# Quick Reference Guide

## For Transportation Planners/Engineers: Generating Traffic & Activity Data for Project-Level Air Quality Analyses

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**AASHTO Committee on Environment and Sustainability**

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# Table of Contents

## Tables



## Figures



### Appendices

# Acronyms/Abbreviations

AADT ........ Annual Average Daily Traffic
AASHTO ........ American Association of State Highway and Transportation Officials
ADT ........ Average Daily Traffic
AEO ........ Annual Energy Outlook
BPR ........ Bureau of Public Roads
CEQA ........ California Environmental Quality Act
DOT ........ Department of Transportation
EA ........ Environmental Assessment
EIS ........ Environmental Impact Statement
EMFAC ........ Emissions Factor Model
EPA ........ Environmental Protection Agency
FAQ ........ Frequently Asked Questions
FHWA ........ Federal Highway Administration
FONSI ........ Finding of No Significant Impact
GHG ........ Greenhouse Gas
HCM ........ Highway Capacity Manual
HDV ........ Heavy-Duty Vehicles
HPMS ........ Highway Performance Monitoring System
LOS ........ Level of Service
MOVES ........ Motor Vehicle Emissions Simulator
MPO ........ Metropolitan Planning Organization
MSAT ........ Mobile Source Air Toxics
NCHRP ........ National Cooperative Highway Research Program
NEPA ........ National Environmental Policy Act
PEL ........ Planning and Environmental Linkages
PM ........ Particulate Matter
SIP ........ State Implementation Plan
TCM ........ Transportation Control Measure
VHT ........ Vehicle-Hours Traveled
VMT ........ Vehicle-Miles Traveled
VSP ........ Vehicle-Specific Power
WSDOT ........ Washington State Department of Transportation

# 1 Introduction

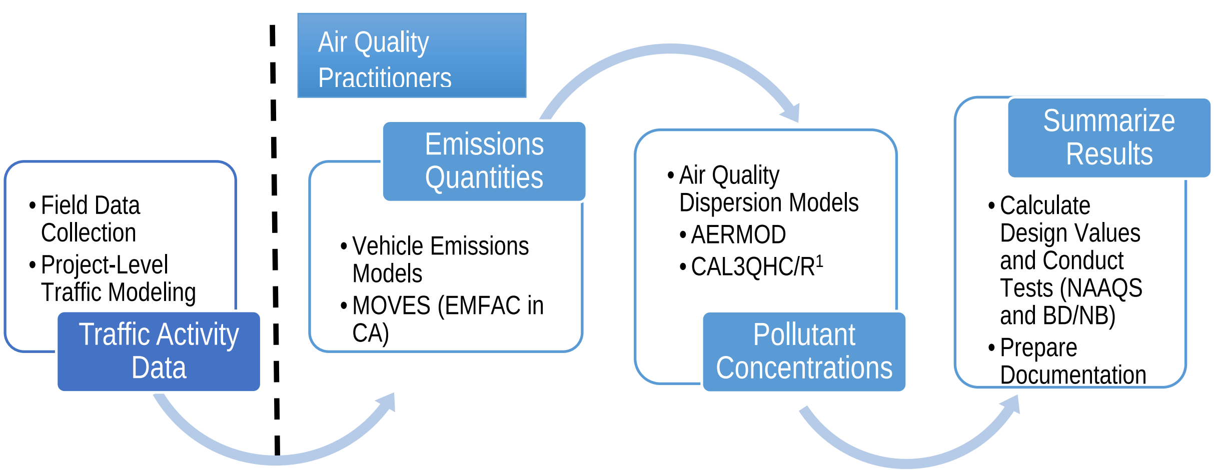
## 1.1 Purpose of this Quick Reference Guide

This quick reference guide is intended to assist traffic analysts who work with traffic data and models in providing the traffic data required for emissions modeling and air quality analysis for transportation projects. It is intended as a supplement to National Cooperative Highway Research Program (NCHRP) Report 765, Analytical Travel Forecasting Approaches for Project-Level Planning and Design. NCHRP Report 765 describes methods, data sources, and procedures for producing travel forecasts for highway project-level analyses.

When a transportation project is undertaken (such as a highway capacity expansion, major interchange improvement, additional lanes at an intersection, or intermodal facility expansion), an air quality analysis may be required to meet federal and/or state requirements related to U.S. Environmental Protection Agency (EPA) transportation conformity regulations, the National Environmental Policy Act (NEPA), associated Federal Highway Administration (FHWA) guidance, and/or state environmental policy. A project-level air quality analysis for any pollutant requires traffic data as inputs into models for estimating vehicle emissions and air pollutant concentrations. These air quality analyses typically have very specific traffic data input requirements that vary by pollutant and sometimes differ from the requirements for planning and design purposes. Furthermore, traffic and air quality practitioners often use different terminology and, therefore, may not fully understand each other's needs.

Coordination is required early in the project development process to ensure that traffic analysts understand the air quality analysts' needs. Lack of such coordination can lead to delays and additional costs in the project evaluation process. Figure 1-1 shows the relationship of the traffic and air quality analyses.

***Figure 1-1. Link between Traffic Analysis and Air Quality Data Needs***




[1] The EPA is finalizing replacement of CALINE3 with AERMOD as preferred appendix A model for refined mobile source applications. A 3-year transition period (till 2020) to transfer to the use of AERMOD for refined modeling applications is currently established. The use of CAL3QHC for CO screening was retained.

This quick reference guide is intended to bridge the gap between the fields of traffic and air quality analyses, thereby ensuring that the right traffic inputs are prepared and provided to support the air quality analysis. This will both streamline and ensure the accuracy of the environmental review for the project.

## 1.2 Continuous Interaction between Traffic and Air Quality Analysts

This guide is not intended to substitute for continuous communication and coordination between the transportation/traffic analyst, the air quality analyst, and other relevant stakeholders—from project inception to completion. All parties should discuss and reach a common understanding of:

- The proposed project and preliminary identification of potential traffic and air quality impacts
- The availability of existing or preliminary traffic data and forecasts that might help the air quality analyst screen the project
- The study area for each pollutant to be analyzed, including the roads/network links to be included which may be potentially affected by potential changes in traffic volumes and operating characteristics
- The timeline for the project and the delivery of traffic data and forecasts in response to the traffic request
- The identification of traffic data needs; suitability of existing data sources; traffic requests to be made to support the air quality analyses (see Appendix A for examples); and the collection of project-specific traffic data needed for air quality analyses
- Any plans for more refined traffic analysis, including the use of a microsimulation model, which could also support the air quality analyses. (Note: Microsimulation would not ordinarily be done just for air quality analysis purposes.)
- Sensitive locations such as schools, hospitals, nursing homes, etc. that may be affected
- The pollutants to be included and the resulting implications for traffic data requirements
- The alternatives that will be evaluated
- The analysis years and time periods to be evaluated
- Key assumptions (e.g., application of consistent growth rates)

An initial goal should be the development of a traffic data collection plan that meets the anticipated requirements of air quality modeling, recognizing that these requirements could change during the project and additional data may be needed. It is important to carefully define a study area and to develop a data collection plan that minimizes the need to collect additional data. Changes in the project scope (if they occur) should be communicated to the air quality analyst in a timely manner to determine whether the technical approach needs to be modified or additional traffic data is required for the air quality analysis.

## 1.3 Organization of This Guide

Depending on the project type, its location, and the air quality attainment status of the area, the air quality analysis for a given project may require one or more of the following types of analysis:

- **Carbon monoxide (CO)** – CO hot-spot analysis for conformity and/or NEPA
- **Particulate matter (PM)** – $PM_{2.5}$ and $PM_{10}$ quantitative hot-spot analysis for conformity
- **Mobile source air toxics (MSAT)** analysis for NEPA
- **Greenhouse gas (GHG)** analysis for some states' environmental policies[1]

Different analysis requirements or guidelines exist for each of these pollutants, with correspondingly different traffic data requirements. This guide is therefore organized to present the traffic data needs for each pollutant.

The remainder of this guide is organized as follows:

- Chapter 2 provides an overview of traffic data requirements and sources to support air quality analysis.
- Chapter 3 explains traffic data requirements and sources for ***CO analysis.***
- Chapter 4 explains traffic data requirements and sources for ***PM conformity (hot-spot) analysis.***
- Chapter 5 explains traffic data requirements and sources for ***MSAT analysis.***
- Chapter 6 explains traffic data requirements and sources for ***GHG analysis.***
- Chapter 7 discusses special situations including:
  - Advanced traffic modeling methods when using MOVES operating mode distribution or drive schedule inputs
  - Reevaluations under NEPA
  - Traffic mitigation measures as they are affected by the air quality modeling results
  - Litigation risk management
- Chapter 8 provides a list of references.
- Appendix A provides sample two-page "traffic information request forms" that list the key traffic data items required for CO, PM, and MSAT.
- Appendix B provides examples of traffic information provided for air quality analyses.
- Appendix C provides definitions for air quality modeling.
- Appendix D provides definition of links in the air quality modeling versus the traffic analysis.

[1] On August 5, 2016, the Council on Environmental Quality issued final guidance for addressing greenhouse gas emissions and climate change impacts in NEPA documents (see *https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf*); however, on March 28, 2017, this guidance was withdrawn pursuant to EO 13783. As of this writing, FHWA has not issued any guidance for addressing GHG emissions.

Chapters 3–5 each contain two components: a flowchart and a table. The flowchart is organized around the major steps in the analysis of each pollutant. Within each step, there are activities required of the transportation/traffic analyst and activities required of the air quality analyst. The flowchart illustrates a typical interaction between the traffic and the air quality analyst during the project.

The table provides a reference for each of the traffic activity inputs required for air quality analysis. The first column of the table indicates the step(s) of the air quality analysis, corresponding to the flowchart, for which the input is relevant. The table then summarizes the impact of that input on emissions or pollution concentrations to assist the analyst in determining which inputs may be of greatest importance for refinement. The table then identifies the various methods that can be used to develop the traffic data input and provides references for further information on the method. The table also identifies whether the method is appropriate to the base year, future year, or both.

## 1.4 How to Use This Guide

To use this guide to assist in providing traffic data for air quality analysis:

1. Review Section 2.1 to obtain an overview of traffic data needs for air quality analysis.
2. Collect basic information on the project and work with the air quality analyst to identify the requirements of the air quality assessment (pollutants, spatial and temporal detail, alternatives, exemptions, etc.).
3. Review the overview of traffic data in Section 2.2, the relevant chapter(s) of this guide (3–6) corresponding to the pollutant(s) that will be analyzed, and the traffic request form in Appendix A, to identify the traffic data needs and potential data sources. If more assistance is needed in reviewing and selecting appropriate traffic data sources, refer to NCHRP Report 765 and other resources listed in Chapter 8 of this guide. Note that each state may have a different guidance. Some state guidance is listed in Chapter 8.
4. Consulting with the air quality analyst, develop a draft traffic data collection plan that meets the anticipated requirements of air quality modeling.
5. Consulting with the air quality analyst, develop the traffic data needed first for screening, and then for detailed analysis as needed.
6. If the project schedule is delayed or the scope is changed, check in with the air quality analyst to see if any traffic data needs have changed, and to identify if any data updates are available and should be used.
7. Refer to Chapter 7 of the guide for more information on special situations, such as notice of project change and litigation risk management, or to Chapter 8 for additional resources.

# 2 Overview of Traffic Data Needs for Air Quality Analysis and Steps in Developing Traffic Data

This section begins with a review of the typical steps in developing traffic data and forecasts for a project-level air quality analysis. This is followed by an overview of the basic traffic data requirements and options to support air quality analysis.

## 2.1 Typical Steps in Developing Traffic Data & Forecasts for a Project-Level Air Quality Analysis

For purposes of efficiency, a three-step process is implemented to determine traffic data needs with each successive step requiring more-detailed information. Initially, a request for traffic data relating to a preliminary assessment is often made to determine if there is a potential for air quality impacts. If the preliminary assessment determines the need for further analysis, a request for screening analysis traffic data and forecasts is often made before any decision is made to request detailed traffic data and forecasts. This process is intended to avoid the time and cost of developing detailed traffic data and forecasts if they will ultimately not be needed for the air quality analysis for a project.

A fourth step, mitigation, may be needed if the detailed air quality analysis indicates an impact above the threshold criteria. This additional step would involve developing mitigation measures and reanalyzing the traffic and air quality effects. See Chapters 3 to 6 for details on the traffic data and forecast needs for each pollutant and for the detailed description of the interaction between the traffic and air quality analysts. Appendix A provides examples of traffic requests for each step of the air quality analyses by pollutant. These request forms in addition to the flow charts in Chapters 3 to 5 may help to clarify the process to the traffic analyst.

1. **Preliminary Assessment**

   – The air quality analyst receives notice of the project, conducts a preliminary review of available planning and design information for the project, and together with the other specialists determines whether the project requires an air quality analysis. If so, and if the traffic information is not already available, the air quality analyst develops an initial traffic request for preliminary or screening analysis traffic data and forecasts that can be used to screen the project.

2. **Develop Screening Data and Forecasts (if needed)**

   – The screening analysis traffic data request typically addresses one or several pollutants (CO, PM, MSATs, and GHGs) and may be based on the templates provided in **Appendix A** or similar standard formats. It may be limited in nature, e.g., to forecast average daily traffic (ADT) and truck percent, which if available already (e.g., for preliminary planning and design needs) would eliminate the need for a screening analysis traffic request for air quality.

   – The screening analysis traffic data request may refer to this guide for additional background on the preparation of traffic data and forecasts for air quality analyses; it may also request data from available traffic studies or planned studies (e.g., traffic impact assessments, operational analyses, microsimulation, etc.) for the project.

- **Safety studies** of which the traffic analyst or other project or agency staff is aware should also be highlighted, as projects that qualify for an exemption (such as may be supported by a safety study) under the federal transportation conformity rule[2] (see Chapter 8) would not require an air quality analysis for purposes of conformity. State DOTs additionally may establish programmatic agreements or their equivalent with FHWA to extend the exemption to air quality analysis for purposes of NEPA.
- The air quality analyst transmits the initial/screening analysis traffic request to the traffic analyst.
- The traffic analyst reviews the screening traffic request and checks with the air quality analyst on any questions. The traffic analyst will typically provide the air quality analyst a target date for the delivery of the requested screening analysis data and forecasts.
- When completed, the traffic analyst transmits the requested screening traffic data and forecasts to the air quality analyst.

  *Notes:*

  - It is important for the traffic analyst to provide capacity constrained forecasts with realistic speeds and (diesel) truck and bus percentages, as the screening for air quality analyses typically involves comparing forecast data such as ADT or truck and bus volumes to threshold values. If the ADT or truck and bus volume exceeds the applicable thresholds, with speeds (correspondingly) low or very low, then the project may not be screened out and a detailed air quality analysis requiring detailed traffic data and forecast may be needed.
  - Examples of screening data as required for each pollutant are provided in **Appendix B**.
- The air quality analyst reviews the delivered screening data and forecasts and determines if the project may be screened out for air quality or if more-detailed traffic data and forecasts will be needed for one or more pollutants. The air quality analyst may screen projects with various means including the EPA conformity rule list of exempt projects, programmatic agreements between FHWA and a state department of transportation (DOT) that establish thresholds for air quality analyses, and thresholds established in federal guidance or the equivalent.

**3. Develop Detailed Traffic Data and Forecasts (if needed)**

- If the project is not screened out in the previous step, the air quality analyst may revise the traffic request to specify more-detailed data and forecasts for one or more pollutants. The revised traffic request should take into consideration the already available or planned traffic studies. Often the more-detailed data and forecasts needed are listed or referenced on the initial (screening) traffic request with a note that they will be needed if the project cannot be screened out using the preliminary or screening traffic data and forecasts. In these cases, the air quality analyst only needs to advise the traffic analyst that those detailed data and forecasts are now needed.

[2] See: 40 CFR 93.126, "Table 2 – Exempt Projects", in which safety is a major category of exempt projects. *https://www.gpo.gov/fdsys/pkg/CFR-2008-title40-vol20/xml/CFR-2008-title40-vol20-sec93-126.xml*

- On projects of greater scope and rush projects, a traffic request for both screening and detailed traffic data may be made at the same time. In these cases, it is typically expected by the air quality analyst that the project will not be screened out and therefore the development of detailed traffic data and forecasts will need to be initiated without delay.
- Modeling Years: Air quality modeling may be conducted for base, opening and design years for each Build Alternative as well as the No Build Alternative, with supporting traffic data and forecasts needed for each year and alternative. Modeling of all years and alternatives provides transparency for NEPA documentation, and may otherwise be needed for EPA transportation conformity rule requirements. In practice, whether all years are modeled may vary by pollutant.
- The air quality analyst transmits the revised traffic request to the traffic analyst.
- The traffic analyst reviews the revised traffic request and checks with the air quality analyst on any questions. The traffic analyst will typically provide the air quality analyst a target date for the delivery of the requested detailed data and forecasts.
- When completed, the traffic analyst transits the requested detailed traffic data and forecasts to the air quality analyst.
- Examples of detailed data as required for each pollutant are also provided in **Appendix B**.

  *Notes:*

  - It is important for the traffic analyst to provide capacity constrained forecasts with realistic speeds and (diesel) truck and bus percentages to generate realistic emission forecasts. This is particularly important for PM analyses, for which the margin for error in meeting the air quality tests may be relatively very small.
  - Modeled emissions for all pollutants increases with traffic volume.
  - Modeled emissions may also increase substantially with low speed operations, which may result from over-estimates of volumes and compounds the effect of increasing modeled emissions.
  - Modeled emissions may also increase significantly with speed for higher-speed operations, depending on the pollutant, road type (restricted versus unrestricted access) and road grade.
- The air quality analyst reviews the delivered detailed data and forecasts for completeness, and initiates air quality modeling. If the modeling shows that the project passes the applicable air quality tests for each pollutant, no further action will be needed.

**4. Mitigation (if needed)**

- If the modeling shows that the project will not pass the applicable air quality tests for any pollutant, mitigation may be needed, which may or may not be sufficient to pass the air quality tests.

  *Notes:*

  - If the margin for error is known in advance to be small (as may often be the case for PM analyses), the traffic analyst should ensure that any traffic mitigation already in place or planned is incorporated as appropriate into the initial set of detailed traffic data and forecasts delivered to the air quality analyst (Step 2).

- In these cases, if traffic mitigation is to be implemented, the air quality analyst may request revised traffic data and forecasts to support a revised air quality analysis.
- The traffic analyst will deliver to the air quality analyst revised traffic data and forecasts as needed reflected the traffic mitigation.
- The air quality analyst will update the modeling for the air quality analysis with the revised traffic data and forecasts as appropriate. If the air quality modeling based on the revised traffic data and forecasts shows that the project will pass the applicable air quality tests, then the project may be cleared for air quality. If not, then the project may not be cleared for air quality and may not be implemented absent other changes (e.g., design changes, delay in opening year, etc.).

## 2.2 Traffic Data to Support Air Quality Analysis

The project-level traffic data needed for air quality analysis may be a combination of field traffic data collection and model data for the base year, along with modeling and/or other projection of base-year data for the future analysis year(s). This traffic data may need to support emissions modeling and/or dispersion modeling, depending upon the analysis requirements. Emissions modeling, which produces quantities of emissions, is normally done using the EPA Motor Vehicle Emission Simulator (MOVES) model in 49 states (in California, the Air Resources Board's Emissions Factor Model [EMFAC] model is used). Dispersion modeling, which produces pollutant concentrations given emission estimates, may be done with models such as AERMOD or CAL3QHC/R. The structure of these models' inputs is one of the drivers of the traffic data requirements, although the air quality analyst can generally take suitable traffic data and format it for the specific model being used.

