeds. This was done to determine how well the two data sets matched. The MOBILE5b EFs versus COSIM interpolated EFs were graphed and compared to a one-to-one line. Also, the slope of the line was determined. This was done for all years and all regions. Figure E2 is an example of the North Attainment region for 1999. It displays the difference from of the MOBILE5b versus COSIM EFs from a one-to-one line. The slopes for all of the years and regions were consistent with to the one-to-one slope. Slopes ranged from 1.04-1.07, and R^2 values were all approximately 0.997.

The error in linear interpolation of the EFs results in an over prediction of the CO concentration by a small amount. Therefore, applying linear interpolation between the 5-mph intervals is considered a valid method for COSIM to determine EFs.

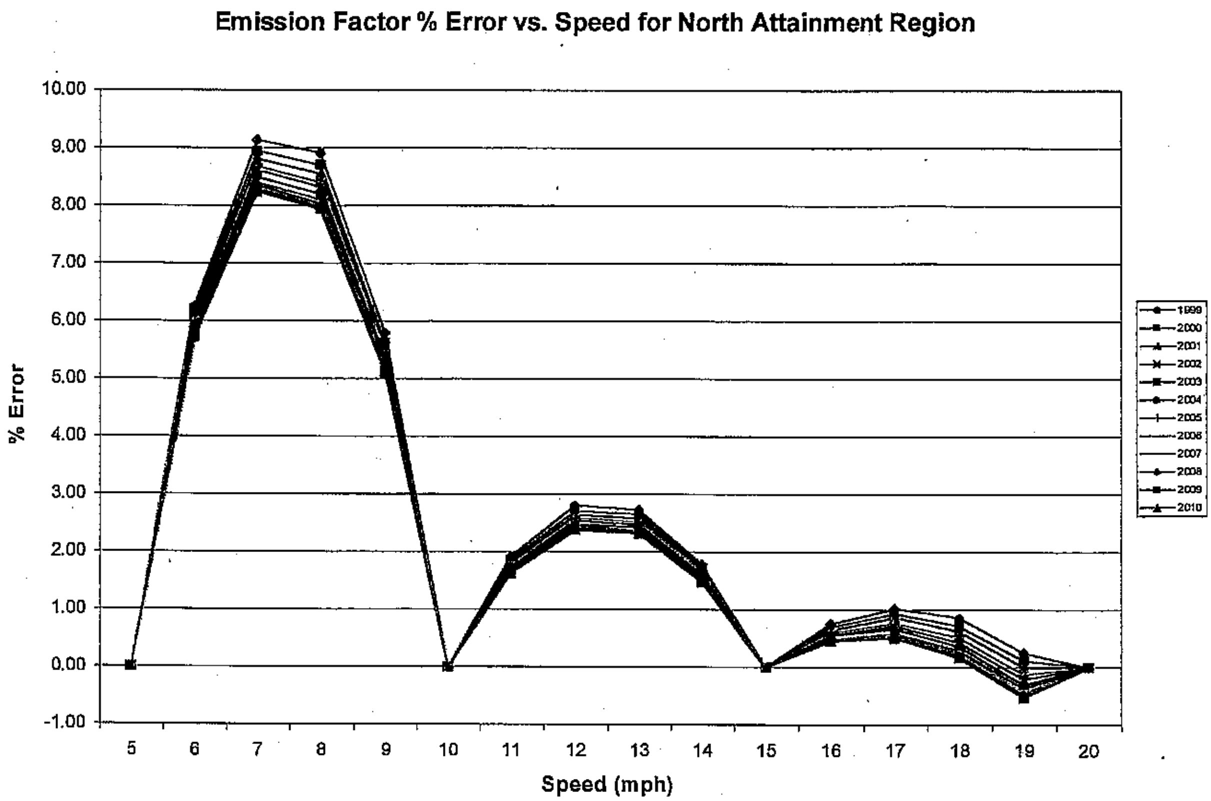


Figure E1 *EF percent error vs speed for North Attainment region.*

Table E1 *Percent error and difference between CAL3QHC CO concentrations with MOBILE5b and COSIM interpolated EFs.*

Year	CO Conc. w/ M5b EFs (ppm)	CO Conc. w/ COSIM Interpolated EFs (ppm)	Error (%)	Difference (ppm)
1999	14.6	15.1	3.3	0.5
2000	14.5	14.9	2.7	0.4
2001	14.1	14.6	3.4	0.5
2002	14.0	14.5	3.4	0.5
2003	13.9	14.4	3.5	0.5
2004	13.8	14.1	2.1	0.3
2005	13.7	14.0	2.1	0.3
2006	13.6	14.0	2.9	0.4
2007	13.5	13.9	2.9	0.4
2008	13.5	13.9	2.9	0.4
2009	13.5	13.9	2.9	0.4
2010	13.3	13.9	4.3	0.6