The traffic data needs for the preliminary assessment, screening, and refined assessments vary by pollutant. Detailed explanations of the traffic data needs and of the interaction between the traffic and the air quality analysts are provided in Chapters 3 to 6 and in Appendix A. The key data requirements that vary by pollutant and level of assessment include:

- Identification of specific roadway facilities (including as needed off-network facilities) such as truck and bus terminals) for emission and dispersion modeling
- The format and level of detail of the traffic data – annual average daily traffic (AADT), level of service (LOS), vehicle-miles of travel (VMT), vehicle type splits, turning movements, speeds, etc.
- Temporal details – which hour(s) of the day and which seasons are critical for air quality analysis for the project
- Scenarios – which project alternatives and years are to be analyzed and compared

Table 2-1 summarizes the traffic data needs by pollutant. These needs are driven by EPA requirements for conformity analysis, and by FHWA guidance for NEPA analysis (see Chapter 8 for references). State environmental regulations and/or guidance may also affect traffic data needs. GHG is not included in this table, since there are no nationally defined requirements or guidelines and analysis methods may vary by state. More detail on some parameters is provided in the traffic request forms in Appendix A.

### *Table 2-1. Traffic Data and Analysis Needs by Pollutant*

| Details | PM Hot-spot Analysis | CO Hot-spot Analysis | MSAT Analysis |
|---|---|---|---|
| Conducted for: | EPA Conformity | EPA Conformity, NEPA | NEPA |
| Definition of affected links and intersections | ▪ Section 1.3 of EPA PM Hotspot Guidance: "The area substantially affected by the project"[a]<br>▪ State DOTs may conduct for state requirements or NEPA | ▪ NEPA: determined by analyst or State guidance[b]<br>▪ Conformity: top intersections based on volumes and LOS per EPA guidance[c] | +/-5-10% change in traffic volume, travel time, or delay affected by project. Limit links to a subset of NEPA traffic set of affected links[d] |
| Traffic data required for project screening/ assessment | ▪ AADT<br>▪ LOS and volumes at affected intersections<br>▪ Percentage of heavy-duty vehicles (HDV) or diesel HDV in AADT and intersection traffic | ▪ LOS, volumes, speeds, truck percentages and signal timing at affected intersections[e] | ▪ AADT<br>▪ Increase in diesel vehicles at intermodal facilities |
| Traffic data required for refined analysis | ▪ Volumes by link<br>▪ Vehicle-hours travelled (VHT) fractions by vehicle type by link<br>▪ Congested speed by link<br>▪ Road grade by link<br>▪ MOVES road type | ▪ Volumes by link<br>▪ VHT fractions by vehicle type by link<br>▪ Turning movements<br>▪ Posted & free-flow speed by link<br>▪ Road grade by link<br>▪ MOVES road type[e] | County level (recommended):<br>▪ VMT by vehicle type and MOVES road type (including ramp fraction)<br>▪ VMT fractions by month, weekday/weekend, and hour of day<br>▪ Average speed distribution[g] |
| Additional traffic data required for dispersion modeling | Signal timing by intersection (CAL3QHCR model only, within 3-year transition period) | ▪ Signal timing by intersection<br>▪ Saturation flow rates<br>▪ Type of roadway<br>▪ Type of link (free-flow or queue) | N/A[h] |
| Temporal details | By 16 time periods to represent 4 seasons of year and 4 times of day. May need 24 hour-by-hour daily periods for 4 seasons for refined dispersion analysis | ▪ Screening: Single hours that represents the traffic scenario during AM and PM peak conditions or up to 4 peak periods<br>▪ Refined[f]: May include multiple hours to represent different peak times of day or 24 hour-by-hour traffic conditions and weekday/weekend or more detailed | By 16 time periods to represent 4 seasons of year and 4 times of day (same as for PM) |
| Scenarios | ▪ Typically, base (existing) year; opening and design years for Build and No Build scenarios<br>▪ May exclude design year if opening year is clearly peak emissions (PM)<br>▪ May exclude No Build scenario if it is shown that National Ambient Air Quality Standards are met (CO, PM) | | |

[a] See Appendix A for PM for more details.
[b] NEPA: Typically focused on locations with queuing, e.g., congested intersection(s), highway segments and interchanges. May follow detailed EPA conformity guidance on discretionary basis.
[c] Conformity: Apply EPA guidance for ranking intersections, which is excerpted in Appendix A for CO.
[d] See Appendix A for MSAT for more details and background.
[e] See Appendix A for CO for more-detailed data requirements for CO assessment and screening analyses.
[f] Refined analysis is rarely needed for CO. Dispersion modeling is rarely performed for MSAT analysis.
[g] The traffic data needs for MSAT analysis assume MOVES is being run at the county scale, per FHWA guidance. If MOVES is run at the project scale, the traffic data needs will be similar to those listed for PM hot-spot analysis. More specific definitions of the traffic data terms in this table are provided in Appendix C.
[h] Dispersion modeling is rarely performed for MSAT analysis.

Note that MOVES can be run at the *project scale* (for individual links), or at the *county scale* (for an area). Normally, the project scale is used for CO and PM analysis, but the county scale may be used for MSAT analysis (per FHWA guidance) or for GHG analysis. MOVES can be used at the county scale for project-level analysis, but the inputs will be different, as they will be expressed as distributions covering the entire modeled area, rather than as data for specific roadway segments. The traffic analyst should be sure to confirm with the air quality analysis if there is any question about the scale of application.

## 2.3 Traffic Data and Modeling Options

Travel forecasting is a critical component of predicting the potential air quality effects of a proposed project, which typically compares the air quality effects for the future No Build (or No Action) condition with the Build (or Proposed Action) condition. The traffic data and modeling plan developed at the start of the project should support the needs of the air quality analysis as well as the project alternatives evaluation, using methods appropriate to the scale and scope of the project. Basic data and simple forecasting methods may be appropriate for smaller-scale projects, while larger-scale projects with potentially significant traffic and environmental impacts may warrant more resource-intensive approaches such as subarea mesoscale or (dynamic) microsimulation modeling.

NCHRP Report 765 provides detailed guidance on travel forecasting procedures at the project level, and the traffic analyst is encouraged to use that document as a reference source. Reference is made throughout this document to relevant sections of Report 765. This section provides a summary of traffic analysis methods common to all pollutant analyses. Chapter 7 of this guide provides more information on **advanced travel forecasting methods,** which may be appropriate for larger, more complex projects. FHWA also provides information on traffic analysis tools on its web site.[3]

### 2.3.1 Traffic Volumes

Traffic analysis for both screening and refined air quality analysis should begin with a reliable set of **base-year traffic volume estimates** for links included in the analysis area, expressed in terms of annual average daily traffic (AADT) or average daily traffic (ADT). These may be obtained from recent traffic counts conducted by a local or regional planning agency or state/county DOT, or counts conducted specifically for the project study. Base-year counts may be all that is needed for some air quality screening purposes.

For some pollutants, **classification counts**—showing at a minimum the percentage or volume of trucks or heavy-duty vehicles—may be needed. For more-detailed air quality modeling, **hourly traffic volumes** will be needed, at different levels of detail depending on the purpose. In some cases (e.g., PM Hot Spot studies), these volumes will be needed for multiple hours representing different times of the day, different days of the week, and possibly different times of the year. **Level of service (LOS) metrics and/or turning movement counts** at intersections may also be needed.

If the air quality analyst is applying MOVES at the county scale, which may be done for MSAT or GHG emissions, the amount of **VMT by road type** in the study domain will be needed, as well as the **ramp**

[3] FHWA, Traffic Analysis Tools web page, https://ops.fhwa.dot.gov/trafficanalysistools/index.htm.

**fraction** (fraction of VMT on restricted-access roads that occurs on ramps), if available (see Appendix C for a definition of MOVES road types).[4]

Depending on the level of detail in the source data, the traffic analyst might apply a factor to convert daily traffic to peak-hour volumes and other factors to determine volumes by direction of travel (see NCHRP Report 765, Chapter 6.8) or variations in truck percentages. Further temporal refinements (e.g., volumes by hour, or day-of-week or monthly factors) may also be needed (see NCHRP Report 765, Chapter 8 and NCHRP WOD 210, Volume 1, Section 4.4). It is possible that regional or state guidance is available to the traffic analyst for doing allocations by the hour of the day.

**Forecast (analysis) year(s) traffic volumes** are also required for quantitative air quality analysis. Future years for which modeling may be needed include the year the project is open to traffic (i.e., the project opening year) and the design year. Project-level travel forecasting comprises two parts: a) background traffic growth, and b) project-specific incremental traffic, either trips generated by new development or diverted trips. The No Action projected traffic volumes are based on the background growth while the Proposed Action traffic volumes include both the background growth and the incremental traffic induced and/or diverted by the proposed project. Projections of future traffic should consider the effects of a constrained roadway network and increases in congestion.

**Background traffic growth** is ideally obtained from the metropolitan planning organization (MPO) regional multimodal travel demand model (see NCHRP Report 765, Chapter 5), which would also have the capability to define a refined subarea/window with much finer network detail within the study area developed specifically for the project analysis (see NCHRP Report 765, Chapter 7). Such a model would be appropriately calibrated on existing (observed) field conditions, ground counts, and screen line data and then modified to reflect projected changes in land use (and/or activities) and anticipated changes in the transportation system. The modeled volumes by link may not closely match actual traffic volumes for each link, especially on lower-volume links; however, overall corridor travel should match reasonably well with the calibrated model results.

If an MPO model is not available or has not been updated recently, short-range or mid-range growth rates can be derived from trend analysis of historical traffic data on Highway Performance Monitoring System (HPMS) sections (as obtained from the state DOT) or other roadway links near the study area, or from projected population and employment growth from a local or regional planning agency. See NCHRP Report 765, Chapter 3.6 and Chapter 10 for more information.

Since travel demand models are regional in nature, project-level refinements of their outputs may be used to produce more realistic volumes for roadways that are in line with existing traffic counts on those roadways. The refinement procedures are grouped in four categories: traffic volumes, turning movements, directional splits, and speeds. These refinement procedures can be found in NCHRP Report 765, Chapter 6.

**Generated traffic** is generally related to changes in land use either included or directly supported by the proposed project. The trips entering and leaving a development site by hour can be determined by using the *ITE Trip Generation Handbook* or from local before/after traffic surveys for similar development.

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[4] MOVES2014 allows ramp fraction as a user input, although default values are provided. Note that ramp fraction may be eliminated as a user input in future versions of MOVES.

Site-specific generated traffic is then assigned to various corridors based on a market analysis. Further assignment of generated traffic to parallel or competing routes can be done manually (based on relative travel time and costs), by employing a subarea/windowing of the regional model, or by employing a microsimulation model capable of traffic assignment. If the regional transportation model already includes the project-related site development, the model will handle the induced trips directly.

**Diverted traffic** is often attributable to projects that improve corridor capacity (roadway widening) or projects that remove a significant bottleneck. Diverted traffic can also be caused by construction activities, changes in toll policies, or changes in lane utilization. The estimation of diverted traffic for major projects is best handled by a regional model with subarea windowing capabilities since trips originating from outside the study area may use different entry points to the study area and areas outside the study area may be affected. For smaller projects, a subarea or corridor-level model may be adequate if traffic impacts are mostly confined within the study area (e.g., a shift in traffic between adjacent parallel routes).

In metropolitan areas with significant mass transit systems, a transportation project could result in a **mode shift** between auto and transit, which may need to be accounted for depending on the scope and magnitude of the project. These shifts in mode share are best handled by a multimodal transportation model. If such a model is not available, the use of elasticities based on the experience of similar projects may be adequate (but should be used with caution).

In some cases, traffic data may be available from related or non-related studies performed at nearby or adjacent areas. These should always be used with caution to ensure that the traffic data is current and usable for the intended purpose.

### 2.3.2 Traffic Speeds

Traffic speeds are one of the most importance influences on pollutant emission factors and, therefore, on local air quality. The specific requirements for speed data depend upon the pollutant, level of analysis (screening or refined), and scale of MOVES application (project or county). Speed data will be required for each link in the modeled study area domain. Requirements may include an average and/or congested link speed that does or does not include intersection delays (see traffic request forms in Appendix A for details), or an average link speed by time period (hour). If MOVES is applied at the county scale, a “speed distribution,” or a distribution of vehicle-hours of travel (VHT) across 16 speed categories, in the study area is needed (see Appendix C for a definition of the speed categories). Speeds by vehicle type (at a minimum, trucks vs. cars) may be helpful for some analyses if available.

For **existing conditions**, speed data may be available from Traffic Management Centers or online sources. If speed data are not readily available it may be necessary to conduct speed and delay runs, or purchase speed data from “big data” sources aggregated from mobile GPS devices, cellphones, and/or Bluetooth readers. These data can be used to determine the average link speed at different times of day. State DOTs and MPOs are increasingly purchasing speed data from private providers although caution is recommended regarding potential bias issues. Lacking any other speed data, the posted speed limit is sometimes used as a proxy for average speed by link.

**Forecast year speeds** by link must be obtained from a travel demand model, a mesoscale subarea model, or a microsimulation model capable of traffic assignment. If a model is used for forecast year speed data, it should also be used for the base-year speeds for consistency. Travel demand model output is typically poor in defining the speeds on the network but speed estimates can sometimes be improved through post-processing. This might be accomplished through deterministic techniques, including Bureau of Public Roads (BPR) equations and Highway Capacity Manual (HCM) methods that are based on demand volumes and saturation flow rates. NCHRP Report 765, Chapter 6 and NCHRP Web-Only Document 210 provide more information on speed post-processing methods. Speed is one of the most important inputs to emissions models and careful attention should be given to ensuring the reasonableness of the speed or speed distribution estimates.

### 2.3.3 Other Traffic Data

Other traffic-related data elements may be required by the air quality analyst. Within the CAL3QHC model for intersection links considering CO, details are needed related to **signal timing**, including the overall cycle length, red time for given movements, and signal offsets. The preferred source of signal timing data is from existing signal permits from the local jurisdiction or county or state highway agency. If the signal timing is not readily available, field measurement of signal timing may be adequate. The signal timing at actuated signals is dependent upon traffic volumes and multiple measurements may be needed to estimate the average cycle length and red time at each approach.

The traffic analyst, as a part of HCM (or equivalent) analysis of these locations, may propose signal optimization measures for these locations under proposed and/or future No Build conditions. That assessment will allow determination of the LOS for those locations as well as other details such as the average delay and queue length by approach movement (e.g., left-turn lanes by direction), which will assist in the refined definition of links in PM hot-spot studies.

**Length and grade** are also inputs for links in the MOVES model. Data might come from a review of the preliminary design plans and profiles from the project design team, which may be done by the traffic or air quality analyst. The traffic analyst may need to consider the potential for effects on speed and LOS.

**Start, parked, and hoteling fractions** inputs to MOVES provide information on vehicle start, parking, and idling patterns for “off-network” analysis (e.g., within a terminal or parking lot, rather than on a roadway link) using the MOVES project-level scale. They may be needed if emissions from an intermodal facility are being analyzed. Data can be collected through field surveys or using information from other similar facilities.

# 3 Carbon Monoxide Analysis

This section summarizes the procedures and data sources for providing traffic data for input to project-level CO analysis.

**Figure 3-1** shows the typical steps for how traffic data activity informs air quality analysis throughout the CO analysis process. The yellow boxes show traffic-related analysis and data development typically undertaken by the traffic analyst, while the green boxes show air quality analysis steps typically undertaken by the air quality analyst.

Step 1 of this process, Project Assessment, includes project definition, traffic data collection, preliminary air quality assessment, and optional steps to support use of available programmatic agreements[5] or similar screening tools and FHWA categorical finding for CO. Step 2 identifies the data for screening analysis, and Step 3 identifies the data for refined analysis, if needed.

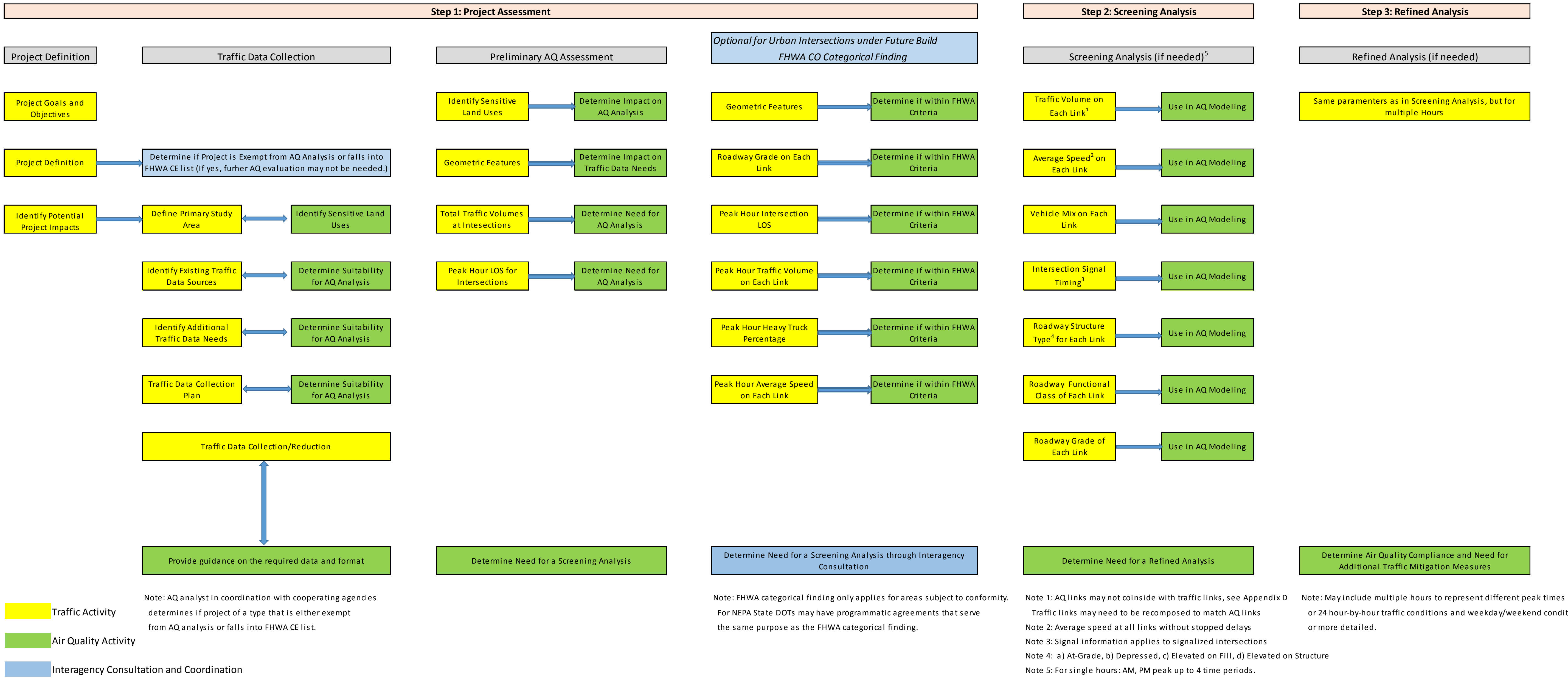
**Table 3-1** identifies data sources and methods for developing traffic data inputs to CO analysis.

- “Project stage/step” refers to the steps shown in Figure 3-1. One step may include multiple traffic/activity inputs.
- “Traffic/activity input” describes the specific traffic data input covered in that row or rows of the table.
- “Impact on emissions and concentrations” presents data from sensitivity analyses related to the impact of that input on emissions estimates. This information can help the analyst prioritize resources toward refining the most significant inputs.
- “Method” describes methods available for developing the traffic data item. More than one method may be possible for each item.
- “Base year” and “future year” columns identify whether the method is suitable for base-year analysis, future year analysis, or both.
- The “References” column identifies reports that provide more detail on developing the traffic data input.
- The “Comments” column provides additional information related to the input.

In addition to these resources, Appendix A provides a sample traffic information request form for CO analysis. The form provides checklists of the traffic data items needed for (1) project assessment, (2) screening analysis, and (3) refined analysis. Appendix B provides examples of traffic data supplied by agencies.

5 See FHWA CO Categorical Hot-Spot Finding with MOVES2014a: *https://www.fhwa.dot.gov/environment/air_quality/conformity/policy_and_guidance/cmcf_2017/hotspot_memo.cfm and NCHRP Programmatic Agreements for Project-Level Air Quality Analyses Using MOVES, CAL3QHC/R and AERMOD: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(78)_FR.pdf*

### *Figure 3-1. Typical Traffic Analysis and CO Air Quality Analysis Interaction*




**SEE APPENDIX A TRAFFIC REQUEST FORM FOR CO**

*Table 3-1. Data Sources and Methods for Traffic Inputs for Project-Level Carbon Monoxide Analysis*

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions and Concentrations[1] | Method | Base Year | Future Year | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Project Assessment, Step 1 | Intersection LOS at locations potentially affected by the project | Important if future year LOS is D or worse[2] | LOS is usually an output of traffic analysis or traffic simulation software | X | X | NCHRP Report 765, 2.3.1, 2.4.3 | Highway Capacity Manual (HCM) software (HCS7, release 7.4), microsimulation model, or areawide mesoscale traffic model/data |
| | | | If LOS is not included in the general model output, NCHRP Report 765 describes in detail the HCM Sixth Edition computational methodology | X | X | NCHRP Report 765, Section 10.4, pp 252-257 | |
| Project Assessment, Step 1 | Total traffic volume at intersections potentially affected by the project | Important to determine whether further analysis is required | Turning movement counts (video or manual) to establish baseline conditions or automatic traffic recorders counts at each approach; use of traffic assignment model to determine change in traffic volumes at each intersection; manual traffic assignment may be appropriate for simple networks. | X | X | NCHRP WOD 210, Vol. 2, Section 4.3.3, p 4-24 to 4-26 | Collected using pneumatic road tubes, radar, video, manual counts, or other methods |
| Project Assessment, Step 1: (for FHWA CO categorical finding) Screening Analysis, Step 2: potentially for more years of analysis, more time periods. Refined Analysis, Step 3: for multiple hours, potentially for days of the week | Traffic volumes for each approach including turning movements, if at intersections or interchanges | Very substantial impact | State DOT or MPO traffic count database | X | X | | AADT maps and reports are usually produced by State DOTs, sometimes larger MPOs have more-detailed maps |
| | | | Project-specific traffic counts | | | NCHRP WOD 210, Vol. 2, Section 4.3.3, p 4-24 to 4-26 | Collected using pneumatic road tubes, radar, video, manual counts, or other methods |
| | | | Trend analysis, growth rates or elasticities applied to base-year counts | X | X | NCHRP Report 765, Ch 3.6 & 4 | Some DOT websites will include traffic forecasts or growth rates. |
| | | | MPO or State travel demand forecasting model | | | NCHRP Report 765, Ch 3.6 & 4 | |
| | | | Manual gravity tool | | | NCHRP Report 765, Ch 3.6 & 4 | Designed for situations not covered by a travel demand model |
| | | | Traffic impact study tools | | | NCHRP Report 765, Ch 3.6 | Assist with forecasting traffic increases due to development along corridor |
| | | | Turning movement sketch tools | | | NCHRP Report 765, Ch 3.6 & 4 | May be useful if separate links are defined for turning movements |
| Project Assessment, Step 1: (to support FHWA CO categorical finding) | Percentage of heavy-duty trucks | | Vehicle classification counts or HPMS database | | X | NCHRP Report 765, Ch 9.3<br>NCHRP WOD 210, Vol. 2, Section 4.2.3 | The data may also be available from regional travel demand model output, state/county inventory of traffic counts, and/or MPO. |
| Project Assessment, Step 1: (to support FHWA CO categorical finding)<br>Screening Analysis,<br>Step 2<br>Refined Analysis,<br>Step 3 | Average speed (excluding stopped delays)<br>at each approach | Important to determine whether further analysis is required | Speed and delay runs (excluding the delays at intersections) can be used to determine the average link speed. Posted speed limit is sometimes used when other data is not available. Speed data during off-peak periods from big data providers may also be useful. | X | X | NCHRP Report 765 Section 3.4 | The average approach delays at intersections can be estimated using HCM software and then subtracted from the total link travel time to determine the average speed. |
| Project Assessment, Step 1(to support FHWA CO categorical finding) Screening Analysis,<br>Step 2<br>Refined Analysis,<br>Step 3 | Vehicle mix on each link (as available)[3] | Vehicle mix has a substantial impact:<br>diesel vs gasoline<br>car vs truck<br>Heavy vs light trucks (single-unit vs combination trucks) | Vehicle classification counts are the most common method of obtaining vehicle mix for each link. | X | X | NCHRP WOD 210, Section 4.2.3 | |
| | | | Regional average vehicle mix by road type | | | | |
| | | | Vehicle classification counts | | | NCHRP Report 765, Ch 9.3<br>NCHRP WOD 210, Vol. 2, Section 4.2.3 | |

[1] Impact is based on the following changes in results: Modest = <5%; Moderate = 5–15%; Substantial = 15–50%; Very Substantial = >50%.
[2] Future years may include opening and design years.
[3] Vehicle mix is a fraction of volume by vehicle class and, in this case, it is equal to the percent of vehicle hours travelled (VHT) by each vehicle class on each link – see Appendix D for details.

*Table 3-1. Data Sources and Methods for Traffic Inputs for Project-Level Carbon Monoxide Analysis (continued)*

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions and Concentrations[4] | Method | Base Year | Future Year | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Screening Analysis, Step 2 Refined Analysis, Step 3 | Signal timing at each intersection | Substantial impact at high-volume/capacity ratio | Official signal timing plans by time of day generally available from local jurisdictions; signal timings can also be measured in the field using a stop watch, if necessary. | X | X | NCHRP Report 765, Section 5.4 | Signal timing for actuated and semi-actuation signals can vary as a function of demand. |
| Screening Analysis, Step 2 Refined Analysis, Step 3 | Road grade by link | Very substantial (steep grades) | Available from microsimulation models or specific GIS databases; approximate grades can be scaled from U.S. Geologic Service maps; more accurate grades may be available from as-built plans | X | X | NCHRP WOD 210, Vol. 2, Section 4.4 | GIS database may be available from local jurisdiction or state DOT. |
| Screening Analysis, Step 2 Refined Analysis, Step 3 | Highway functional class (road type) by link | Modest | Derive MOVES classification based on functional classification and rural or urban location | X | X | NCHRP Report 765 Ch 9.3 Table 9-4 | Usually available from regional models or roadway inventory databases; conversion from functional class to MOVES road types may be required. |
| Refined Analysis, Step 3 | Traffic volumes on each link for multiple hours or 24-hours during weekdays and weekends | Very substantial impact | Traffic assignment model output by hour for each link | X | X | NCHRP Report 765, 7.1, 7.2 | Regional model enhanced to provide additional subarea detail may be used.; post-processing may be required to produce hourly volumes based on temporal distribution. |
| Refined Analysis, Step 3 | Roadway structure type | Modest | Roadway structure type: at-grade, elevated on fill, elevated on structure, or depressed | X | X | | Usually available from as-built drawings; field observations; or online mapping services. |
| Refined Analysis, Step 3 | Vehicle mix on each link for multiple hours or 24-hours during weekdays and weekends | Vehicle mix has a substantial impact | Travel demand model output; traffic assignment model output | X | X | NCHRP Report 765, 9.3 | Generally model outputs include autos, buses, small trucks, medium trucks, and heavy trucks. |
| Refined Analysis, Step 3 | Average speed by link for each hour of the day, excluding stopped delays during weekdays and weekends | Very substantial impact | Speed and delay runs (excluding the delays at intersections) can be used to determine the average link speed. Posted speed limit is sometimes used when other data is not available. Speed data during off-peak periods from big data providers may also be useful. | X | X | NCHRP Report 765, 3.4 | The average approach delays at intersections can be estimated using HCM software and then subtracted from the total link travel time to determine the average speed. |

[4] Impact is based on the following changes in results: Modest = <5%; Moderate = 5–15%; Substantial = 15–50%; Very Substantial = >50%.

# 4 Particulate Matter Analysis

This section summarizes the procedures and data sources for providing traffic data for input to project-level PM analysis.

**Figure 4-1** shows the typical steps for how traffic data activity informs air quality analysis throughout the PM analysis process. The yellow boxes show traffic-related analysis and data development typically undertaken by the traffic analyst, while the green boxes show air quality analysis steps typically undertaken by the air quality analyst.

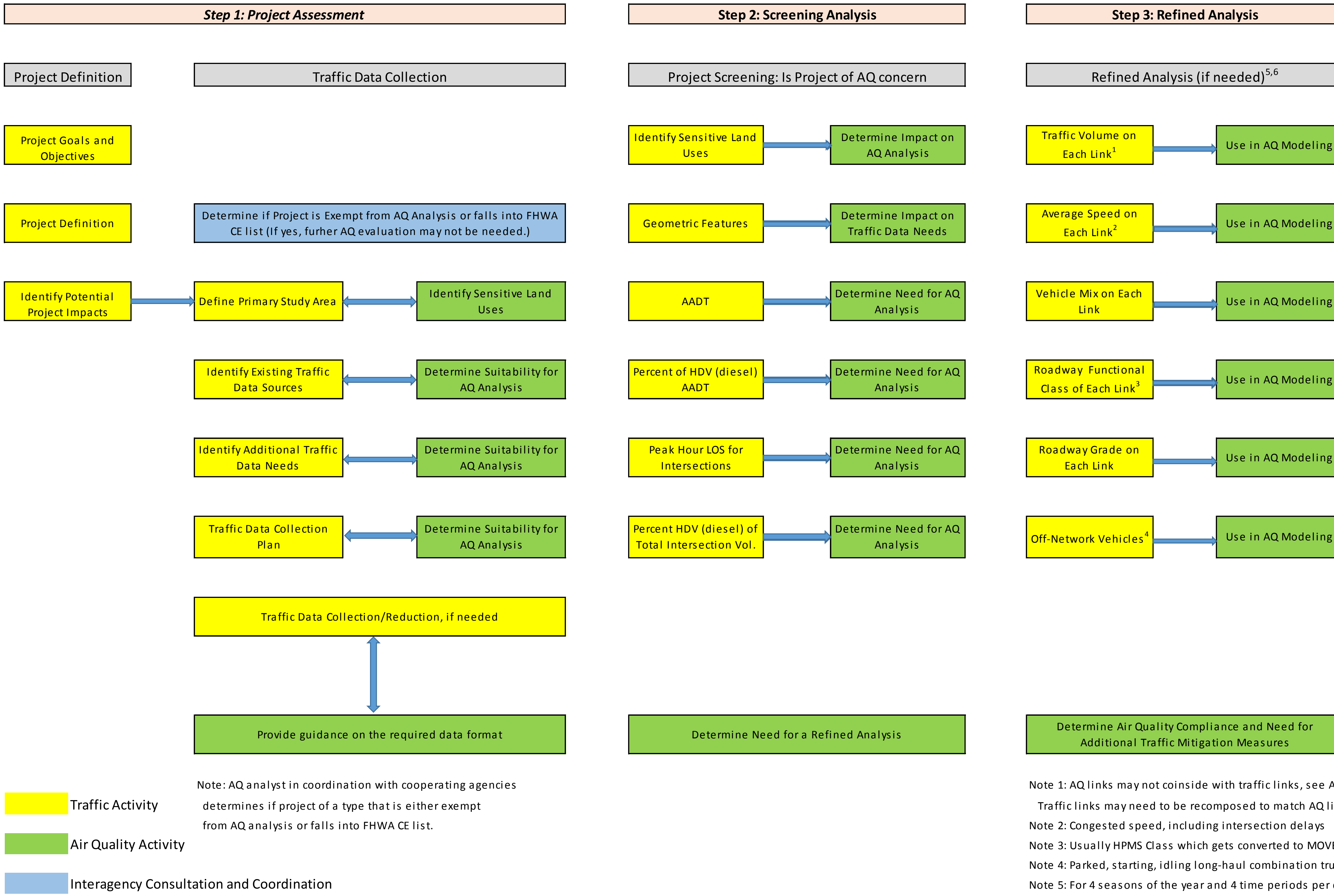
Step 1 of this process, Project Assessment, includes project definition and traffic data collection. Step 2 identifies the data for screening analysis, and Step 3 identifies the data for refined analysis, if needed.

**Table 4-1** identifies data sources and methods for developing traffic data inputs to PM analysis.

- "Project stage/step" refers to the steps shown in Figure 4-1. One step may include multiple traffic/activity inputs.
- "Traffic/activity input" describes the specific traffic data input covered in that row or rows of the table.
- "Impact on emissions and concentrations" presents data from sensitivity analyses related to the impact of that input on emissions estimates. This information can help the analyst prioritize resources toward refining the most significant inputs.
- "Method" describes methods available for developing the traffic data item. More than one method may be possible for each item.
- "Base year" and "future year" columns identify whether the method is suitable for base-year analysis, future year analysis, or both.
- The "References" column identifies reports that provide more detail on developing the traffic data input.
- The "Comments" column provides additional information related to the input.

In addition to these resources, Appendix A provides a sample traffic information request form for PM analysis. The form provides checklists of the traffic data items needed for (1) project assessment and (2) refined analysis. Appendix B provides examples of traffic data supplied by agencies.

***Figure 4-1. Typical Traffic Analysis and PM Air Quality Analysis Interaction***




Note: AQ analyst in coordination with cooperating agencies determines if project of a type that is either exempt from AQ analysis or falls into FHWA CE list.

**SEE APPENDIX A TRAFFIC REQUEST FORM FOR PM**

Note 1: AQ links may not coinside with traffic links, see Appendix D
Traffic links may need to be recomposed to match AQ links
Note 2: Congested speed, including intersection delays
Note 3: Usually HPMS Class which gets converted to MOVES classess
Note 4: Parked, starting, idling long-haul combination trucks only
Note 5: For 4 seasons of the year and 4 time periods per day -- 16 runs.
May need 24 hour-by-hour daily periods for 4 seasons
Note 6: Traffic and AQ analysts specify links for modeling -- see App A (PM) for details.

***Table 4-1. Data Sources and Methods for Traffic Inputs for Project-Level Particulate Matter Analysis***

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions and/or Concentrations[1] | Method | Base Year | Future Year[2] | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Project Assessment, Step 1 | Qualitative | | Project description, study area, anticipated impacts, sensitive locations, etc.. | | | | Qualitative assessment based on project description, study area, and sensitive locations adjacent to the project. |
| Project Screening, Step 2 | Annual average daily traffic (AADT) by link | Very substantial | State DOT or MPO traffic count database | | X | | AADT maps and reports are usually produced by State DOTs, sometimes larger MPOs have more-detailed maps |
| | | | Project-specific traffic counts | | | NCHRP WOD 210, Vol. 2, Section 4.3.3 | Collected using pneumatic road tubes, radar, video, manual counts, or other methods |
| | | | Trend analysis, growth rates or elasticities applied to base-year counts | | | NCHRP Report 765, Ch 3.6 & 4 | Some DOT websites will include traffic forecasts or growth rates |
| | | | MPO or state travel demand forecasting model | | | NCHRP Report 765, Ch 3.6 & 4 | |
| | | | Subarea or corridor refined model | | | NCHRP Report 765, Ch 7 | |
| | | | Traffic impact study tools | | | NCHRP Report 765, Ch 3.6 | Assist with forecasting traffic increases due to development along corridor |
| | | | Turning movement sketch tools | | | NCHRP Report 765, Ch 3.6 & 4 | May be useful if separate links are defined for turning movements |
| Project Screening, Step 2 | Percentage of heavy-duty vehicles (HDV) in AADT or percentage of diesel HDV in AADT | Very substantial | Vehicle classification counts | | X | NCHRP Report 765, Ch 9.3 | Limitation: HDV only, not diesel % |
| | | | License plate surveys (matched to registration data) | | | NCHRP WOD 210, Vol. 2, Section 4.1.3 | |
| | | | Registration data (from state motor vehicles office or IHS Automotive) or MOVES default | | | NCHRP Report 765, Ch 9.3<br>NCHRP WOD 210, Vol. 2, Section 4.2.3 | Limitation: Areawide, not project location-specific |
| | | | Travel demand model or subarea model with multiclass assignment | | | NCHRP Report 765, Ch 3.2.2.4 | Limitation: Provides HDV only, not diesel % |
| Project Screening, Step 2 | Intersection level of service (LOS) | Very substantial | Highway Capacity Manual (HCM) software or microsimulation model | | X | NCHRP Report 765, Ch 2.3 | Usually for the peak hours. |
| | | | Highway Capacity Manual methodology | | | NCHRP Report 765, Ch 10.4 | |
| Project Screening, Step 2 | Intersection percentage of HDV in total peak-hour volume or percentage of diesel HDV in hourly volume | Very substantial | Study-specific data | | X | | Terminal studies usually include this type of data, whereas intermodal nodes may not. |
| | | | Other methods - see "Percentage of HDV in AADT or percentage of diesel HDV in AADT" | | | | |
| Refined Analysis, Step 3 | Highway functional class (road type) by link[3] | Moderate | MOVES road types based on HPMS functional classification and rural or urban location type link designation | X | X | NCHRP Report 765 Ch 9.3 Table 9-4 | Usually available from regional models or roadway inventory databases; conversion from functional class to MOVES road types may be required. |
| Refined Analysis, Step 3 | Hourly traffic volumes for a 24-hour period for each approach including turning movements, if at intersections/interchanges (for 4 seasons for dispersion analysis). | Substantial | Balanced flows derived from ground counts for existing conditions; model output for existing and future conditions. | X | X | NCHRP Report 765 Ch 11 | |

[1] Impact is based on the following changes in results: Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%.
[2] Future years may include opening and design years.
[3] Air Quality links may not correspond to the traffic links (see Appendix D for links definition and Appendix A (PM) details).