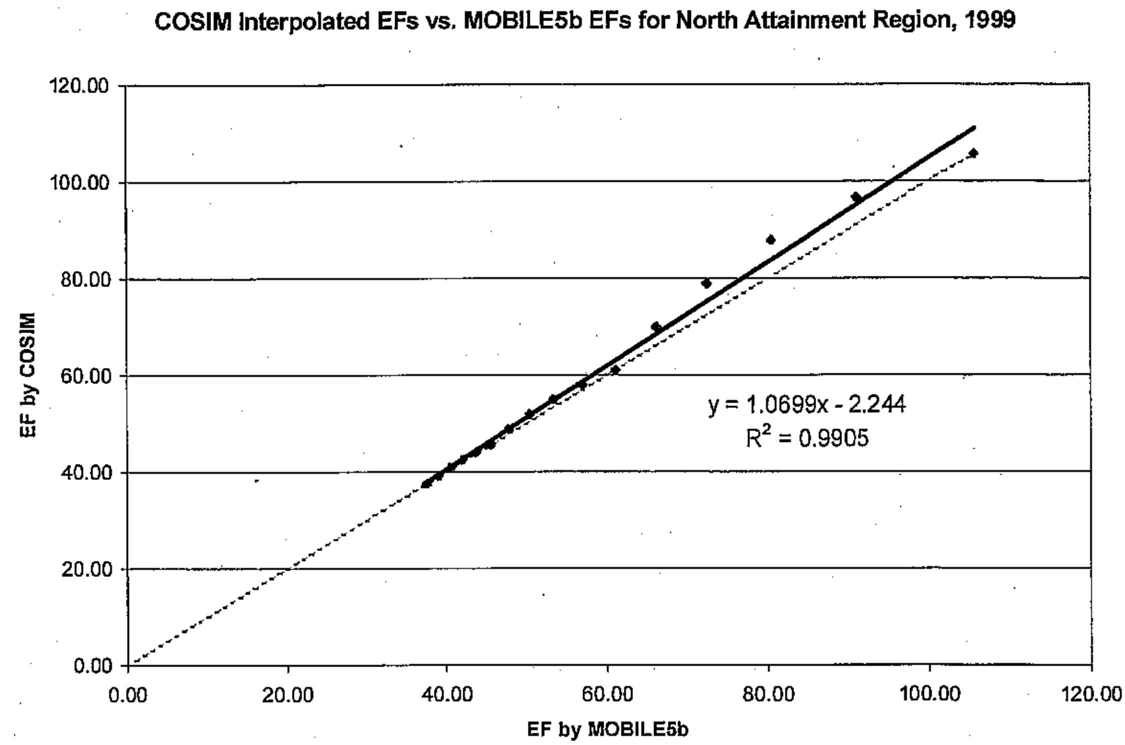


Figure E2 *Comparison of interpolated COSIM EFs and MOBILE5b EFs at the same speeds for Illinois North Attainment Region, 1999.*

Appendix F: Case Study Tests Using Three CO Screening Models

Table F1 *COSIM volume inputs and result summary of screening model tests on Sixth and Monroe.*

Date	Model Averaging Hour	COSIM Volumes B-A Thru (vph)	B-D Right (vph)	C-D Thru (vph)	C-A Left (vph)	COSCREEN98 & Colorado Volumes (vph)	Highest CAL3QHC Detailed Analysis 1-hr ave. Conc. (ppm)	Highest COSIM 1-hr ave. Concentration (ppm)	Highest Florida 1-hr ave. Concentration (ppm)	Highest Colorado 1-hr ave. Concentration (ppm)
7/7/97	8	964	58	260	124	1022	2.9	6.5	8.6	12.3
	9	984	131	395	171	1115	3.7	7.3	9.1	12.9
	10	670	104	261	112	774	3.4	6.2	7.3	11.1
	11	732	122	269	148	854	3.6	6.7	7.7	11.4
	12	749	155	340	147	904	3.8	6.8	8.0	11.6
	13	952	169	429	214	1121	4.0	7.6	9.1	12.9
	14	939	143	420	191	1082	4.0	7.4	8.9	12.7
	15	846	125	363	134	971	4.0	6.9	8.3	12.1
	16	783	117	328	118	900	3.9	6.7	8.0	11.6
	17	896	136	422	138	1032	4.1	7.2	8.6	12.5
	18	869	77	387	118	946	3.4	6.9	8.1	12.0
8/24/98	11	819	122	291	119	941	3.8	6.5	7.9	11.0
	12	1005	132	344	128	1137	3.9	6.9	8.9	12.0
	13	960	122	385	133	1082	4.0	7.1	8.5	11.9
	14	812	124	305	93	936	4.0	6.4	7.9	11.0
	15	750	105	280	86	855	3.7	6.2	7.4	10.6
	16	833	132	370	112	965	4.0	6.8	7.9	11.2
	17	746	82	320	94	828	3.5	6.5	7.2	10.5
	18	456	59	132	54	515	2.6	5.0	5.6	8.4
8/25/98	6	488	44	340	278	618	2.5	6.5	7.2	8.9
	7	1083	83	499	303	1166	3.5	8.1	9.1	12.1
	8	1060	158	377	171	1218	3.8	7.3	9.4	12.4
	9	709	119	313	45	828	3.5	6.2	7.2	10.5
	10	678	117	259	93	795	3.5	6.2	7.0	10.2
	11	800	135	281	109	935	3.5	6.4	7.9	11.0
	12	992	129	447	167	1121	3.8	7.4	8.7	11.9
	13	963	172	361	117	1135	3.9	6.9	8.8	12.0
	14	792	139	317	67	931	3.8	6.7	7.9	11.0
	15	766	120	323	133	886	3.6	6.7	7.6	10.8
	16	879	98	434	182	977	3.8	7.3	7.9	11.2
	17	792	75	365	103	867	3.1	6.7	7.5	10.7
	18	480	58	774	656	1429	3.8	8.7	11.1	13.3
8/26/98	6	492	55	247	173	547	2.8	6.0	5.9	8.5
	7	1113	102	298	108	1215	3.6	6.8	9.4	12.4
	8	1076	154	381	121	1230	3.7	7.1	9.5	12.4
	9	639	95	275	67	734	3.1	6.0	6.8	9.9
	10	664	127	239	75	791	3.4	6.1	7.0	10.2
5/24/99	12	945	79	421	120	1024	3.2	7.1	7.9	10.7
	13	917	67	326	77	984	2.9	6.6	7.6	10.7
	14	872	72	297	76	944	2.9	6.3	7.5	10.5
	15	812	91	341	77	903	3.2	6.6	7.2	10.3
	16	1031	63	452	94	1094	3.1	7.2	8.1	11.3
	17	687	43	274	54	730	2.5	5.9	6.5	9.3
	18	398	32	146	27	430	2.1	4.3	4.7	7.3
	19	344	23	94	21	367	1.7	3.7	4.4	6.6
5/25/99	6	585	27	85	22	612	2.7	4.9	5.9	8.4
	7	1205	65	266	53	1270	3.5	6.6	9.2	11.9
	8	929	65	305	93	994	3.0	6.5	7.6	10.7
	9	731	64	266	37	795	2.8	6.0	6.7	9.6
	10	650	72	244	55	722	2.8	5.8	6.4	9.3
	11	873	60	390	96	933	2.8	6.8	7.5	10.4
	12	986	77	358	84	1063	2.9	6.8	8.0	11.1
	13	861	106	329	71	967	3.2	6.6	7.5	10.7
	14	843	73	276	64	916	2.7	6.2	7.4	10.3
	15	774	73	293	70	847	2.7	6.3	6.9	10.2
	16	897	55	449	106	952	2.6	7.1	7.5	10.5
	17	672	48	248	50	720	2.4	5.8	6.4	9.3
	18	474	54	177	43	528	2.3	5.1	5.4	7.8
	19	312	50	134	32	362	1.9	3.9	4.2	6.4
5/26/99	6	447	36	91	27	483	2.5	4.5	5.0	7.6
	7	1131	65	271	49	1196	3.5	6.5	8.8	11.6
	8	801	83	301	44	884	3.4	6.2	7.1	10.2
	9	567	66	190	39	633	2.8	5.4	5.9	8.5
	10	684	58	231	67	742	2.8	5.8	6.5	9.4
	11	795	58	405	108	853	3.3	7.0	7.0	10.2

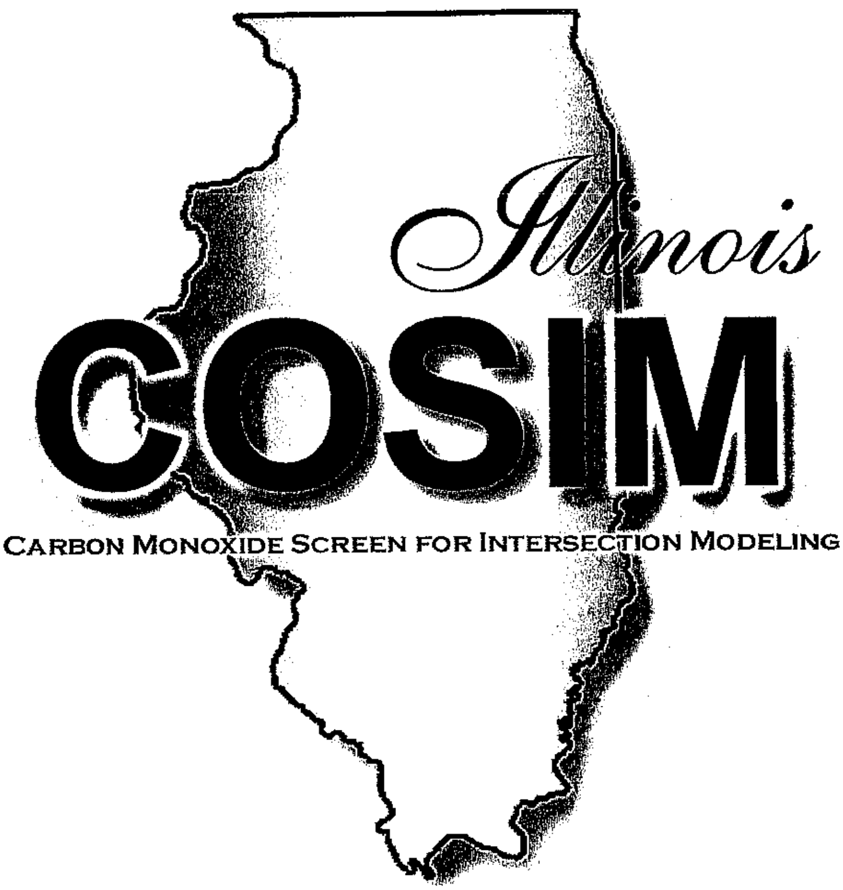
Table F2 *Result summary of screening model tests on University and Main.*