*Table 4-1. Data Sources and Methods for Traffic Inputs for Project-Level Particulate Matter Analysis (continued)*

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions and/or Concentrations[4] | Method | Base Year | Future Year[5] | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Refined Analysis, Step 3 | Vehicle mix on each link (VHT fraction, as available)[6] | Very substantial (car vs. heavy-duty truck, single-unit vs. combination truck)<br>Moderate (car vs. light truck, long-haul vs. short-haul truck) | See "Percentage of HDV in AADT or percentage of diesel HDV in AADT"<br>Vehicle classification counts<br>Multiclass regional travel demand model. | X | X | | Note: Model output provides HDV not diesel HDV |
| Refined Analysis, Step 3 | Average (congested) speed by link[7] by hour for a 24-hour period (for 4 seasons for dispersion analysis) | Moderate (high speeds) to very substantial (low speeds) | Observed speed data from GPS, Bluetooth, ITS, private aggregators, etc. | X | X | NCHRP WOD 210, Vol. 1, Section 4.7.3<br>NCHRP Report 765, Table 3-2 | There may be many options for observed speed data especially on high-volume roads. |
| | | | Travel demand model or subarea model | | | NCHRP WOD 210, Vol. 1, Section 4.7.3<br>NCHRP Report 765, Table 3-2 | Post-processing can improve speed estimates and develop hourly speeds based on v/c ratios; need to compare with observed speeds. |
| | | | Traffic simulation model | | | NCHRP Report 765, Table 3-2 | If developed for the study area, will provide more reliable speed estimates than a regional travel demand model; model should be calibrated on observed speeds. |
| Refined Analysis, Step 3 | Road grade by link (change in elevation per unit length of roadway) | Substantial (steep grades) | As-built or design plans are the best source for grade information. Approximate grades can be scaled from U.S. Geologic Service maps. | X | X | NCHRP WOD 210, Vol. 2, Section 4.4 | GIS database may be available from local jurisdiction or state DOT<br>Some microsimulation models have inputs for grade (or terrain) |
| Refined Analysis, Step 3 | Number of off-network vehicles parked, starting or hoteling (for long-haul combination trucks only) | Very substantial | Multiple options for local data collection including entrance/exit data, parking studies, field observation, fleet records, satellite imagery, and heavy-duty vehicle telematics data | X | X | | NCHRP WOD 210, Vol. 2, Section 4.7.3<br><br>Long-haul truck volumes may be obtained from the Freight Analysis Framework database or from external truck trips in a regional model. |
| | | | Growth rates or project-specific forecasts | | | | |

4 Impact is based on the following changes in results: Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%.
5 Future years may include opening and design years.
6 Vehicle mix is a fraction of volume by vehicle class and, in this case, it is equal to a fraction of vehicle hours travelled (VHT) on each link – see Appendix D.
7 May include different speeds for different vehicle classes on one stretch of roadway. See Appendix D for a definition of a link.

# 5 Mobile Source Air Toxics Analysis

This section summarizes the procedures and data sources for providing traffic data for input to project-level MSAT analysis. The air quality analyst will determine whether a county- or project-scale analysis approach will be applied for MSATs, with key considerations including the availability of needed traffic data and forecasts and (if the project-level option is selected) road grades for the affected links.

**Figure 5-1** shows the typical steps for how traffic data activity informs air quality analysis throughout the MSAT analysis process. The yellow boxes show traffic-related analysis and data development typically undertaken by the traffic analyst, while the green boxes show air quality analysis steps typically undertaken by the air quality analyst.

Step 1 of this process, Project Assessment, includes project definition and project assessment. Step 2 identifies the data for screening analysis, and Step 3 identifies the data for air quality assessment analysis, if needed. Step 3 data is limited to a subset of NEPA or planning traffic network. The air quality analyst will typically determine whether a county- or project-level analysis approach will be applied for MSATs, with key considerations including the availability of needed traffic data and forecasts and (if the project-level option is selected) road grades, particularly for affected links.

**Table 5-1** identifies data sources and methods for developing traffic data inputs to MSAT analysis.

- "Project stage/step" refers to the steps shown in Figure 5-1. One step may include multiple traffic/activity inputs.
- "Traffic/activity input" describes the specific traffic data input covered in that row or rows of the table.
- "Impact on emissions" presents data from sensitivity analyses related to the impact of that input on emissions estimates. This information can help the analyst prioritize resources toward refining the most significant inputs.
- "Method" describes methods available for developing the traffic data item. More than one method may be possible for each item.
- "Base year" and "future year" columns identify whether the method is suitable for base-year analysis, future year analysis, or both.
- The "References" column identifies reports that provide more detail on developing the traffic data input.
- The "Comments" column provides additional information related to the input.

In addition to these resources, Appendix A provides a sample traffic information request form for MSAT analysis. The form provides checklists of the traffic data items needed for (1) project assessment, (2) determining affected network segments, (3) data needs for MOVES county-scale analysis, and (4) data needs for MOVES project-scale analysis. Appendix B provides examples of traffic data supplied by agencies.

***Figure 5-1. Typical Traffic Analysis and MSAT Air Quality Analysis Interaction***

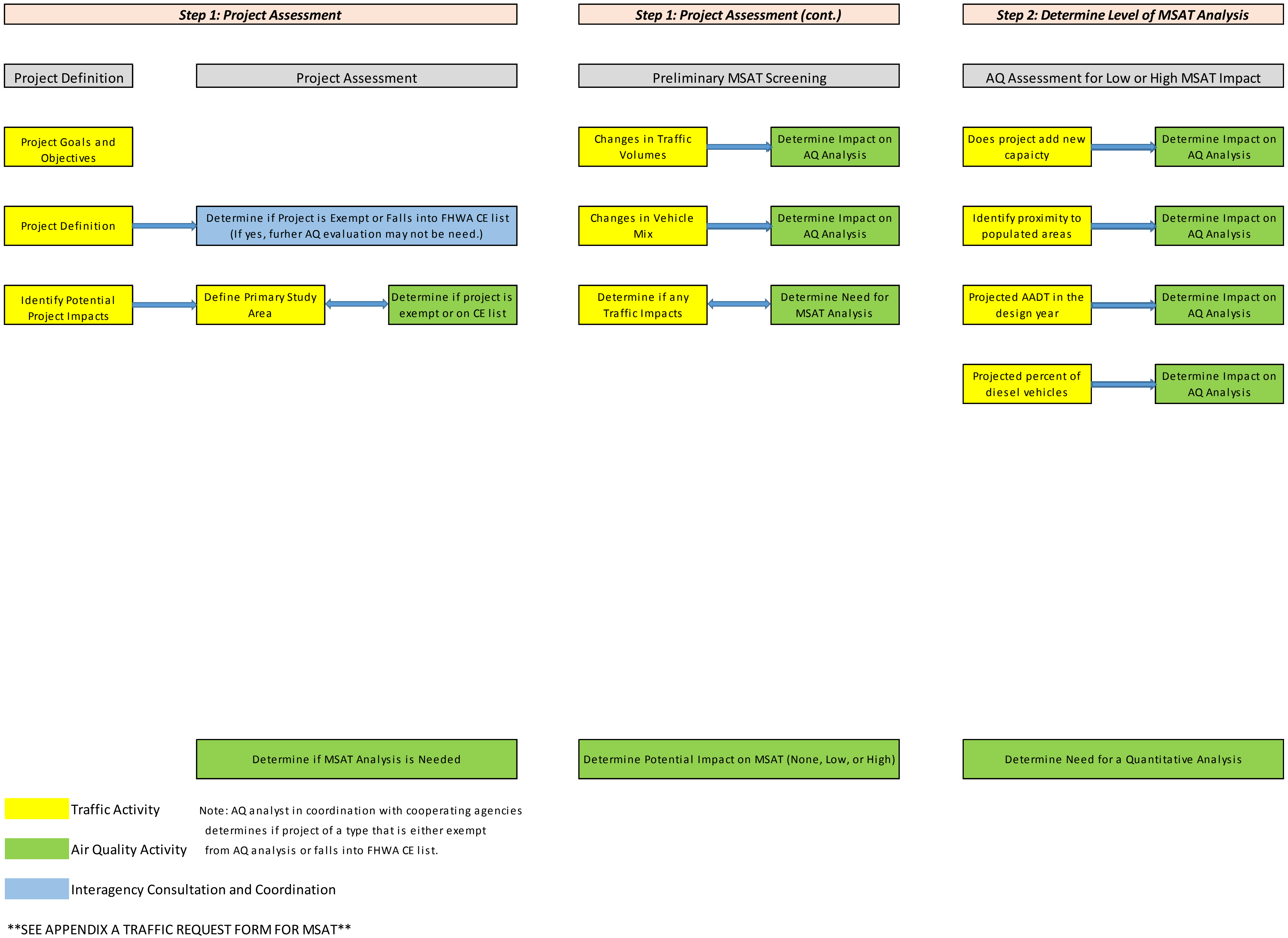
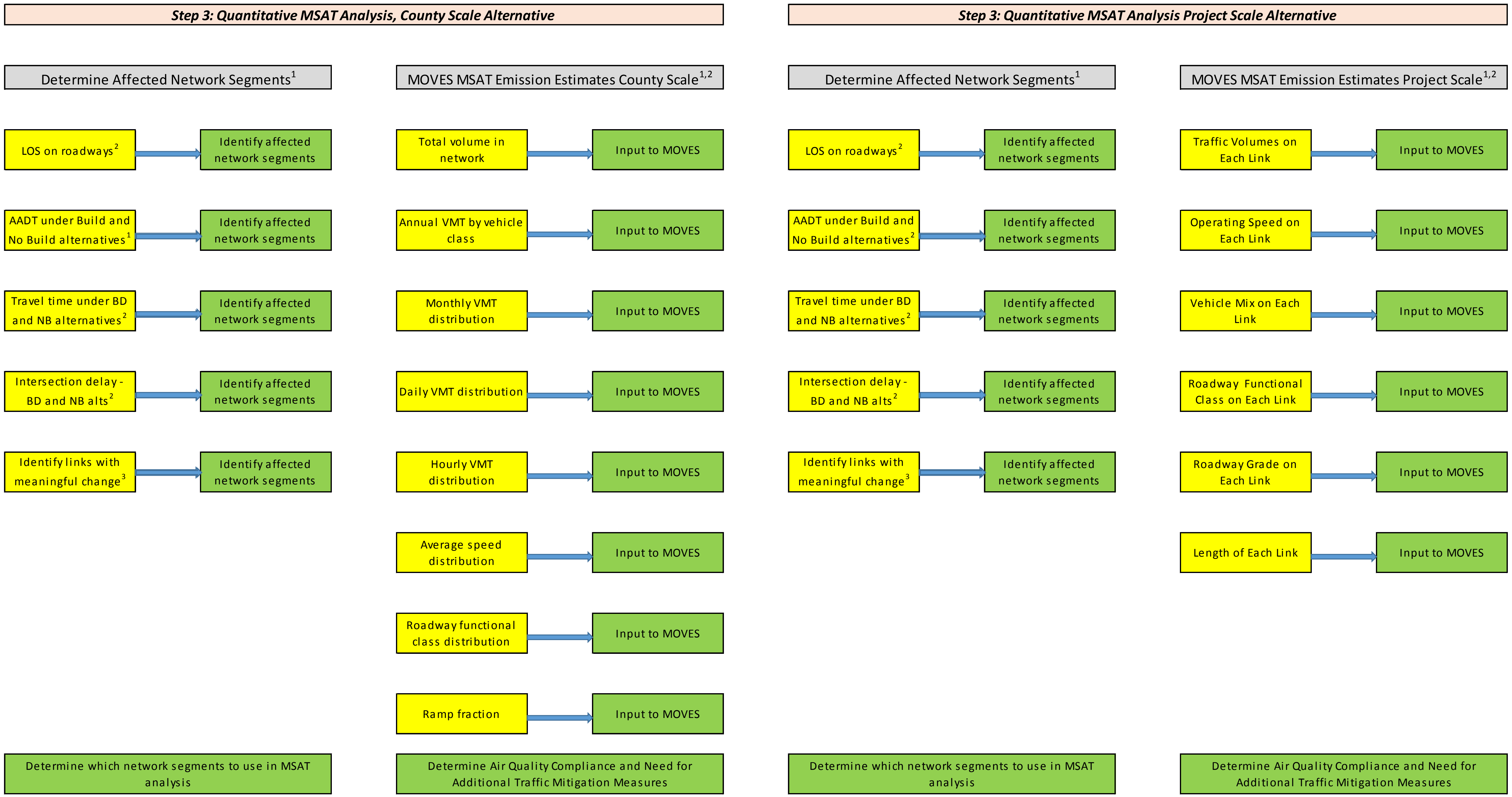


***Figure 5-1. Typical Traffic Analysis and MSAT Air Quality Analysis Interaction (continued)***




Note 1: A subset of NEPA or planning traffic network
Note 2: Future opening and design years may be used
Note 3: Links with meaningful changes in volumes, travel times, or intersection delays
https://www.fhwa.dot.gov/environMent/air_quality/air_toxics/policy_and_guidance/msat/

Note 1: On affected network based on NEPA traffic analysis.
Note 2: For 4 seasons of the year and 4 time periods per day -- 16 runs.

Note 1: A subset of NEPA or planning traffic network
Note 2: Future opening and design years may be used
Note 3: Links with meaningful changes in volumes, travel times, or intersection delays
https://www.fhwa.dot.gov/environMent/air_quality/air_toxics/policy_and_guidance/msat/

Note 1: On affected network based on NEPA traffic analysis.
Note 2: For 4 seasons of the year and 4 time periods per day -- 16 runs.

**SEE APPENDIX A TRAFFIC REQUEST FORM FOR MSAT**

***Table 5-1. Data Sources and Methods for Traffic Inputs for Project-Level MSAT Analysis***

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions[1] | Method | Base Year | Future Year[2] | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Project Assessment, Step 1 | Annual average daily traffic for the project design year | Very Substantial | State or MPO traffic count database | | X | | AADT maps and reports are usually produced by State DOTs, sometimes larger MPOs have more-detailed maps. |
| | | | Project-specific traffic counts | | | NCHRP WOD 210, Vol. 2, Sec. 4.3 | Collected using pneumatic road tubes, radar, video, manual counts, or other methods. |
| | | | Trend analysis, growth rates, or elasticities applied to base-year counts | | | NCHRP Report 765, Ch 10.4 | Some DOT websites will include traffic forecasts or growth rates. |
| | | | | | | NCHRP Report 765, Ch. 3.6 & 4 | |
| | | | MPO or State travel demand forecasting model | | | NCHRP Report 765, Ch. 3.4 & 4 | |
| | | | Subarea or corridor refined model | | | NCHRP Report 765, Ch. 7 | |
| | | | Traffic impact study tools | | | NCHRP Report 765, Ch. 3.6 | Assist with forecasting traffic increases due to development along corridor. |
| Project Assessment, Step 1 | Information on increased numbers of diesel vehicles at intermodal freight facilities | Very Substantial | Field observation (entrance/exit data, parking studies) | | X | NCHRP WOD 210, Vol. 2, Section 4.7.3, page 4-56 to 4-59 | |
| | | | Land use/trip generation data | | | ITE Trip Generation | Scale future truck trips based on existing trips per unit of activity generator (e.g., land area, port berths, employees) and projected increase in scale of activity |
| Define affected network, Step 2 | LOS on roadway segments | Substantial | HCM analysis for weaving, merging, or diverging segments usually based on density (vehicles/lane/mile), volume/capacity ratio for basic highway segments. | | X | HCM Sixth Edition Manual | HCM Sixth edition software may be used for determining the LOS on highway segments. |
| Define affected network, Step 2 | AADT on roadway segments under Build and No Build Alternatives | Substantial | NB and BD AADT may be obtained from regional travel demand model | | X | | |
| Define affected network, Step 2 | Travel time on roadway segments under Build and No Build alternatives | Substantial | Travel times may be obtained from regional travel demand model. | | X | | Big data providers may be a good source for existing travel time data using GPS or cell phone data. |
| Define affected network, Step 2 | Intersection delays under Build and No Build alternatives | Substantial | HCM analysis | | X | HCM Sixth Edition Manual | |

1 Impact is based on the following changes in results: Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%.

2 Future years may include opening and design years.

**Table 5-1. Data Sources and Methods for Traffic Inputs for Project-Level MSAT Analysis (continued)**

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions[3] | Method | Base Year | Future Year[4] | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Quantitative Analysis, Step 3 County Scale | VMT by vehicle class | Very Substantial | Vehicle classification counts | X | X | NCHRP 210 Vol. 1 Sec. 4.3 | Presents data sources for VMT by vehicle class including HPMS, local traffic counts, ITS data, state registration database, and others. |
| | | | Extrapolation of classification count trends | | | NCHRP Report 765, Ch. 9.3 | |
| | | | Travel demand model + vehicle classification counts | | | NCHRP Report 765, Ch. 3.6, 4 & 9.3 | Combine VMT by road type from travel demand model with vehicle classification counts to get VMT by road type and vehicle class. If the travel demand model produces VMT by multiple vehicle types, such as passenger vehicles and trucks, it could also be combined with the vehicle classification counts. |
| Quantitative Analysis, Step 3 County Scale | Road type distribution | Modest to moderate | HPMS segment data | X | X | NCHRP WOD 210, Vol. 1, Section 4.5.3 | Volume data for many segments in HPMS are likely to be estimated rather than observed, with vehicle type volumes by segment based on regional averages. |
| | | | Travel demand model | | | NCHRP WOD 210, Vol. 1, Section 4.5.3 | The travel demand model will directly provide only 1-3 vehicle types (e.g., light vehicles, medium trucks, heavy trucks). For other vehicle types, the closest corresponding category may need to be used. |
| | | | Project-specific classification counts | | | | Classification counts could be conducted on all or a representative sample of affected links (if not already available); volumes multiplied by link length and summed to produce VMT by road type for each vehicle type. |
| Quantitative Analysis, Step 3 County Scale | Ramp Fraction | Modest | Travel demand model | X | X | | The travel demand model can be used to calculate percentage of VHT that occurs on ramps for rural restricted-access roadways (MOVES road type 2) and urban restricted-access roadways (MOVES road type 4). |
| Quantitative Analysis, Step 3 County Scale | Average Speed Distribution | Very Substantial | Observed speed data from GPS, Bluetooth, ITS, private aggregators, etc. | X | X | NCHRP WOD 210, Vol. 1, Section 4.7.3 | There may be many options for observed speed data especially on high-volume roads. |
| | | | Travel demand model | | | NCHRP WOD 210, Vol. 1, Section 4.7.3 | Congested speeds from the travel demand model can be used to calculate the average speed distribution input, which is a set of 16 fractions that sum to 1 representing percentage of VHT by speed bin. A time of day model could be used to calculate different distributions for as many times of day are represented by the model. Post-processing can improve speed estimates. |
| | | | Traffic simulation model | | | NCHRP Report 765, Table 3-2. | If developed for the study area, will provide more reliable speed estimates than a regional travel demand model. |
| Quantitative Analysis, Step 3 County Scale | Temporal VMT Adjustments | Modest | Traffic counts from HPMS, state DOT, or local source | X | X | NCHRP WOD 210, Vol. 1, Sec. 4.4 | Local or regional 24-hour counts can be used to compute hourly VMT fractions. Permanent count stations can be used to develop weekday vs. weekend and monthly fractions. |
| | | | Travel demand model | | | NCHRP Report 765, Sections 8.5 to 8.7<br>NCHRP WOD 210, Vol. 1, Sec. 4.4 | Some travel demand models may be used to disaggregate daily volumes into three or four time periods. Further disaggregation by hour will require the use of count data or MOVES defaults. |
| Quantitative Analysis, Step 3 County Scale | Source Type (Vehicle) Population by Vehicle Type | Modest to Moderate | Values populating MOVES model, adjusted to affected network based on VMT fractions and average VMT per vehicle by vehicle type | | | NCHRP Report 765, Section 9.3, pp 224-227 | Source Type Population data could come from the State or MPO and may be based on registration or inspection and maintenance data. |
| Quantitative Analysis, Step 3 Project Scale | Highway functional class (road type) by link | Modest | Derive MOVES classification based on functional classification and rural or urban location | X | X | NCHRP Report 765 Ch 9.3 Table 9-4 | Usually available from regional models or roadway inventory databases; conversion from functional class to MOVES road types may be required. |

[3] Impact is based on the following changes in results: Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%.