Date	Model Averaging Hour	Highest CAL3QHC Detailed Analysis 1-hr ave. Conc. (ppm)	Highest COSIM 1-hr ave. Concentration (ppm)	Highest Florida 1-hr ave. Concentration (ppm)	Highest Colorado 1-hr ave. Concentration (ppm)
9/23/98	6	3.9	5.7	5.6	8.0
	7	6.1	8.9	7.0	9.2
	8	6.7	8.7	7.0	9.3
	9	5.4	8.9	6.3	8.6
	10	5.3	9.3	6.2	8.2
	11	7.0	6.9	6.3	8.6
9/22/98	12	7.8	9.7	6.8	9.0
	13	7.6	9.5	6.5	8.8
	14	6.5	9.4	6.8	8.8
	15	8.0	10.0	6.8	8.9
	16	8.4	10.7	7.4	9.6
	17	7.9	10.8	7.0	9.2
3/17/99	6	4.3	5.4	5.3	7.5
	7	6.3	8.8	6.8	8.8
	8	6.0	9.0	6.2	8.4
	9	5.3	8.8	5.5	7.7
	10	5.3	8.8	5.9	8.0
	11	6.0	9.6	5.5	7.7
3/16/99	12	5.4	10.1	6.5	8.4
	13	5.4	9.7	6.2	8.2
	14	5.1	9.4	6.2	8.2
	15	5.8	10.1	6.6	8.5
	16	6.1	10.5	6.8	8.6
	17	6.5	10.1	6.7	8.6

Table F3 *Result summary of screening model tests on Irving and Mannheim.*

Date	Model Averaging Hour	Highest CAL3QHC Detailed Analysis 1-hr ave. Conc. (ppm)	Highest COSIM 1-hr ave. Concentration (ppm)	Highest Florida 1-hr ave. Concentration (ppm)	Highest Colorado 1-hr ave. Concentration (ppm)
12/16/94	6	5.3	11.4	8.6	20.6
	7	5.1	10.1	8.0	19.2
	8	5.2	8.8	8.0	19.0
	9	4.6	7.5	6.3	17.2
	10	4.4	8.3	6.0	17.0
	11	4.0	9.4	8.0	19.0
12/21/94	12	3.7	9.0	7.9	18.9
	13	5.6	11.4	8.7	20.7
	14	5.7	12.0	8.7	20.7
	15	6.0	12.6	8.7	20.7
	16	5.3	12.3	8.6	20.3
	17	6.1	13.1	8.9	20.9
12/8/95	6	5.8	8.4	8.0	18.4
	7	7.3	9.9	8.0	18.4
	8	6.8	11.7	8.0	18.4
	9	5.1	9.4	7.5	17.2
	10	4.9	8.9	7.0	17.0
	11	4.1	6.6	6.0	16.2
12/7/95	12	4.3	6.4	5.6	15.6
	13	3.8	5.7	5.0	14.8
	14	5.1	8.0	6.1	16.2
	15	6.7	12.6	8.3	19.0
	16	8.2	13.4	8.4	19.2
	17	7.6	13.4	8.4	19.2

Appendix G: Illinois COSIM User's Manual



USER'S MANUAL

Version 1.0 - August 1999

Written by: Scott Peters
University of Illinois

Prepared for:

Illinois Department of Transportation

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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 occur 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 and Padmini K. Gollapalli 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), William Barbel (IDOT), Sue Stitt (IDOT), Mike Rogers (IEPA), Rob Kaleel (IEPA), Jon-Paul Kohler (FHWA), and Kirk Fauver (FHWA). Additionally, we would like to thank Steve Nadalis (IDOT) for his help with traffic volume analysis and Sam Long (IEPA) for his help with the MOBILE5b input files used in creating 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 MOBILE5 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.

MOBILE5b - 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 eight 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 (NOx), carbon monoxide (CO), carbon dioxide (CO_2), sulfur oxides (e.g., SO_2), 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 MOBILE5b.

MOBILE5b

MOBILE5b 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 eight 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. Therefore project level conformity for the CO standard, as outlined in the 40 Code of Federal Regulations parts 51 and 93 does not apply to Illinois. The COSIM model is concerned specifically with **microscale** intersection analysis and only utilizes MOBILE5b's ability to predict CO emissions. The MOBILE model is frequently updated to encompass changes in vehicle technology and regulations and to reflect emission measurements from updated testing data. MOBILE5b includes updates to account for onboard refueling vapor recovery systems and reformulated gasoline and detergent additives. It also allows for more accurate emission credits for current vehicle I/M programs. The USEPA is currently developing MOBILE6, but until its release the use of MOBILE5b is acceptable for all highway vehicle emission factor modeling (USEPA, 1997). The MOBILE5b emission factors used in COSIM will be updated after the release of MOBILE6.

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 use of COSIM is not required if an intersection project is expected to have a traffic volume of less than 16,000 average daily traffic (ADT) by the end of the first year of operation. If traffic volume is expected to exceed 16,000 ADT by the end of the first year of operation, COSIM should be used to analyze worst-case CO concentrations at nearby sensitive receptors. If the results of COSIM 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 your National Environmental Policy Act (NEPA) document or project report. The COSIM final report should be added to your 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, MOBILE5b 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, 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

Insert Illinois COSIM setup disc 1 of 2 into your computer's 3.5 inch drive. Access the floppy drive and run the *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 shortcut icon will be placed in your *Start* menu and a COSIM program folder will be created in your *Programs* folder. The COSIM folder will contain two icons: COSIM and *Uninstall.*

Uninstalling COSIM

Run *Uninstall* in the COSIM program folder. This will automatically remove all COSIM related files on your computer.

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 IDOT representatives 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

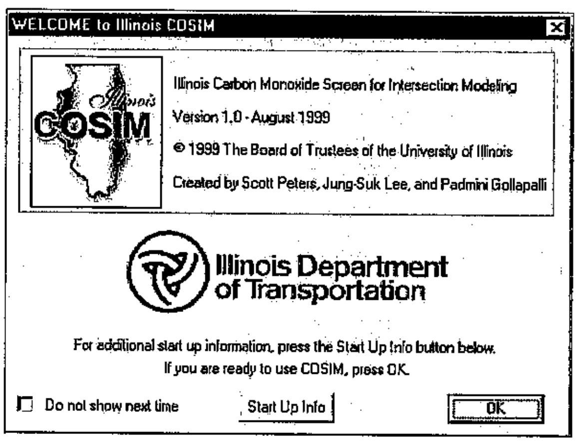
Input Worksheet

After selection of the project intersection(s) to be modeled (based on peak 1-hr traffic volume, vehicle speed, and distance to the closest sensitive receptor), the next step is to obtain the inputs required to run the model. To aid in the model input procedure, we have prepared an input worksheet. 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.

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.

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 ten 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.

GEN Displays the series of general input boxes.

INT Displays the series of intersection input boxes.

REC Displays the receptor input box.

CALC 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. Until CO calculations are made, the title screen will appear in the main view area. After all user inputs are entered and 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.

User Input Variables

User inputs are separated into three categories: general inputs, intersection inputs, and receptor inputs. You must enter the series of input variables in this order. To begin, 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.

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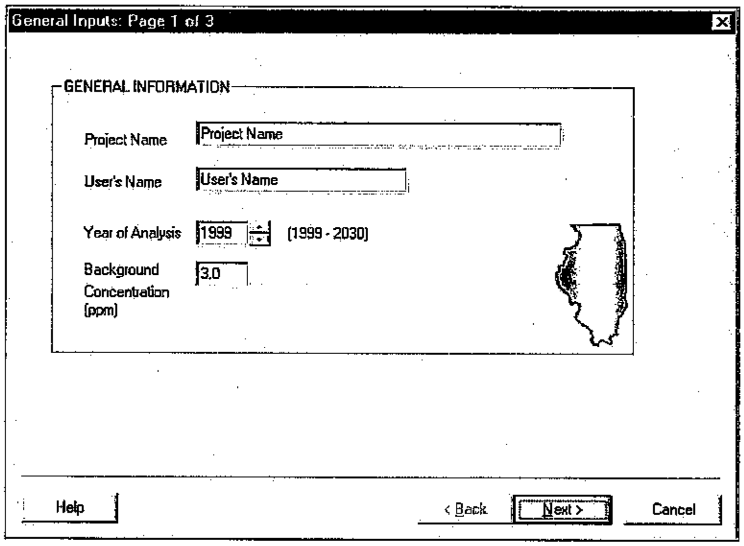

PROJECT NAME - Enter a brief description of the project. This description will be included in the header of the final output.

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 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 MOBILE5b 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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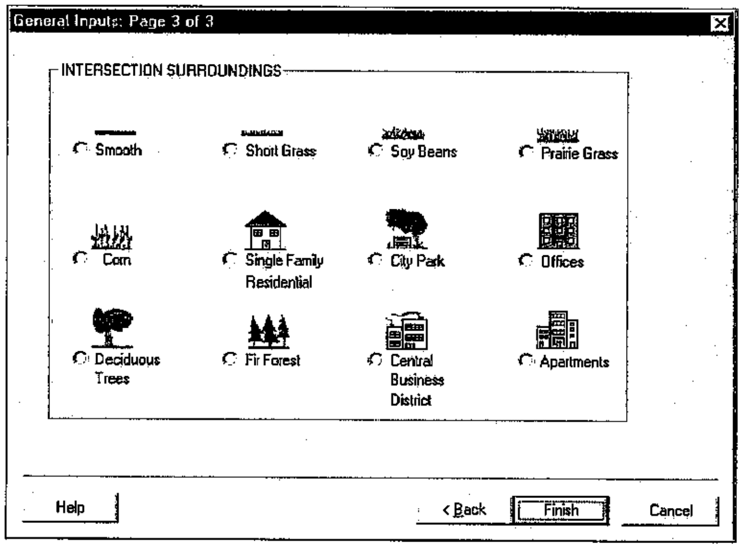