[4] Future years may include opening and design years.

***Table 5-1. Data Sources and Methods for Traffic Inputs for Project-Level MSAT Analysis (continued)***

| Project Stage/Step | Traffic/Activity Input | Impact on Emissions[5] | Method | Base Year | Future Year[6] | Reference(s) | Comments |
|---|---|---|---|---|---|---|---|
| Quantitative Analysis, Step 3 Project Scale | Traffic volumes for each approach; may be required for multiple hours/24-hours (for 4 seasons for dispersion analysis) | Substantial | Balanced flows derived from ground counts for existing conditions; model output for existing and future conditions. | X | X | NCHRP Report 765 Ch, 11 | Obtain affected network from NEPA (planning) traffic analysis, if available. The MSAT criteria can then be applied to the NEPA affected network links to identify the MSAT affected link. (See Table 1.) |
| Quantitative Analysis, Step 3 Project Scale | Vehicle mix on each link (or VHT fraction as available)[7]; may be required for multiple hours/24-hours (for 4 seasons for dispersion analysis) | Substantial | Vehicle classification counts | X | X | NCHRP Report 765, Ch. 9.3 | |
| | | | License plate surveys (matched to registration data) | | | NCHRP WOD 210, Vol. 2, Section 4.1.3 | |
| | | | Registration data (from state motor vehicles office or IHS Automotive) or MOVES default | | | • NCHRP Report 765, Ch 9.3<br>• NCHRP WOD 210, Vol. 2, Section 4.2.3 | Areawide, not project location-specific |
| | | | Travel demand model or subarea model with multiclass assignment | | | NCHRP Report 765, Ch 3.2.2.4 | |
| Quantitative Analysis, Step 3 Project Scale | Operating (congested) speed by link[8]; may be required for multiple hours/24-hours (for 4 seasons for dispersion analysis) | Moderate (high speeds) to very substantial (low speeds) | Observed speed data from GPS, Bluetooth, ITS, private aggregators, etc. | X | X | NCHRP WOD 210, Vol. 1, Section 4.7.3 | There may be many options for observed speed data especially on high-volume roads. |
| | | | Travel demand model or subarea model | | | NCHRP WOD 210, Vol. 1, Section 4.7.3 | Post-processing can improve speed estimates and develop hourly speeds based on v/c ratios |
| | | | Traffic simulation (dynamic) model | | | NCHRP Report 765, Table 3-2. | If developed for the study area, will provide more reliable speed estimates than a regional travel demand model |
| Quantitative Analysis, Step 3 Project Scale | Road grade by link | Substantial (steep grades) | Available from microsimulation models or specific GIS databases; approximate grades can be scaled from USGS maps; more accurate grades may be available from as-built plans | X | X | NCHRP WOD 210, Vol. 2, Section 4.4 | GIS database may be available from local jurisdiction or state DOT |
| Quantitative Analysis, Step 3 Project Scale | Link length | Substantial | Available from regional or microsimulation models or online maps. | | | | |

5 Impact is based on the following changes in results: Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%.
6 Future years may include opening and design years.
7 Vehicle classification is a fraction of volume by vehicle class and in this case, is equal to a fraction of vehicle hours travelled (VHT) on each link – see Appendix D.
8 May include different speeds for different vehicle classes on one stretch of roadway. See Appendix D for a definition of a link.

# 6 Greenhouse Gas Analysis

## 6.1 Introduction

As of this writing, there is no federal requirement for GHG analysis for transportation projects. However, some states include GHG analysis as part of the state's project-level environmental analysis requirements. Some states also may require energy analysis, which is closely related to GHG analysis, as GHG emissions are driven mainly by energy consumption by fuel type.

EPA provides guidance for developing state and local transportation GHG emissions inventories using MOVES (EPA, 2016), but its use is not required. The EPA guidance is regularly updated to reflect the most recent version of MOVES. GHG emission analysis for an individual transportation project is not covered under the EPA guidance for GHG emissions.

FHWA has included information on the use of MOVES for energy or GHG analysis in training materials prepared by its Resource Centers. FHWA notes that energy analysis has always been addressed in NEPA, but that qualitative analysis has generally been sufficient. FHWA suggests that GHG impacts be considered at a planning level, through planning and environmental linkages (PEL), so that system-wide impacts of a program of investments are considered. The emissions difference between project alternatives is often small, and GHG is a pollutant of concern at a global level, in contrast to other pollutants that have localized impacts.

## 6.2 GHG Analysis Methods

**MOVES.** The MOVES model can provide GHG emissions estimates, based on similar traffic data parameters required for CO, PM, and/or MSAT analysis. If MOVES is run at a county level, the requirements and appropriate data sources will be similar to those shown in Table 5-1 for Step 3 County Scale MSAT evaluation. If MOVES is run at a project (link) level, the requirements will be similar to those shown in the Step 3 PM Refined Analysis of Table 4-1 for PM analysis or in Table 5-1 for Step 3 Project Scale MSAT evaluation. The traffic data required for MOVES may come from a travel demand model, observed traffic speeds and counts with growth rates, and/or other methods as described in the tables for the other pollutants. The GHG emissions estimates produced by MOVES are tied mainly to energy parameters since nearly all GHG emissions from vehicle operations are a direct function of fuel consumption. Table 6.1 lists the most important traffic input parameters for GHG emissions analysis using MOVES, with minor variations depending upon whether MOVES is applied at a project (link) or county (area) scale. For project-scale application, these inputs are needed for each time period (hour of day, month/season) to be analyzed. See Appendix A for binning of these variables and Appendix C for more specific definitions.

***Table 6-1. Important Traffic Inputs to MOVES for GHG Analysis***

| Project (Link) Level Application | County (Area) Level Application |
|---|---|
| • Link volume (total vehicles/hour)<br>• Fraction of vehicle-hours traveled on link by vehicle type<br>• Link average speed<br>• Length and grade of link | • Total VMT by vehicle type<br>• Fraction of VMT by road type for each vehicle type<br>• Speed distribution (%vehicle-hours of travel by speed bin) |

Note: MOVES does not at present consider road grade in county-level analysis.

**EMFAC.** EMFAC is the equivalent model to MOVES for use in California. The general traffic data requirements are similar but not identical to those for MOVES. EMFAC also reflects specific characteristics of the California vehicle fleet. Project analysts in California should refer to state-specific guidance for the estimation of project-level GHG emissions in California.

**Fuel consumption factors.** GHG analysis can also be performed without using MOVES, by applying fuel consumption factors and GHG intensities (emissions per fuel unit) to VMT estimates. Fuel consumption factors can be obtained from the U.S. Department of Energy's Annual Energy Outlook (AEO), or from a state or locally developed GHG inventory. While this may be adequate for regional inventories, however, it is less useful for making comparisons between project alternatives. This is because the primary driver of GHG emissions differences between alternatives (aside from any VMT differences) is likely to be vehicle speeds, which is not captured in the use of a single average fuel consumption per mile rate. MOVES (or EMFAC in California) has the advantage of providing speed-based emission factors that will allow for more differentiation between alternatives. The Washington State DOT guidance on project-level GHG analysis (Washington State DOT, 2016) states that the EPA MOVES model is used to develop emission rates based on the vehicle type and modeled speed.

# 7 Special Situations

This chapter covers a number of special topics, including:

- Advanced traffic parameters, which are required when the traffic and air quality analysts decide to use MOVES operating mode distribution or drive schedule inputs instead of average speeds;
- Project reevaluation – what is required for air quality analysis when a reevaluation of the project is required for NEPA purposes, and what the implications are for traffic data;
- Traffic mitigation measures and how they should be considered in the air quality analysis; and
- Techniques to manage the risk of litigation that may relate to or cite the air quality analysis.

## 7.1 Advanced Traffic Parameters when Using MOVES Operating Mode Distribution or Drive Schedule Inputs

For MOVES project-level runs there are three options for describing vehicle speed activity:

- **Average Speed** – A single average speed is input for each link.
- **Drive Schedules** – A set of second-by-second speeds, also known as vehicle trajectories, is input for each link. The road grade associated with each link and second is also input. MOVES converts these inputs to operating mode distributions.
- **Operating Mode Distribution** – A set of fractions representing the percentage of time spent in each operating mode bin is input. An operating mode bin is generally defined by MOVES as a combination of vehicle-specific power and speed. A variety of acceleration categories (bins) are defined as well as braking, idling, and extended idling. See Table 4.6.4 in NCHRP Web-Only Document 210, Volume 2, for a full list of MOVES operating mode bins.

Detailed project-level analysis for any pollutant may benefit from a more-detailed way to describe vehicle speed activity through drive schedules or operating mode distributions. The analyst will need to use MOVES in project-level mode to take advantage of these advanced inputs.

Options for developing operating mode distributions or drive schedules include:

- Field data collection using GPS or data loggers using car-following methods. This method can capture drive cycles under a range of real-world conditions. However, it only captures current conditions and cannot forecast how drive cycles might change in the future under the various project alternatives.
- Traffic microsimulation models. These models are capable of providing second-by-second vehicle trajectories as an output. However, research is still underway on the validity of these trajectories. Also, these models are only applied in a few situations, typically major highway projects, due to their cost and complexity. Even if developed for the project situation, they might not be executed for the range of scenarios that are necessary for the air quality studies (such as the number of alternatives and study years). Finally, the NEPA document should typically include an assessment of how the project will affect activity on the regional transportation network, and MSAT guidance in particular

calls for looking at emissions impacts on the affected network, not just the project. This assessment may therefore need to consider traffic impacts that extend beyond the modeling bounds of a project-level microsimulation application.

- Application of sample drive cycles or operating mode distributions developed by other studies for representative situations, as described in Section 7.1.2.1 below.

### 7.1.1 Advantages and Disadvantages of Using Drive Schedule or Operating Mode Distribution Inputs

Accuracy is the primary benefit of using the advanced approach of providing drive schedules or operating mode distributions for MOVES project-level runs. The average speed approach in either county-level or project-level MOVES runs is potentially less accurate since it relies on MOVES default drive schedules built in the MOVES model for operating conditions corresponding to an average speed, vehicle, and facility type. If operating conditions differ significantly from those under which the MOVES defaults were developed (e.g., very high or low amounts of acceleration for a given average speed), the resulting emissions estimates may also be less accurate. Developing drive schedule or operating mode distributions using local modeling or field data can help to better account for atypical driving conditions. The accuracy of emissions estimates is an important consideration, especially for PM hot-spot analysis for which background concentrations are often high compared to the National Ambient Air Quality Standards leaving little room for project contribution, so the margin of error for the traffic, emission and dispersion modeling is relatively small. In these cases, the accuracy of the absolute value of emissions estimates from MOVES is critical to determining accurate concentration values from the dispersion modeling. Accuracy may be less of an issue in cases where the MOVES emissions results are not used for their absolute values, but rather to calculate percentage differences in emissions between project alternatives, Build/No Build conditions, or between years. This is often the case to satisfy NEPA or state environmental laws/policies (e.g., for MSAT or GHG analysis). However, in many cases transportation projects affect congestion and operational characteristics of roadways, and it is still desirable to use this advanced approach to pick up those differences in the comparisons.

There are several disadvantages of using the advanced approach of providing drive schedules or operating mode distributions for MOVES project-level runs:

- **Trajectory Validation** – Drive schedules or operating mode distributions, which are usually developed from either field GPS data or microsimulation models, must be an accurate reflection of local conditions to improve the accuracy of emissions estimates from MOVES. Commercially available field GPS data often does not have a frequent enough ping rate to obtain second-by-second speeds. While it is possible to obtain trajectory information from microsimulation models, questions have been raised about how well those trajectories reflect real-world conditions since these models are typically calibrated and validated to average speed and delay, not second-by-second speeds. The FHWA is currently sponsoring research to understand how well microsimulation models validate against detailed real-world field data.

- **Cost/Resources** – The cost of collecting field data with second-by-second speeds or developing a microsimulation model is high compared to developing average speeds from regional travel demand models or less detailed field data collection methods such as vehicle probe data, ITS sensors, or permanent counting stations. Also, microsimulation models are typically applied at limited geographic scales such as corridors and subareas, not the regional level.

- **Analysis Years** – Real-world data can reflect only current conditions, but future years are also needed for all project-level air quality analysis. Microsimulation models can be used to predict conditions in future years, but the years available from a previously built microsimulation model may not correspond to the years needed for the analysis. Additional microsimulation model work may be required to create additional years; however, this situation may also arise with regional travel demand models for the average speed approach.

The significantly greater level of effort to apply the drive cycle or operating mode distribution approach is likely the reason for its very limited adoption. However, a number of tools and methods have been developed to help reduce the effort associated with this approach. The next section discusses tools and methods available from recent research.

### 7.1.2 Tools and Methods Available to Support This Approach

Recent research has provided several tools and methods for mitigating some of the cost and resource disadvantages of using drive schedules or operating mode distributions while attempting to increase the accuracy of describing vehicle speed activity and thus the accuracy of emissions estimates. It is expected that additional future research will yield more tools and methods that complement the currently available ones.

#### *7.1.2.1 Operating Mode Library Approach*

To help mitigate the cost of developing microsimulation models, there is a middle ground approach between using average speeds and drive schedules or operating mode distributions developed from scratch with a microsimulation model or observed field data. This approach, which is described in a 2010 FHWA report,[1] is to use v/c ratios, link types, and other parameters to look up the appropriate operating mode distribution based on a library of operating mode distributions developed from microsimulation runs conducted for that research project, which produced thousands of vehicle trajectories on each link. The idea is that these lookup parameters will be relatively easy to obtain from travel demand model outputs or field data and will allow for the use of operating mode distributions that reflect local conditions better than the MOVES default drive schedules used in the average speed approach. The FHWA project prepared the following microsimulation run scenarios, each with an associated operating mode distribution available:

- Microsimulation modeling of congested conditions
  - Freeway On-Ramp
    - V/C levels: 0.9, 1.0, 1.10, 1.15, 1.20, 1.25, 1.40, and 1.50.[2]
    - With and without ramp metering (with ramp metering excludes the V/C ratio of 1.10)
  - Freeway-to-Freeway Interchange
    - V/C levels: 0.90, 1.00, 1.10, 1.15, 1.20, 1.25, and 1.40.

[1] FHWA (2010). *Advances in Project Level Analyses*, prepared by E.H. Pechan and Cambridge Systematics, *https://www.fhwa.dot.gov/environment/air_quality/conformity/research/project_level_analyses/*

[2] The V/C ratio refers to the peak hour. Four-hour simulations were performed to capture queueing effects.

- Freeway Incident
  - V/C levels: 0.9, 1.0, 1.15, 1.25, and 1.40.
  - Blockage: 1 lane of 4, 2 lanes of 4, 3 lanes of 4.
  - Duration: 30 minutes, 45 minutes, 60 minutes, 90 minutes.
- Signalized Arterial
  - V/C levels (total approach volume divided by total approach capacity): 0.7, 0.8, 0.9, 0.95, 1.0, 1.1, 1.2)
  - Signal control: fixed time, actuated.

- Microsimulation Modeling of Port Travel
  - Local street network near port where trucks mix with cars
  - Approaching and stopping at port gate
  - Inside port gate

These scenarios are based on somewhat limited data and may not be considered as "representative" since some of the operating mode distributions are built into MOVES for common situations, but they are meant to be an improvement over average speed for special situations, such as ports or incidents on freeways. NCHRP Project 08-101 is expanding this library of operating mode distributions for special situations and is incorporating real-world GPS data with microsimulation results on the same link types to make the distributions more "representative."

#### *7.1.2.2 MOVES Operating Mode Data Import Tool*

Most commercially available microsimulation models can produce vehicle trajectories for use with the MOVES drive schedule input; however, these models often provide a separate trajectory (second-by-second speed profile) for each vehicle. This can lead to large files with an enormous number of records. For example, a multiple-hour simulation in a high-volume corridor can easily produce files that exceed 100 million records. MOVES can process drive schedules with separate trajectories for multiple vehicles, but providing such enormously large drive schedule inputs to MOVES may lead to long MOVES run times. Therefore, NCHRP research led to the creation of a tool to pre-process drive schedules for large numbers of vehicles into much smaller operating mode distributions input files for MOVES. This MOVES Operating Mode Data Import Tool is available for download[3] with "MOVES Tools" package associated with NCHRP Web-Only Document 210. The documentation associated with the tools package provides a user guide for the tool. NCHRP Web-Only Document 210, Volume 2, Section 4.6.5, Example 4.6.1, explains the basic calculation structure of the tool.

## 7.2 Project Reevaluation

A reevaluation is an analysis of the changes in a project or existing environment at specified times in the project development process. Reevaluations need to be performed when and anytime there has been little activity on a project or prior to requesting FHWA to take an action.[4] Differences often occur between the conceptual design evaluated in the environmental studies and NEPA process and the post-NEPA process final design and engineering phase of a project. A reevaluation considers the design changes relative to previous environmental analyses conducted pursuant to NEPA, as well as the

[3] *http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-38_MOVES-Tools.zip*

[4] ICF, Reevaluations of NEPA Documents, NCHRP Project 25-25(28), 2008

impacts of other changes that have taken place since that time (e.g., land use, background traffic, vehicle emissions rates).

A reevaluation is not a NEPA document, but still part of an environmental record. However, in the case of an environmental impact statement (EIS), the reevaluation can determine whether there is a need for a supplemental EIS; and for an environmental assessment (EA) with a Finding of No Significant Impact (FONSI), the FONSI could be overturned. Revaluation procedures typically look at whether any changes that occurred since the initial documentation would cause adverse impacts in the various areas covered, including air quality. States vary in the extent to which they have established standard procedures and requirements for reevaluation. A report prepared for American Association of State Highway and Transportation Officials (AASHTO) provides guidance to more universally establish and apply more systematic and standardized reevaluation processes.[5]

If a reevaluation does determine the need for a supplemental EIS or other revision to the environmental documentation, it might be necessary to redo the air quality analysis. If the project changes, traffic conditions and impacts may change. Changes in traffic analysis and results should ripple to all disciplines that are affected by traffic, including air quality. Changes in traffic may or may not significantly affect air quality results. The effects depend on which traffic parameters change, and how sensitive the air quality impacts are to these parameters and their changes. A revision of the air quality analysis may only be needed if the changes in traffic patterns have the potential to adversely affect air quality. The lead agency usually determines if the reevaluation is required.

Other factors affecting air quality may also have changed since the original environmental documentation. For example, emission factors may change, because of newer vehicle technology (if the evaluation years change or new regulations are implemented), and possibly changes to the emission factor model (e.g., a new release of MOVES). Vehicle emission rates are most likely to decrease over time (meaning the updated analysis would show less of an adverse air quality impact). However, in some cases, updated models and data may show increases in some pollutants. If the air quality analyst has reason to believe that air quality may be adversely impacted by changes since the original documentation, a re-analysis using the latest traffic, emissions, and other supporting data may be needed.

If reevaluation analysis is conducted for traffic, it is important to translate traffic changes to all other environmental disciplines affected by it and not only air quality. Using the same traffic alternative across the entire environmental assessment helps to defend the project against litigation (see Section 7.4).

## 7.3 Traffic Mitigation Measures

### 7.3.1 Overview of Traffic Mitigation Measures

Mitigation of impacts is a key element of NEPA. Mitigation may include actions to avoid, minimize, repair or restore, reduce over time, or compensate for negative impacts.[6] Mitigation is considered when the impacts of an alternative exceed acceptable thresholds or values. Traffic mitigation measures may be introduced to address air quality and/or other traffic-related impacts that are considered

[5] ICF, 2008

[6] FHWA, NEPA and Transportation Decision-making, *https://www.environment.fhwa.dot.gov/projdev/tdmmitig2.asp*, accessed July 2017.

unacceptable. Air quality analysis, as a rule, is conducted for the preferred alternative with the traffic mitigation measures already included. The same traffic alternative should be considered for all disciplines in the NEPA document (e.g., noise, energy, public health) for consistency purposes.

Many roadway improvement projects often reduce air quality impacts by reducing congestion and improving traffic flow. However, in some situations emissions and/or impacts may increase. For example, a highway widening project may lead to higher emissions from higher-speed traffic, depending upon the pre-project range of operating speeds, due to higher traffic volumes. The same project may bring traffic emissions closer to sensitive land uses increasing air quality impacts. Air quality impacts might increase near the project, even if they are reduced elsewhere, as a result of induced or diverted traffic. For example, an intermodal port access project may result in changes to truck routing or facilitate an increase in truck traffic. If traffic priority is given to the highway or arterial mainline, emissions at cross-street intersections may increase even if mainline emissions decrease. Roadway projects may also result in temporary air quality impacts during construction due to lane closures and detours.

Examples of measures to mitigate air quality impacts from roadway projects include the following:

- Adjustments to the project to improve traffic operations to reduce emissions, such as traffic signal optimization, provision of turning lanes, left turn prohibitions, parking restrictions, ramp metering, or modification of lane assignments to maximize lane utilization
- Construction equipment – newer (cleaner) equipment, emission reduction retrofits, alternative fuels
- Alternative fuel or clean vehicles in other local fleets (e.g., school buses, utility trucks, drayage trucks)
- Idle reduction measures (truck stop electrification, anti-idling ordinances)
- Identification of truck routes to avoid sensitive residential areas
- Corridor-level travel demand management (e.g., shuttles, park-and-ride, information on alternative routes and modes, pedestrian and bicycle access improvements), either for the duration of construction or permanently

### 7.3.2 Evaluating Traffic Mitigation Measures

The effects of mitigation measures on air quality impacts should be considered in the air quality analysis. For analysis purposes, traffic mitigation measures can be divided into three general categories:

- Travel demand management (e.g., reducing vehicle-travel). These measures can be evaluated by reducing VMT on study area links, based on the reduction in vehicle-trips expected from the measure.
- Transportation systems management (making traffic operate more efficiently). These measures can be evaluated by changing traffic operations inputs to emissions modeling (typically average speed, but potentially changes to drive cycles or operating mode distributions as described in Section 7.1).
- Vehicle and fuel technology (making vehicles cleaner). These types of measures are evaluated by changing emission rates (grams per mile or grams per hour). This can be done either within the emissions model (for examples, MOVES provides capabilities to analyze alternative fuels) or by adjusting emission factors off-model for inputting into dispersion models.

The traffic analyst plays an important role in the evaluation of the first two types of measures, which are evaluated as part of the traffic analysis. A variety of tools and methods are available to assist in evaluating the emissions impacts of traffic mitigation measures. FHWA resources include:

- "Multi-Pollutant Emissions Benefits of Transportation Strategies" (2005)[7] - Descriptions of strategies and sample emissions calculations.
- "Handbook for Estimating Greenhouse Gas Emissions for Integration in the Planning Process" (2013) – While focused specifically on GHG emissions, some of the tools and methods referenced can be applied to other pollutants.
- "Off-Model Air Quality Analysis: A Compendium of Practice"[8] - Prepared by the FHWA Southern Resource Center.
- CMAQ Emissions Calculator Toolkit. https://www.fhwa.dot.gov/environment/air_quality/cmaq/toolkit/

EPA resources include the following:

- "Methodologies for Estimating Emissions and Travel Activity Effects of TCMs" (1994) – Describes basic principles of air quality transportation control measure (TCM) analysis.
- "Diesel Retrofits: Quantifying and Using Their Benefits in SIPs and Conformity" - Guidance for State and Local Air and Transportation Agencies (2014).
- "Commuter Programs: Quantifying and Using Their Emission Benefits in SIPs and Conformity," EPA-420-B-14-004 (2014).

Resources have also been generated by California agencies, including the following:

- California Air Resources Board (2013), "Methods to Find the Cost-Effectiveness of Funding Air Quality Projects"[9] – Describes methods in a Word document which accompanies an Access tool with emission factor tables.
- California Governor's Office of Planning and Research (2014). "Updating Transportation Impacts Analysis in the CEQA Guidelines: Appendix F: Available Models for Estimating Vehicle Miles Traveled."
- California Department of Transportation (2017). "Quantitative Particulate Matter Hot-Spot Analysis Best Practices Guidebook."[10] This guidebook includes traffic-related mitigation measures.

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7 ICF and ESTC, Inc. for FHWA, 2005

8 *https://www.fhwa.dot.gov/resourcecenter/teams/planningair/pubs2.cfm*

9 *https://www.arb.ca.gov/planning/tsaq/eval/eval.htm*

10 California Department of Transportation (2017). Quantitative Particulate Matter Hot-Spot Analysis Best Practices Guidebook; Version 2.0; CTAQ-RT-15-317.02.6.

## 7.4 Litigation Risk Management

Traffic analysts need to be aware of potential litigation risk. Forecasting methodologies and their applications are often a source of significant disagreement among agencies and interest groups, and are frequently the focus of project-level litigation. This risk may be minimized by the following:

- Identification of appropriate study area and affected links (including making sure that MSAT analysis is limited to a subset of the NEPA traffic network)
- Selection of a *level of analysis* appropriate to the scale of the project and its impacts
- Use of *state-of-practice* or *state-of-the-art* data sources and analysis methods (e.g., as described in this Quick Reference Guide and in FHWA guidance[11])
- Use of *consistent assumptions* across each stage of analysis and impacts analyzed*.* This includes consistency in all traffic forecasts between traffic analyses for various pollutants (CO, PM, MSATs, GHGs), between alternatives, between traffic analyses for air quality, other environmental analyses (e.g., noise) and those for design purposes, and even with other studies that may be underway in the area
- Clear demonstration and explanation of the *validity* of the forecasting process along with the *reasonableness* of the forecasts
- Application of *quality assurance/quality control* (QA/QC) procedures at each step of the process to ensure that procedures are consistently applied and properly implemented

Transparency in methods and assumptions can help to minimize questions that may lead to litigation. Transparency can be achieved through careful documentation of methods and assumptions, as well as the reasons for selecting these methods and assumptions. It is generally a good idea to provide an Air Quality Technical Report as an appendix to the environmental documentation, so that sufficient detail on the analysis can be provided for technical reviewers while ensuring that the summary document remains accessible to non-technical readers. The technical report should identify details such as traffic volumes and growth assumptions by alternative, base and forecast year speeds, vehicle type mix, and other key inputs to the air quality analysis, as well as the sources of these key inputs. The air quality analyst should collaborate with the traffic analyst to develop this report.

Inconsistencies make it easier for skeptics to question project study findings and conclusions. Assumptions, data, and results should be systematically reviewed to ensure internal consistency; careful crosschecking is a valuable effort that enhances the credibility of the documentation for the public, agency reviewers, and a reviewing court.[12] Consistency problems are often created by:

- Changes in traffic forecasts as the study progresses. Air quality analysis may be updated as travel demand results are refined.

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[11] Federal Highway Administration (2010). *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA.*

[12] TransTech Management, Inc., Parsons Brinckerhoff, and Akin, Gump, Strauss, Hauer & Feld LLP (2005). Synthesis of Data Needs for EA and EIS Documentation – A Blueprint for NEPA Document Content, NCHRP Project 25-25(01).

- Different guidance and methods provided for different pollutants. Both PM and MSAT analyses require consideration of affected facilities – including facilities other than those to be improved (see Table 2.1). The criteria for each pollutant are different and may require inclusion of facilities beyond those evaluated for design purposes (unrelated to air quality). The traffic analyst may be able to reduce inconsistencies by defining the same affected network for multiple pollutants (e.g., PM and MSAT, given that diesel PM is common for both pollutants). The set of affected links for PM would typically be much smaller than those for MSATs and tend to be limited to only those links immediately adjacent or near the project links, e.g., adjacent or nearby congested interchanges, intersections and/or link(s) with a high percentage of diesel vehicles that are clearly impacted by the project and/or near sensitive receptors.
- Different assumptions for different alternatives. It is critical that any differences in emissions impacts between alternatives be attributable to the alternatives themselves, not to differences in model assumptions.
- Changes in assumptions from one study to the next. While this may be an unavoidable consequence of updates to data, logical explanations should be provided for notable changes.
- The extent to which other actions (unrelated to the NEPA action being analyzed) are included in the forecasts, e.g., regional road improvements in a model forecast year run or major development projects that may affect No Build traffic volumes.

Every effort should be made to use consistent data and, where inconsistencies may be unavoidable, to explain the reason for the inconsistencies. Consistency in data sources should be considered starting with early coordination between the traffic and air quality analyst to develop a traffic data collection plan that meets air quality analysis requirements (see Chapter 1.1 and Appendix A).

DOTs may also consider implementing a policy that all traffic and activity data and forecasts should be provided by staff with appropriate training and experience generating or providing that information, as a means to avoid potential liabilities in litigation particularly for high profile projects. Sample text from Virginia DOT's air quality resource document (VDOT, 2016) is provided below.

> *"2.6.3 Transportation Planning and Engineering Staff Responsible for Traffic and Activity Data and Forecasts*
>
> > *2.6.3.1 Traffic and Activity Data Preparation by Traffic Engineering and/or Transportation Planning Staff*
> >
> > *Traffic and activity data are prepared or specified by appropriate traffic engineering and transportation planning staff ... Traffic and activity data and forecasts are critical inputs for project-level air quality analyses, and accordingly are to be generated by staff with the appropriate training and experience for that task. Conversely, staff that do not have the appropriate training and experience are not to prepare, update or otherwise modify traffic and activity forecasts.*

*2.6.3.2 Exceptions*

*Exceptions are made as reasonable and appropriate, e.g. for assembling readily-available data including but not limited to posted speeds, VDOT Traffic Monitoring System/ Highway Performance Monitoring System (HPMS) data, and/or published reports that present data and forecasts including, but not limited to, the traffic and related data assembled for the periodic emission inventory.”*

# 8 References

## 8.1 Traffic Data Sources

- NCHRP Report 765 – Analytical Travel Forecasting Approaches for Project-Level Planning and Design, Transportation Research Board 2014: *https://www.nap.edu/login.php?action=guest&record_id=22366*
- NCHRP Web-Only Document 210 (Project 25-38) – Input Guidelines for Motor Vehicle Emissions Simulator Model –Volume 1, Practitioner's Handbook for Regional Level Inputs. Available at *http://onlinepubs.trb.org/onlinepubs/nchrp/NCHRP_W210Vol1.pdf*
- FHWA, Advances in Project Level Analyses, November 2010: *https://www.fhwa.dot.gov/Environment/air_quality/conformity/research/project_level_analyses/index.cfm*
- FHWA Traffic Analysis Tools website: *http://ops.fhwa.dot.gov/trafficanalysistools/*

## 8.2 General Emissions and Air Quality Modeling Guidance

- EPA, MOVES2014a User's Guide, November 2015: *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNCY.txt*
- FHWA (2010). *Advances in Project Level Analyses*, prepared by E.H. Pechan and Cambridge Systematics, *https://www.fhwa.dot.gov/environment/air_quality/conformity/research/project_level_analyses/*
- NCHRP Web-Only Document 210 (Project 25-38) – Volume 2: Practitioners' Handbook: Project Level Inputs, and MOVES Tools, 2014, available at: *http://www.trb.org/Main/Blurbs/172040.aspx*
- FHWA training course: NEPA Air Quality Analysis for Highway Projects, Materials from February 2015 training, accessed July 2017 *https://azdot.gov/docs/default-source/planning/fhwa-workshop.pdf?sfvrsn=2*
- RSG and Lakes Environmental, Combined Interface for Project Level Air Quality Analysis, pending publication, prepared for NCHRP Project 25-48, 2017
- 40CFR93.109 – Criteria and Procedures for Determining Conformity of Transportation Plans, Programs, and Projects: *https://www.law.cornell.edu/cfr/text/40/93.109*
- NCHRP Programmatic Agreements for Project-Level Air Quality Analyses Using MOVES, CAL3QHC/R and AERMOD: *http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(78)_FR.pdf*

## 8.3 Guidance by Pollutant

- CO:
  - EPA, Using MOVES2014 in Project-Level Carbon Monoxide Analyses, March 2015: *https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100M2FB.pdf*
  - EPA, Guideline for Modeling Carbon Monoxide from Roadway Intersections, November 1992: *https://www3.epa.gov/ttn/scram/guidance/guide/coguide.pdf*

- FHWA Technical Advisory T6640.8A, October 30, 1987: *https://www.environment.fhwa.dot.gov/guidebook/vol2/doc7i.pdf*
- EPA, User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, September 1995: *https://www3.epa.gov/ttn/scram/userg/regmod/cal3qhcug.pdf*
- Addendum to the User's Guide to Cal3QHC Version 2.0 (CAL3QHCR User's Guide), September 1995: *https://www3.epa.gov/ttn/scram/userg/regmod/cal3qhcrug.pdf*
- FHWA, Carbon Monoxide Categorical Hot-Spot Finding, Memorandum, April 2017: *https://www.fhwa.dot.gov/environment/air_quality/conformity/policy_and_guidance/cmcf_2017/hotspot_memo.cfm*

• PM:

- EPA, Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and $PM_{10}$ Nonattainment and Maintenance Areas, November 2015: *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NMXM.pdf*
- EPA, Appendices to Hot-Spot PM Guidance, November 2015: *https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100NN22.pdf*
- NCHRP 25-25 Task 71 – Templates for Project Level Analysis Using MOVES, CAL3QHC/R and AERMOD, September 2012: *http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(71)_FR.pdf*

• MSAT:

- FHWA, "Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents," October 18, 2016: *https://www.fhwa.dot.gov/environMent/air_quality/air_toxics/policy_and_guidance/msat/*
- "Frequently Asked Questions (FAQ) Conducting Quantitative MSAT Analysis for FHWA NEPA Documents": *https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/moves_msat_faq.cfm*
- NCHRP 25-25 Task 70 – Assessment of Quantitative Mobile Source Air Toxics in Environmental Documents. Available at: *http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(70)_FR.pdf*

• GHG:

- EPA, Using MOVES for Estimating State and Local Inventories of On-Road Greenhouse Gas Emissions and Energy Consumption, June 2016: *https://www.epa.gov/sites/production/files/2016-06/documents/420b16059.pdf*
- C. Dresser, Using MOVES to Estimate on-Road GHG and Energy Consumption, NTAQS presentation, August 2012 *https://www.dvrpc.org/NTAQS/pdf/MOVES_GHG_Guidance-Dresser.pdf*

– J. Houk, Greenhouse Gas Emissions Analysis of Regional Transportation Plans with EPA's MOVES Model, 19th Annual International Emissions Inventory Conference, September 2010 *https://www3.epa.gov/ttnchie1/conference/ei19/session6/houk.pdf*

MOVES Sensitivity:

– Volpe National Transportation Systems Center, MOVES2010a Regional Level Sensitivity, December 2012

– G. Noel, M. Glaze, MOVES Project Level Sensitivity Analysis Update, Transportation Research Board, January 2013

– NCHRP Web-Only Document 210 (Project 25-38) – Input Guidelines for Motor Vehicle Emissions Simulator Model – Volume 3, Chapter 7, Sensitivity Analysis. Available at *http://onlinepubs.trb.org/onlinepubs/nchrp/NCHRP_W210Vol3.pdf*

– G. Noel, MOVES Project Level Sensitivity Analysis, STAQS presentation, August 2015

– Wu M., Puppala S., Ginzburg H., MOVES2014a Project Level Sensitivity Tests, AWMA Paper #2017-264543 presented at the AWMA 110th Annual Conference, Pittsburg, PA, June 5-8, 2017

## 8.4 Some State and Local Regulations and Guidance

- Texas Department of Transportation. Environmental Handbook for Air Quality, May 2017: *https://www.txdot.gov/inside-txdot/division/environmental/compliance-toolkits/air-quality.html*
- Virginia Department of Transportation. Project-Level Air Quality Analysis Resource Document, April 2016. Available at: *http://www.vdot.virginia.gov/projects/environmental_air_section.asp*
- Hawaii Department of Transportation. Guidelines for Project-Level Traffic Forecasting, December 2015: *https://ntl.bts.gov/lib/60000/60300/60339/HawaiiProjectForecasting.Final.Draft.pdf*
- New York State Department of Transportation. Environmental Procedures Manual, Chapter 1. Air Quality. Dates vary by section and span January 2001 to December 2012: *https://www.dot.ny.gov/divisions/engineering/environmental-analysis/manuals-and-guidance/epm*
- Georgia Department of Transportation. Environmental Procedures. Chapter 6, Physical Environment. Section 6.2 Air Quality Analysis, February 2012.
- Colorado Department of Transportation. Air Quality Analysis and Documentation Procedures (2010, suggested updates December 2015).
- New Jersey Department of Environmental Protection, Division of Air Quality, Bureau of Technical Services. Guideline on Air Quality Impact Modeling Analysis (2009): *http://www.state.nj.us/dep/aqpp/downloads/techman/1002.PDF*
- California Environmental Quality Act (CEQA) Guidelines (Title 14 California Code of Regulations section 15000 et seq.): *http://resources.ca.gov/ceqa/docs/2016_CEQA_Statutes_and_Guidelines.pdf*
- Massachusetts Executive Office of Energy and Environmental Affairs: Revised Massachusetts Environmental Policy Act Greenhouse Gas Emissions Policy and Protocol (2010): *http://www.mass.gov/eea/agencies/mepa/greenhouse-gas-emissions-policy-and-protocol-generic.html*

- Washington State Department of Transportation: WSDOT Guidance - Project-Level Greenhouse Gas Evaluations under NEPA and SEPA (2016): *https://www.wsdot.wa.gov/NR/rdonlyres/8F4C392F-1647-45A7-A2CD-37FB79D45D62/0/ProjectGHGGuidance2016.pdf*
- Washington State Department of Transportation: Environmental Procedures Manual. Chapter 425: Air. (2017): *https://www.wsdot.wa.gov/publications/manuals/fulltext/M31-11/em.pdf*
- New York City, Mayor's Office of Sustainability: City Environmental Quality Review. Chapter 17, Air Quality (2014, update is coming): *http://www.nyc.gov/html/oec/downloads/pdf/2014_ceqr_tm/2014_ceqr_technical_manual.pdf*