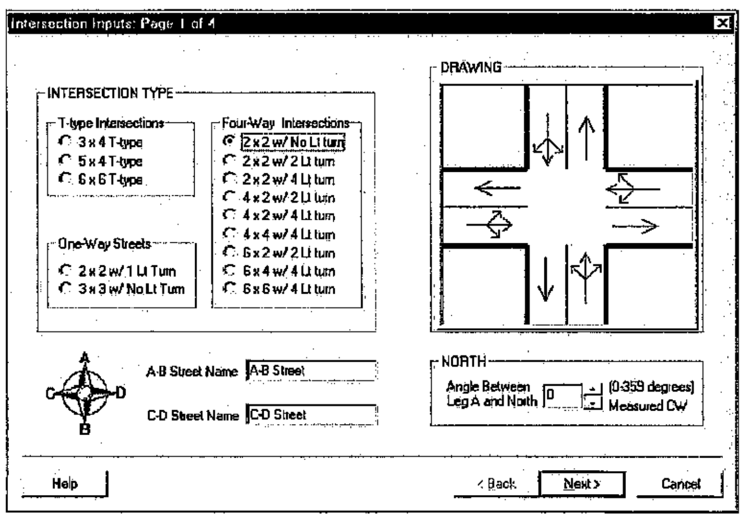
INTERSECTION SURROUNDINGS - Select the predominant type of surroundings. If more than one type of surrounding prevails at the intersection, choose the type of surrounding that is closest to ground level. The icons are arranged from left to right, top to bottom in order of increasing height. For example, 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.

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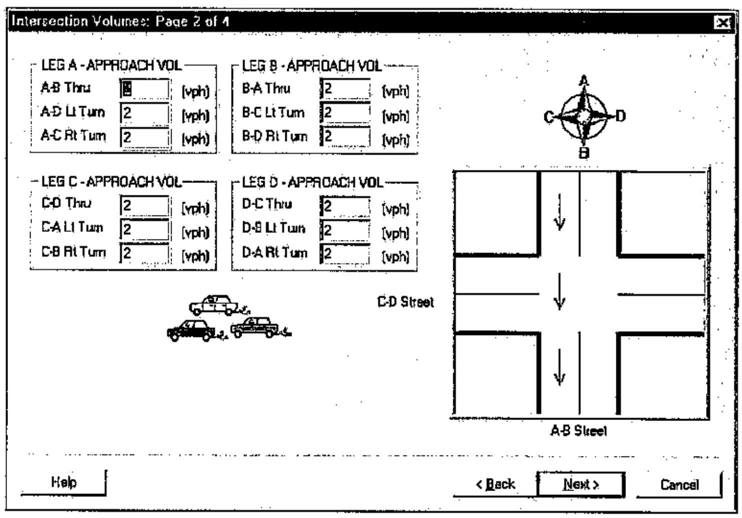
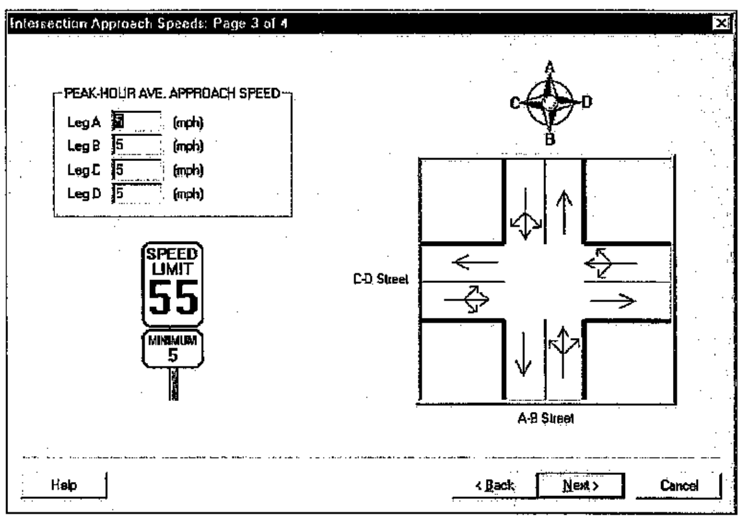


Intersection Volumes - Intersection volumes are separated into three types of movements for each direction: through, left turn, and right turn. All direction designations refer to the direction in which the traffic is approaching the intersection. Through, left turn, and right turn designations refer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

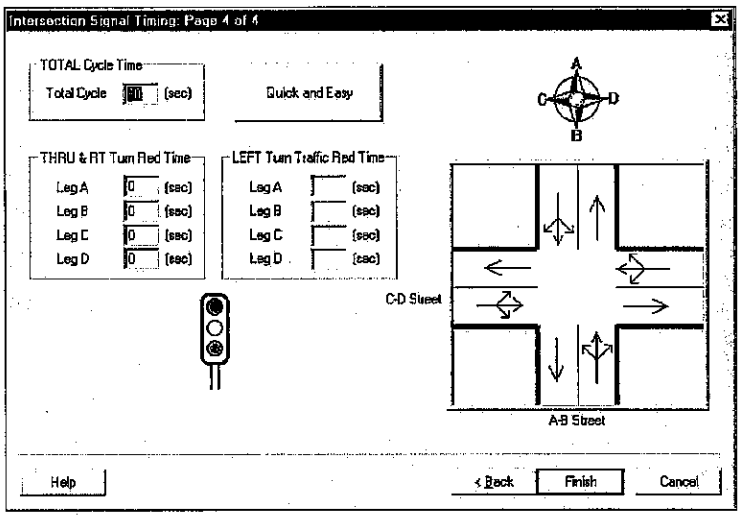
Page 3 of 4



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. 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.

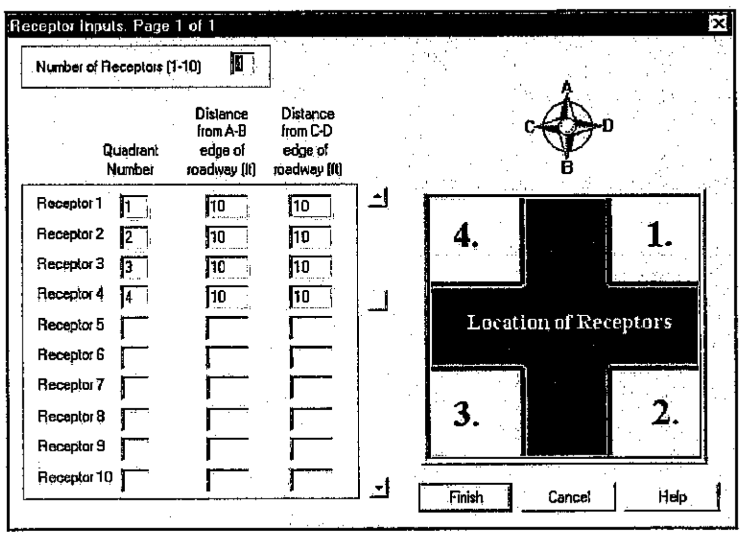
Receptor Inputs

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. Saving a file in COSIM is similar to the procedure in other Windows programs. The user 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. 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

Illinois CO Screen for Intersection Modeling

08-02-99

09.00 PM

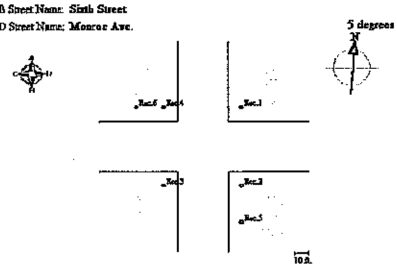
Sixth and Monroe, Downtown Springfield - District 6 - Sangamon County

Performed by: **Ben D. Banana**

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	7.9	6.4	Pass
2	2	10	10	9.7	7.7	Pass
3	3	10	10	9.7	7.7	Pass
4	4	10	10	11.0	8.6	Pass
5	2	10	36	10.4	8.2	Pass
6	4	30	10	11.5	8.9	Pass

*Project PASSES 8-hr NAAQS. Largest 8-hr concentration is 8.9 ppm, at receptor 6

NOTES:

8-hr ave. calculated by applying a persistance factor of 0.7 to 1-hr ave. and adding background.

All concentrations include a background concentration of 3.0 ppm.

Page 1 of 4

Illinois COSIM

USER INPUTS

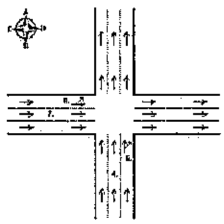
Sixth and Monroe, Downtown Springfield - District 6 - Sangamon County

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

USER INPUTS continued...

Sixth and Monroe, Downtown Springfield - District 6 - Sangamon County

Emission Factors Based On:

District: **6**

County: **Sangamon**

Township: **Not Relevant For Analysis**

Year: **1999**

MOBILE5b Emission Factors:

Idle Emission Factor (g/hr): 430.93

Approach	Speed (mph)	EF (g/mile)
Leg A	---	----
Leg B	20	34.06
Leg C	20	34.06
Leg D	---	----

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

USER COMMENTS

Sixth and Monroe, Downtown Springfield - District 6 - Sangamon County

User Comments:

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

Page 4 of 4

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 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 summaries 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.