## 8.5 Traffic Mitigation

- California Air Resources Board, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 2009: *https://www.arb.ca.gov/planning/tsaq/eval/sc-emftables.pdf*
- California Department of Transportation, Quantitative Particulate Matter Hot-Spot Analysis Best Practices Guidebook (Version 2.0) CTAQ-RT-17-317.02.6
- California Governor's Office of Planning and Research, Updating Transportation Impacts Analysis in the CEQA Guidelines: Appendix F: Available Models for Estimating Vehicle Miles Traveled, 2014
- FHWA Southern Resource Center, Off-Model Air Quality Analysis: A Compendium of Practice, 1999: *https://moser.tamu.edu/Reference/Handbook.Pages/Documents/FHWA/off%20model%20AQ%205.2.pdf*
- FHWA, Handbook for Estimating Greenhouse Gas Emissions for Integration in the Planning Process, 2013: *https://www.fhwa.dot.gov/environment/sustainability/energy/publications/ghg_handbook/index.cfm*
- FHWA, Multi-Pollutant Emissions Benefits of Transportation Strategies, 2006: *https://www.fhwa.dot.gov/environment/air_quality/conformity/research/mpeb.pdf*
- FHWA, NEPA and Transportation Decision making, *https://www.environment.fhwa.dot.gov/projdev/tdmmitig2.asp*
- EPA, Commuter Programs: Quantifying and Using Their Emission Benefits in SIPs and Conformity, EPA-420-B-14-004, 2014:
- EPA, Diesel Retrofits: Quantifying and Using Their Benefits in SIPs and Conformity, 2014
- EPA, Methodologies for Estimating Emissions and Travel Activity Effects of TCMs, 1994

## 8.6 Litigation Risk Management and Reevaluations

- FHWA, Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA, 2010: *https://www.environment.fhwa.dot.gov/projdev/travel_landUse.asp*
- TransTech Management, Inc., Parsons Brinckerhoff, and Akin, Gump, Strauss, Hauer & Feld LLP, Synthesis of Data Needs for EA and EIS Documentation – A Blueprint for NEPA Document Content, NCHRP Project 25-25(01), 2005: *http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(1)_FR.pdf*
- ICF, Reevaluations of NEPA Documents, NCHRP Project 25-25(28), 2008: *http://onlinepubs.trb.org/onlinepubs/archive/notesdocs/25-25(28)_FR.pdf*

# Appendix A Examples of Traffic Information Requests for Air Quality Analyses

# Traffic Information Request Form: Carbon Monoxide (CO) Analysis

*This form is intended to assist traffic and transportation analysts and planners in providing air quality analysts the traffic data needed for air quality modeling. This form describes the traffic data requirements for CO hot-spot analysis.*

This traffic information request is a three-part request. The first part is to assess the project and determine the appropriate level of analysis needed, if any. The second part is for a screening analysis. The third part is for a detailed analysis which is done only if the screening analysis demonstrates a need for it.

## PROJECT ASSESSMENT (PRELIMINARY SCREENING)

General project information and high level traffic data is needed to determine the appropriate level of analysis for a project and see if it qualifies for any exemptions, categorical exclusions, programmatic agreements, etc. Specifically, urban intersection projects may qualify for the FHWA CO categorical finding. General project information may be obtained from the project description. A description of the project will have been created to support the project-level traffic analysis which usually precedes the air quality analysis. The following information is needed for the project assessment:

- ☐ What type of project is it: highway (e.g., capacity expansion/widening), terminal/transfer point (e.g., bus terminal, port, intermodal facility), or an intersection improvement project?
- ☐ For area subject to EPA transportation conformity rule requirements for CO:[1]
  - – Where is the project located? What area will it affect based upon traffic impacts?
  - – Intersection level of service at all locations potentially affected by the project during the peak hours (existing and future build)
  - – Total traffic volumes at all intersections potentially affected by the project during the peak hours (existing and future build)
  - – Are there any sensitive land uses directly adjacent to the project such as schools, hospitals, or environmental justice areas, etc.?

[1] The air quality analyst is to determine based on this information if the project meets one of the four criteria listed in 40 CFR 93.123(a), which would require a quantitative CO analysis. The four criteria are (1) sites of violation or possible violation as identified in the State Implementation Plan (SIP); (2) LOS D, E, or F intersections; (3) top three intersections based on traffic volume as identified in the SIP; and (4) top three intersections based on LOS as identified in the SIP. If quantitative CO analysis is required, this information is also used to determine the top three intersections based on LOS and volumes to model. Other considerations may cause leading agencies request CO analysis to be conducted to demonstrate compliance as required by 40 CFR 93.116. At present, there are no non-attainment areas for CO: *https://www.epa.gov/green-book/green-book-carbon-monoxide-1971-area-information*.

- ☐ For urban intersections in CO non-attainment/maintenance areas the following traffic inputs for the future build condition at each approach:[2]
  - Peak hour average approach speed without delays (miles per hour)
  - Peak hour approach volume (vehicles per hour)
  - Peak hour intersection level of service (LOS)
  - Heavy-duty trucks (%)
  - Additional intersection geometric details the traffic analyst has available including angle of cross streets, maximum grade for intersection, maximum grade on cross street, number of through lanes, number of left turn lanes, lane width, and median width.
- ☐ Outside CO non-attainment/maintenance areas:[3]
  - Information required varies from state to state, but generally intersection LOS and traffic volumes for future build condition are needed.

## TRAFFIC DATA FOR SCREENING ANALYSIS (WORST-CASE MODELING)

If the project assessment calls for a quantitative CO analysis, a worst-case approach to the screening analysis is generally preferred as it significantly streamlines the modeling process and, given the conservative assumptions that tend to overestimate traffic volumes, emissions and ambient concentrations, its results may be less likely to be challenged in litigation. Approaches vary from state to state, but in general worst case inputs for one or more peak hours are used to predict the one-hour CO concentration. If needed, a persistence factor is used to convert the one-hour concentration to an 8-hour concentration. The following traffic inputs are needed for a CO screening analysis for the alternatives analyzed:

- ☐ Analysis years: Existing, No Build (opening and design years), Build (opening and design years)
- ☐ Traffic volumes by each approach link and each departure link during peak hour(s)
- ☐ Detailed lane configuration diagrams including turning movements
- ☐ Roadway functional class category for all links (urban or rural; restricted or unrestricted access, with or without ramps) at selected intersections or interchanges (See Appendix C for roadway types.)
- ☐ Roadway Type for each link (at grade, fill, bridge, or depressed)
- ☐ Road grade on each link (%, where 100% = 45 degree slope)
- ☐ Signal timing information by approach for peak hour(s)
  - Total cycle length for each intersection
  - Type of signal (pre-timed, actuated, or semi-actuated)
  - Red time for each phase of the signal
  - Clearance interval lost time for each phase

[2] The air quality analyst is to determine if the project qualifies for an FHWA CO categorical hot-spot finding based on these traffic parameters and other parameters required.

[3] The air quality analysis is to specify the information needed for identifying project locations to model based on that state's NEPA CO practices.

  - Arrival type of vehicle platoon by approach for peak hour (s) (worst (=1) through most favorable (=5))

- ☐ Saturation flow rate (vehicles per hour of effective green time) by approach for peak hour(s)
- ☐ Vehicle mix (link source type fraction) by each approach link and each departure link for peak hour(s). (Example: vehicle turning movement counts with classifications)
- ☐ Vehicle average speed on free-flow links. Provide by each approach link and each departure link for peak hour(s). Speeds on exclusive turning lanes should be provided separately. (Example: GPS based speed and delay runs)

## ADDITIONAL TRAFFIC DATA FOR REFINED ANALYSIS

If a project fails the screening analysis, a more refined detailed analysis is conducted. In more recent years this is rare due to low CO emission rates. Typically, a refined analysis will represent multiple time periods over the course of the day (e.g. AM peak, Midday, PM peak, Nighttime) or each of the 24 hours of the day. Weekday/weekend variation in traffic may also be included. Following is the list of additional traffic inputs for a more refined analysis:

- ☐ Vehicle mix (link source type) on each link for multiple hours (or each hour of the day). Vehicle types used in MOVES are listed in Appendix C.
- ☐ Traffic volumes on each link (including turning movements) for multiple hours (or each hour of the day)
- ☐ Vehicle average speed (without stopped delay) by link for multiple hours (or each hour of the day).

# Traffic Information Request Form: Particulate Matter (PM) Analysis

*This form is intended to assist traffic/transportation analysts and planners in providing air quality analysts the traffic data needed for PM hot-spot air quality modeling.*

This traffic information request is a three-part request. The first part is to assess the project and determine the appropriate level of analysis needed, if any. The second part is for a screening analysis. The third part is for a detailed analysis which is done only if the screening analysis demonstrates a need for it. Screening information is required for the Build and No Build Alternatives. Detailed analysis traffic information is required for the Build and No Build Alternatives. The future alternative analysis years may include opening and design years. Depending on local practice or procedures, the planning horizon years may also be modeled.

## PROJECT ASSESSMENT (SCREENING)

General information may be obtained from the project description. This project information would be used to determine whether this is a project of air quality concern for particulate matter. A description of the project will have been created to support the project-level traffic analysis which usually precedes the air quality analysis. The following information is relevant to defining traffic data needs for air quality analysis:

1. What type of project is it: highway (e.g., capacity expansion/widening), terminal/transfer point (e.g., bus terminal, port, intermodal facility), or an intersection improvement project?
2. Is this project a regionally significant project or not?[1]
3. Map of the study area – what are the affected intersections and roadway network links?

***Traffic Data for Screening Analysis***

| Project Type | AADT | Percentage of AADT that is HDV or Diesel HDV | Peak Hour LOS | Percentage of Total Intersection Hourly Volume HDV or Diesel HDV |
|---|---|---|---|---|
| Highway | √ | √ | | |
| Terminal/Transfer Point | √ | √ | | |
| Intersection | | | √ | √ |

HDV -- heavy-duty vehicles (trucks and buses)
Diesel HDV – diesel-fueled trucks and buses, if known
Hourly Volume – forecasted at the intersection(s) usually for peak hours (total intersection volume)

[1] "Regionally significant" is defined as a project on a facility that serves regional transportation needs and would normally be included in the modeling of the metropolitan area's transportation network (40 CFR 93.101; 23 CFR 450.104).

## ADDITIONAL TRAFFIC DATA FOR REFINED ANALYSIS

- ☐ Detailed lane configuration diagrams showing allowable turning movements for each period.
- ☐ Roadway types for all links (urban or rural; restricted or unrestricted access – see Appendix C table 3) at locations selected for refined analysis[2]
- ☐ Vehicle Mix (volume fraction or VHT fraction) of each vehicle type (as available) on each link by hour during a 24-hour period. Vehicle types used in MOVES are listed in Appendix C.
- ☐ Total volume on each link (including turning movements) by hour during a 24-hour period.
- ☐ Average (congested) speed by link, including intersection delays, by hour during a 24-hour period.
- ☐ Road grade on each link
- ☐ Off-network vehicles parked, starting, idling

[2] Links used in the AQ modeling are not necessarily the same as in transportation modeling. See Appendix D for details.

# Traffic Information Request Form: Mobile Source Air Toxic (MSAT) Analysis

*This form is intended to assist traffic and transportation analysts and planners in providing air quality analysts the traffic data needed for air quality modeling. This form describes the traffic data needed for MSAT project analysis on both county or project scales.*

This traffic information request is a three-part request. The first part is to assess the project and determine the appropriate level of analysis needed, if any. The second part is to define the network affected by the project. The third part is a traffic request for data to support a quantitative MSAT emissions analysis.

## PROJECT ASSESSMENT

General project information and high level traffic data are needed to determine the appropriate level of analysis for a project and see if it qualifies for any exemptions or categorical exclusions. FHWA guidance categorizes projects based on MSAT effects into projects with no meaningful MSAT effects, projects with low potential MSAT effects and projects with higher potential MSAT effects. MSAT emissions should be quantified only for the last project type. General project information may be obtained from the project description. A description of the project will have been created to support the project-level traffic analysis which usually precedes the air quality analysis. The following information is needed for the project assessment:

- ☐ What type of project is it: highway (e.g., capacity expansion/widening), terminal/transfer point (e.g., bus terminal, port, intermodal facility), or an intersection improvement project?
- ☐ Does the project qualify for a FHWA categorical exclusion[1] or is it exempt[2]?
- ☐ Does the project create any meaningful traffic impacts, changes in traffic volumes, vehicle mix?
- ☐ Does the project create new capacity or add significant capacity to an existing facility?
- ☐ Is the project located in proximity to populated areas?
- ☐ Is projected annual average daily traffic (AADT) in the design year above or below the range of 140,000 to 150,000?[3]
- ☐ In the case of a terminal/transfer point project, what is the maximum projected volume of diesel vehicles (for a new project) or increase in diesel vehicles (for an existing project)?

[1] The project falls under the 23 CFR 771.117 – FHWA categorical exclusions list.

[2] The project is exempt from the Clean Air Act conformity rule under 40 CFR 93.126 and listed in table 2 of this CFR.

[3] If the AADT range does not seem appropriate for the project, HEPN or HEPE contacts listed in the FHWA 2016 MSAT analysis guidance memorandum. Note that FHWA may revise this traffic threshold; the latest MSAT guidance from FHWA should be consulted.

## DETERMINE AFFECTED NETWORK SEGMENTS

If the project assessment calls for a quantitative MSAT analysis, FHWA recommends analyzing only segments associated with the project and segments with expected meaningful changes in emissions as a result of the project. The segments should be a subset of the NEPA traffic network. To define such project segments parameters listed below are checked against the significance thresholds. However, project specific considerations should be applied in selecting road segments for analysis, for example, to exclude significant changes in traffic on low volume links or links far removed from the project area.

- ☐ Levels of service (LOS) on roadway links for Build and No Build
- ☐ Annual average daily traffic for Build vs No Build
- ☐ Travel time for Build vs No Build
- ☐ Intersection delay for Build vs No Build

The recommended significance threshold is a ±5% change on the congested highway links with LOS D or worse, and a ±10% change on uncongested links with LOS C or better. Changes in travel time and delays are considered significant at ±10%. The Build and No Build alternatives could include several future years, including an opening, design, and/or planning horizon year(s). Different project alternatives are considered as appropriate.

*Note: Traffic analysis normally performed for NEPA (purpose and need, scope, design, etc.) should be the basis of the MSAT analysis and defining the affected environment. If a NEPA traffic study is not available, nor is a traffic impact analysis conducted for planning purposes, then the MSAT analysis may be limited to just the project links. This approach of relying on the NEPA traffic analysis ensures consistency in the MSAT and NEPA traffic analyses (limiting the potential for litigation based on any inconsistencies in the traffic analyses) and substantially streamlines the MSAT analysis process as new or custom traffic analyses just for MSATs are not needed.*

## ADDITIONAL TRAFFIC DATA FOR MOVES ANALYSIS ON THE AFFECTED NETWORK AT COUNTY SCALE

FHWA recommends using MOVES at the county scale for quantitative MSAT analysis.[4] Some county-scale input can be obtained by the air quality analyst from the state DOT, state air agency, MPO, or national defaults embedded in MOVES. Other inputs, including VMT by vehicle class and speed distributions, are likely to be unique for each alternative of a project. The inputs that the traffic analyst may need to provide include:[5]

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[4] The recommendation is because MOVES is typically easier to apply and to error-check at the county scale than at the project scale when multiple segments are being analyzed. The county scale refers to a method of operating MOVES and does not imply that an entire geographic county is being modeled.

[5] The traffic analyst is not expected to have traffic detail at the full level of input classes available in MOVES. For example, forecast year model runs may provide only peak and off-peak VMT, which can be further broken down into hours of the day using hourly distributions from recent study area counts or existing MOVES inputs developed for the state or region. Similarly, speed distributions may be based on peak and off-peak modeled speeds (although post-processing techniques are available to estimate average speeds) and in most cases will be only a single distribution for all vehicle types. The traffic and air quality analyst should coordinate to

- ☐ Annual VMT by vehicle class (vehicle classes used in MOVES and their HPMS translations are listed in the tables in Appendix C)
- ☐ Monthly VMT distribution (fraction of VMT occurring in each month) by vehicle class
- ☐ Daily VMT distribution (fraction of VMT occurring on weekdays vs. weekends) by vehicle class and roadway functional class
- ☐ Hourly VMT distribution (fraction of VMT occurring in each of 24 hours of the day) by vehicle class, functional class, and day of the week
- ☐ Average speed distribution (fraction of vehicle-hours of travel by speed category by vehicle type, road type, hour and day of week)
- ☐ Road type distribution (fraction of VMT on each MOVES road type, by vehicle type)
- ☐ Ramp fraction (fraction of VHT on restricted access roads that occurs on ramps)
- ☐ Annual Number of vehicles in network by vehicle class (adjusted from the total number of vehicles in the county obtained from the State or MPO or MOVES default data)

## ADDITIONAL TRAFFIC DATA FOR MOVES ANALYSIS ON THE AFFECTED NETWORK AT THE PROJECT SCALE

In some cases, the air quality analyst may choose to apply MOVES at the project scale[6]. This analysis is usually done in an inventory mode to estimate MSAT emissions on each link. If this is done, the following inputs will be needed for each affected link:

- ☐ Roadway type (urban or rural; restricted or unrestricted access—see Appendix C table 3)
- ☐ Vehicle mix (fraction by vehicle-hours of travel) of each vehicle type (as available) on each link for each hour to be modeled
- ☐ Volume on each link for each hour to be modeled
- ☐ Congested speed on each link for each hour to be modeled
- ☐ Grade at each link
- ☐ Length of each link

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determine what can be provided for the study area and what will be obtained from regional or statewide averages or default data included in the MOVES model.