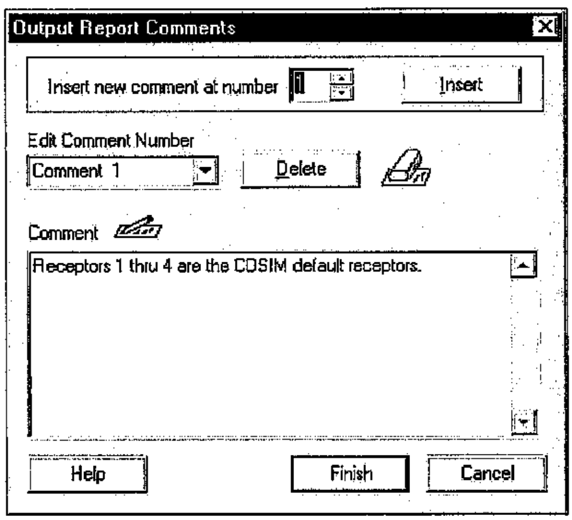
Page three summarizes the EF information and the intersection signal timing. The input variables used to determine the vehicle EFs are presented at the top of the page, followed by the actual EFs used for calculating the CO concentrations. The idle EF is the amount of CO emitted in grams per hour from 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.

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 some users 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.

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.

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 MOBILE5 (Mobile Source Emissions Factor Model), U.S. EPA, Ann Arbor, Michigan, EPA-AA-AQBA-94-01, May (1994).

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).

U.S. Environmental Protection Agency, Memo to EPA Regional Office Air Directors, Aug. 11, (1997).

Appendix

Worksheet Information

To aid in the model input procedure, an input worksheet has been prepared for district use. Using the worksheet is a recommendation, not a model requirement. The worksheet provides a concise, organized method to expedite the data collection process. The data required for the worksheet are explained below. A copy of the worksheet follows this section.

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 has the years 1999 to 2030 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 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.

Illinois COSIM Input Worksheet

Project Name: ____________________________________

Years of Interest: ________________

Intersection Location

IDOT District (1-9): ____________

County: ____________________

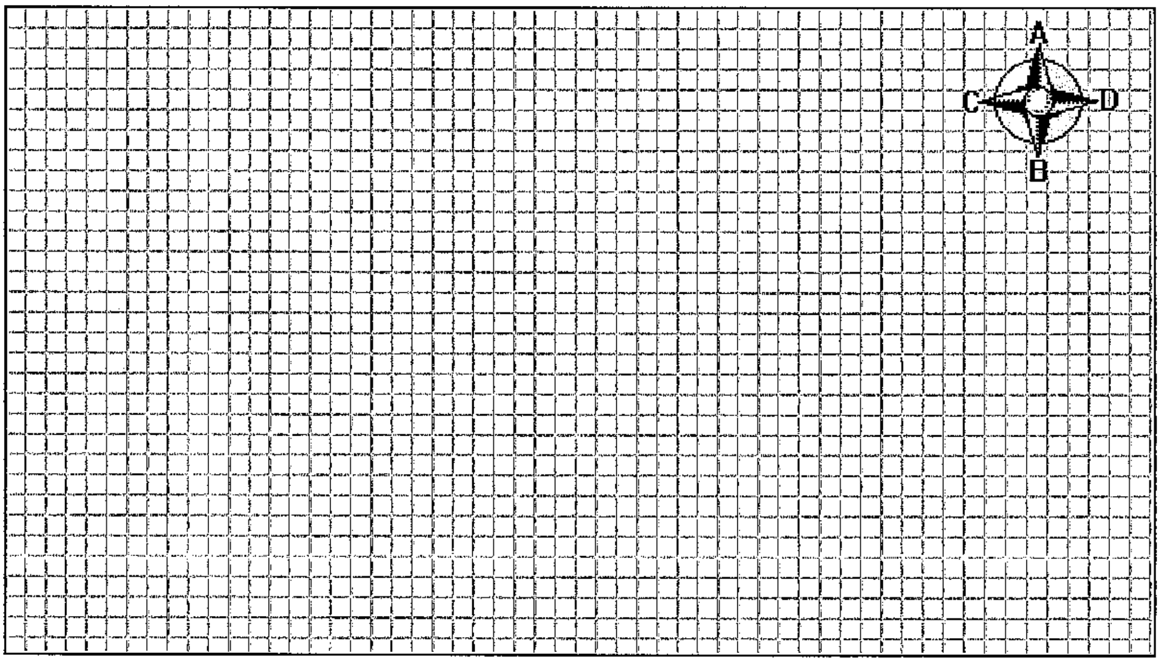
Predominant Surroundings: ____________________

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: ________________________________

Illinois COSIM Input Worksheet

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	

Illinois COSIM Input Worksheet

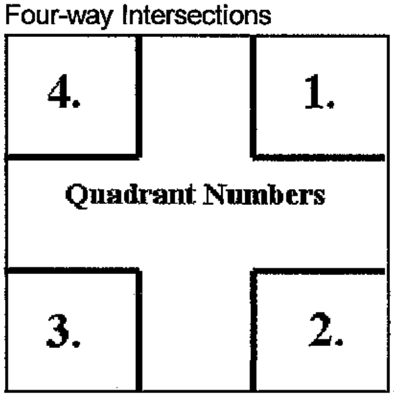
Receptor Locations

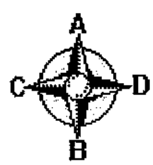
Number of Receptors (1-10): ________

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