[6] See recent FHWA examples at *https://www.fhwa.dot.gov/Environment/air_quality/air_toxics/research_and_analysis/* (Buffalo Gateway Connections FHWA-HEP-16-063 and Illinois Elgin O'Hare Bypass FHWA-HEP-16-066 projects)

# Appendix B Examples of Traffic Data Provided for Requests in Appendix A

# CO Analysis

## PROJECT ASSESSMENT: SEGMENTS OR INTERSECTION SELECTION

***LOS for No Build and Build Conditions***

| Intersection | Baseline 2020 Level of Service | | Option A-1 2020 Level of Service | |
|---|---|---|---|---|
| | AM | PM | AM | PM |
| I-XXX SB to ZZ 117 | F | F | F | F |
| I-XXX NB Off Ramp @ ZZ 124 | F | F | F | D |
| I-XXX SB Off Ramp @ M. Rd. | D | F | F | D |
| I-XXX NB Off Ramp @ ZZ 118 | F | E | F | F |
| I-XXX SB Off Ramp @ ZZ 118 | F | F | F | F |
| I-XXX NB Off Ramp @ YYY | A | A | C | E |
| I-XXX SB Off Ramp @ YYY | A | A | B | C |
| I-XXX NB Off Ramp @ ZZ 121 | F | F | F | F |
| I-XXX SB Off Ramp @ ZZ 121 | B | B | F | F |
| I-XXX NB Off Ramp @ ZZ 109 | F | F | D | C |
| I-XXX SB Off Ramp @ ZZ 109 | F | B | F | B |
| I-XXX NB Off Ramp @ ZZ 80 | F | F | F | F |
| I-XXX SB Off Ramp @ ZZ 80 | F | F | F | F |
| I-XXX NB Off Ramp @ ZZ 85 | B | F | F | F |
| I-XXX SB Off Ramp @ ZZ 85 | C | E | F | F |
| I-XXX NB Off Ramp @ ZZ 144 | B | A | B | A |
| I-XXX SB Off Ramp @ ZZ 144 | A | C | A | D |
| I-XXX NB Off Ramp @ R. Ave. | E | F | B | E |
| I-XXX SB Off Ramp @ R. Ave. | F | F | F | F |
| I-XXX NB Off Ramp @ 7th Street | C | E | B | E |
| I-XXX SB Off Ramp @ 7th Street | D | E | E | F |
| I-XXX NB Off Ramp @ M. Ave./OP | C | E | D | E |
| I-XXX SB Off Ramp @ M. Ave./OP | F | F | F | D |

*Source: WSP*

***Total Intersection Volumes for No Build and Build Conditions***

| Intersection | No Build | | Build Alt. 2 GP & 1 ETL | | Build Alt. 2 GP & 2 ETL | |
|---|---|---|---|---|---|---|
| | AM Volume | PM Volume | AM Volume | PM Volume | AM Volume | PM Volume |
| I-XXX NB Off Ramp @ SG Rd | 6,125 | 10,750 | 6,275 | 11,000 | 6,425 | 11,225 |
| I-XXX SB Off Ramp @ SG Rd | 11,450 | 6,200 | 11,675 | 6,450 | 11,700 | 6,375 |
| I-XXX NB Off Ramp @ ZZ 28 | 6,825 | 10,525 | 6,950 | 10,825 | 7,075 | 11,050 |
| I-XXX SB Off Ramp @ ZZ 28 | 11,250 | 7,125 | 11,600 | 7,500 | 11,625 | 7,475 |
| I-XXX NB Off Ramp @ ZZ 189 | 7,100 | 11,725 | 7,250 | 12,075 | 7,375 | 12,300 |
| I-XXX SB Off Ramp @ ZZ 189 | 10,300 | 7,050 | 10,675 | 7,400 | 10,675 | 7,375 |
| I-XXX NB Off Ramp @ M Rd | 8,100 | 12,850 | 7,900 | 12,625 | 8,025 | 12,850 |
| I-XXX SB Off Ramp @ M Rd | 10,275 | 7,150 | 10,675 | 7,475 | 10,700 | 7,450 |
| I-XXX NB Off Ramp @ SS | 4,200 | 6,700 | 4,200 | 6,700 | 4,200 | 6,750 |
| I-XXX SB Off Ramp @ SS | 11,225 | 7,100 | 11,700 | 7,500 | 11,725 | 7,475 |
| I-XXX NB Off Ramp @ DB | 4,250 | 6,650 | 4,275 | 6,675 | 4,275 | 6,700 |
| I-XXX SB Off Ramp @ DB | 5,425 | 1,950 | 6,100 | 2,550 | 5,975 | 2,375 |
| I-XXX NB Off Ramp @ ZZ 187 | 3,175 | 5,000 | 3,050 | 4,775 | 3,150 | 4,925 |
| I-XXX SB Off Ramp @ ZZ187 | 5,800 | 5,150 | 5,600 | 4,950 | 5,750 | 5,100 |

*Source: WSP*

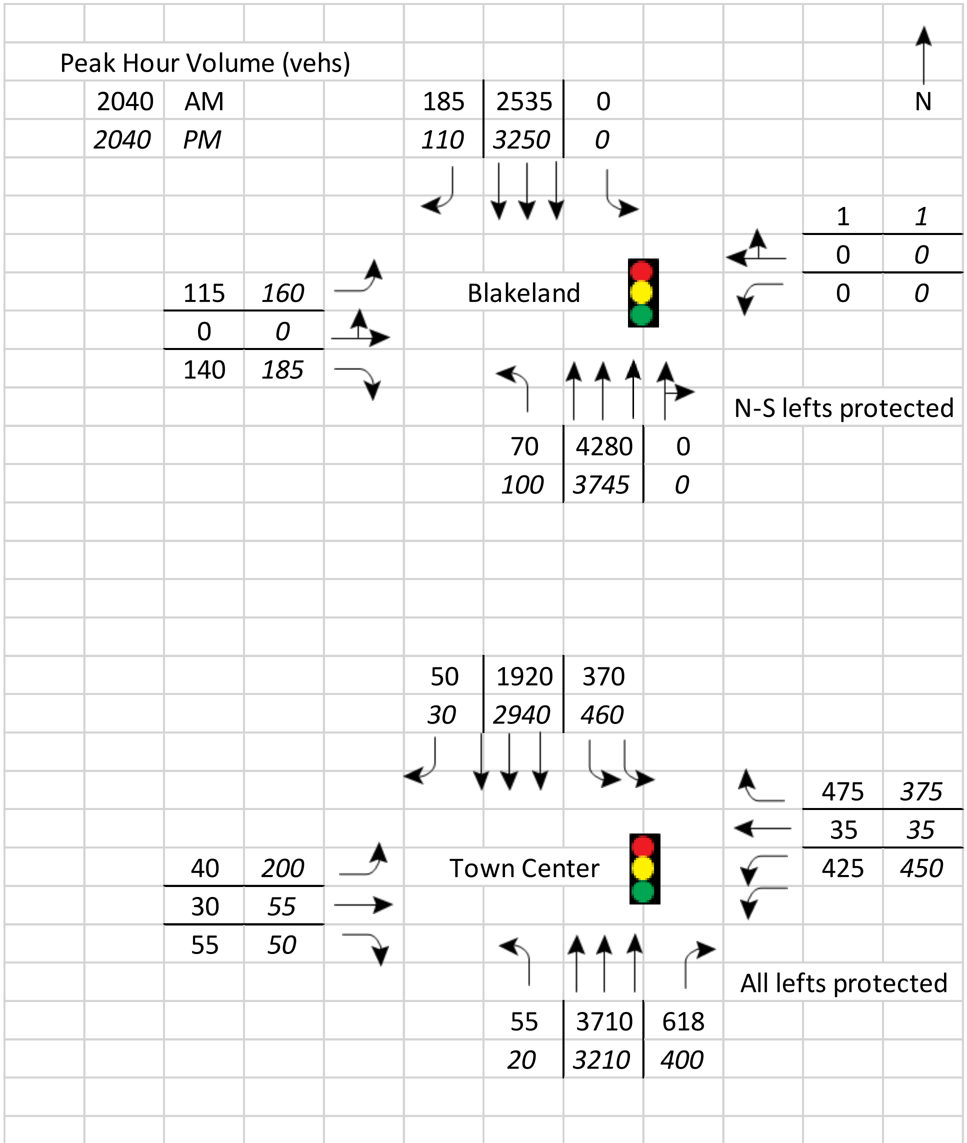
## *Intersection Approach Volumes and LOS for No Build and Build Conditions*

| | 2025 FUTURE WITHOUT THE PROPOSED ACTION | | | | | | 2025 FUTURE WITH THE PROPOSED ACTION | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intersection | NB | SB | EB | WB | Total Vol | LOS | NB | SB | EB | WB | Total Vol | LOS |
| 9th Avenue @ 34th Street | | 1989 | 1026 | 654 | 3669 | C | | 2513 | 1341 | 914 | 4768 | F |
| 7th Avenue @ 34th Street | | 2062 | 906 | 773 | 3741 | C | | 2413 | 1137 | 1047 | 4597 | D |
| 9th Avenue @ 37th Street | | 1872 | | 591 | 2463 | B | | 2579 | | 903 | 3482 | B |
| 7th Ave/Broadway @ 45th Street | | 3472 | | 633 | 4105 | C | | 3618 | | 760 | 4378 | C |
| 36th Street @ 2nd Avenue/QMT portal | | 2822 | 2091 | 977 | 5890 | B | | 2863 | 2253 | 1252 | 6368 | B |
| 2nd Ave@ 59th St/QBBLower@2nd Ave | | 2150 | 905 | 1768 | 4823 | E | | 2150 | 915 | 1937 | 5002 | F |
| 10th Avenue @ 34th Street | 2298 | | 594 | 585 | 3477 | C | 3226 | | 919 | 799 | 4944 | F |
| 10th Avenue @ 30th Street | 1912 | | 550 | | 2462 | B | 2639 | | 885 | | 3524 | E |
| 10th Ave@ 39th St/Lincoln Tunnel North Tube | 5309 | | | 435 | 5744 | B | 5941 | | | 744 | 6685 | B |
| 10th Avenue @ 42nd Street | 2341 | | 344 | 1277 | 3962 | D | 2637 | | 440 | 1343 | 4420 | E |
| 11th Avenue @ 34th Street | | 1283 | 750 | 634 | 2667 | D | | 1999 | 999 | 936 | 3934 | F |
| 11th Avenue @ 37th Street | 285 | 1095 | | 246 | 1626 | B | 419 | 1914 | | 671 | 3004 | E |
| 11th Avenue @ 42nd Street | | 1603 | 596 | 876 | 3075 | C | | 2478 | 871 | 1036 | 4385 | F |
| 6th Avenue @ Broadway/34th Street | 2118 | 897 | 844 | 789 | 4648 | F | 2237 | 914 | 915 | 1063 | 5129 | F |
| 8th Avenue @ 42nd Street | 2160 | | 815 | 732 | 3707 | B | 2344 | | 895 | 796 | 4035 | C |
| Route 9A @ 34th Street | 3011 | 3483 | | 599 | 7093 | C | 2792 | 3517 | | 957 | 7266 | C |
| Route 9A @ 42nd Street | 2736 | 3734 | 22 | 557 | 7049 | B | 2803 | 3868 | 20 | 700 | 7391 | B |
| Route 9A @ 57th Street | 2214 | 5214 | | 611 | 8039 | C | 2310 | 5775 | | 611 | 8696 | C |
| 8th Avenue @ 34th Street | 1817 | | 937 | 739 | 3493 | E | 2089 | | 1179 | 1014 | 4282 | F |
| 3rd Avenue @ 57th Street | 1914 | | 804 | 1002 | 3720 | D | 1967 | | 827 | 1084 | 3878 | D |
| Route 9A @ Canal Street Eastbound | 4084 | 3484 | | | 7568 | D | 4596 | 3589 | | | 8185 | E |
| Route 9A @ Canal Street Westbound | 3521 | 3306 | | 657 | 7484 | C | 4032 | 3385 | | 807 | 8224 | D |
| 57th Street @ Queensboro Br Entrance | | | 437 | 1410 | 1847 | D | | | 441 | 1428 | 1869 | D |
| 34th Street @ Queens Midtown Tunnel | | | 1589 | 550 | 2139 | B | | | 1636 | 630 | 2266 | B |
| Queens Blvd/Jackson Ave/Northern Blvd | 401 | 569 | 1007 | 1103 | 3080 | C | 401 | 569 | 1018 | 1175 | 3163 | C |
| Northern blvd & 41st Avenue | 402 | 1789 | 737 | | 2928 | E | 402 | 1861 | 739 | | 3002 | E |

*Source: WSP*

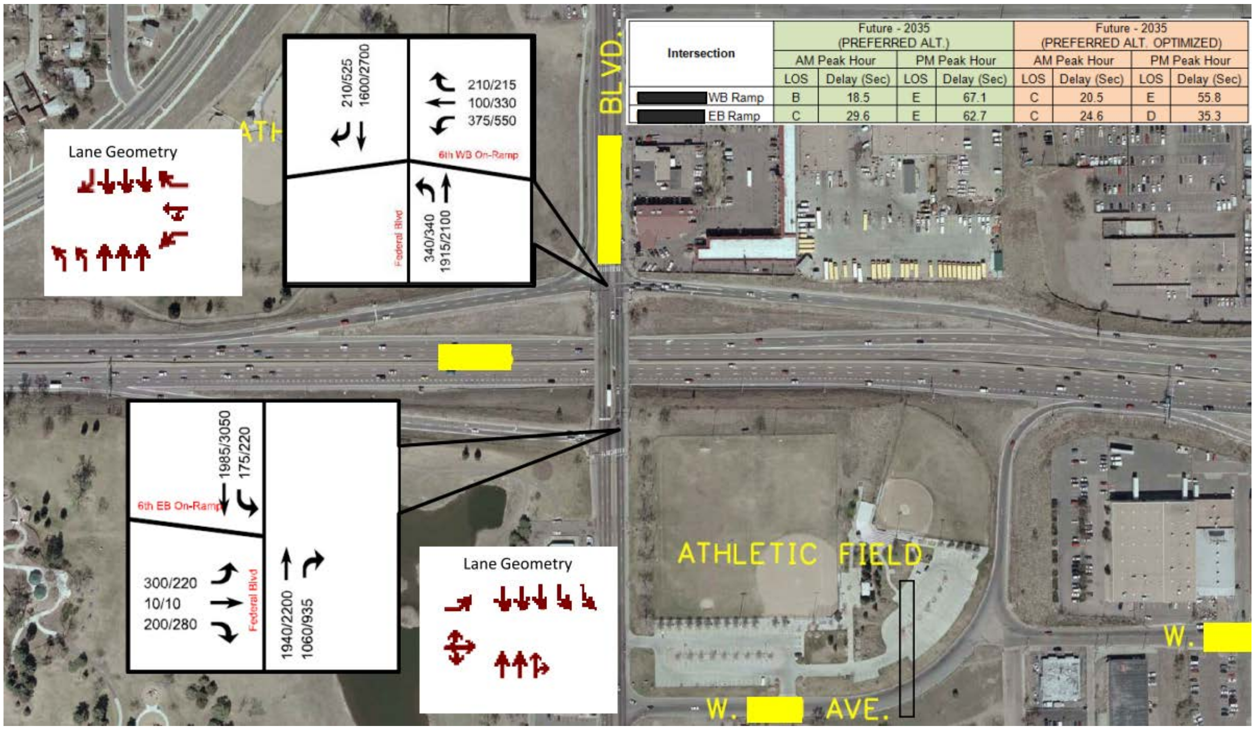
## SCREENING ANALYSIS

***Examples of the Volume and Turning Movement Traffic Data Submissions***




*Source: WSP*

### *Intersection Turning Movement Volumes for the Future Build Condition, Unmitigated and with Mitigation. Mitigated scenario will be used by the air quality analyst.*




*Source: WSP*

### *Intersection Parameters for a CAL3QHC Analysis*

| | Number of Lanes | | | Lost Time (s) | Red Time (s)* | | Calc'd Sat. Flow Rate (v/h/ln)# | | | Cycle Length | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Approach | | Departure | AM & PM | AM | PM | AM | PM | Signal Type | AM | PM |
| West Leg | EBLT | 2 | 1 | 6.0 | 126.1 | 128.7 | 1,260 | 1,734 | Actuated | Variable - Average Model Observed = 140s | Variable - Average Model Observed = 150s |
| | EBTH | 1 | | | | | 1,597 | 1,863 | | | |
| | EBRT | 1 | | Free | Free | | 1,357 | 1,583 | | | |
| East Leg | WBLT | 2 | 2 | 6.0 | 113.5 | 120.8 | 1,700 | 1,700 | | | |
| | WBTH | 1 | | | | | 1,776 | 1,863 | | | |
| | WBRT | 1 | | Free | Free | | 1,524 | 1,553 | | | |
| South Leg | NBLT | 1 | 3 | 5.0 | 139.3 | 146.1 | 1,556 | 1,556 | | | |
| | NBTH | 3 | | 7.0 | 52.0 | 62.6 | 1,631 | 1,621 | | | |
| | NBRT | 1 | | Free | Free | | 1,583 | 1,583 | | | |
| North Leg | SBLT | 2 | 4 | 7.0 | 52.0 | 62.6 | 1,592 | 1,734 | | | |
| | SBTH | 3 | | 7.0 | 64.0 | 71.1 | 1,501 | 1,630 | | | |
| | SBRT | 1 | | | | | 1,344 | 1,552 | | | |
| | NBTH | 3 | 4 | 6.0 | 38.0 | 52.5 | 1,601 | 1,601 | | | |
| | SBLT | 2 | 2 | 6.0 | 108.0 | 109.0 | 1,592 | 1,734 | | | |

Note: TH-through movement; LT – left turn, RT – right turn
*Source: WSP*

### *Traffic HCM Intersection Data Used for a CAL3QHC Analysis*

| Link ID | Direction | Analysis Year | Roadway Type | No Build Volume | Speed | SFR total | Cycle | Green + Yell | Lost time | # Lanes | Signal Type | Arrival Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9032 | NB | 2025 | arterial | 2572 | 14.2 | 6337 | 90 | 48 | 2 | 5 | 1 | 4 |
| 9047 | NB | 2025 | arterial | 2256 | 13.0 | 7822 | 90 | 47 | 2 | 6 | 1 | 4 |
| 9037 | NB | 2025 | arterial | 2250 | 7.3 | 6273 | 90 | 38 | 2 | 5 | 1 | 3 |
| 9609 | NB | 2025 | arterial | 2824 | 3.6 | 4835 | 90 | 48 | 2 | 4 | 1 | 4 |
| 9608 | NB | 2025 | arterial | 2579 | 10.9 | 6382 | 90 | 48 | 2 | 5 | 1 | 4 |
| 9607 | NB | 2025 | arterial | 2489 | 15.3 | 6376 | 90 | 53 | 2 | 5 | 1 | 4 |
| 9606 | NB | 2025 | arterial | 2409 | 14.3 | 6325 | 90 | 52 | 2 | 5 | 1 | 4 |
| 9605 | NB | 2025 | arterial | 2416 | 13.0 | 4886 | 90 | 52 | 2 | 4 | 1 | 4 |
| 9609 | EB | 2025 | arterial | 556 | 6.6 | 1034 | 90 | 37 | 2 | 2 | 1 | 5 |
| 9573 | EB | 2025 | arterial | 731 | 14.6 | 2109 | 90 | 36 | 2 | 3 | 1 | 3 |
| 9673 | EB | 2025 | arterial | 893 | 11.9 | 3931 | 90 | 49 | 2 | 3 | 1 | 3 |
| 9069 | EB | 2025 | arterial | 933 | 2.6 | 2180 | 90 | 32 | 2 | 2 | 1 | 3 |
| 9070 | EB | 2025 | arterial | 642 | 10.0 | 2481 | 90 | 37 | 2 | 2 | 1 | 3 |
| 9609 | WB | 2025 | arterial | 992 | 3.5 | 1996 | 90 | 37 | 2 | 2 | 1 | 3 |
| 9573 | WB | 2025 | arterial | 1151 | 6.4 | 3006 | 90 | 36 | 2 | 3 | 1 | 3 |
| 9867 | WB | 2025 | arterial | 684 | 16.7 | 5229 | 120 | 49 | 2 | 4 | 1 | 3 |
| 9069 | WB | 2025 | arterial | 731 | 12.5 | 3958 | 90 | 48 | 2 | 3 | 1 | 3 |
| 9070 | WB | 2025 | arterial | 581 | 10.1 | 2551 | 90 | 37 | 2 | 2 | 1 | 3 |

*Source: WSP*

## REFINED ANALYSIS

### *Example of 24-hour Volumes at Intersections by Approach*

| | Total 2025 Projected No Build Volumes | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Link Description | 12 AM - 1 AM | 1 AM - 2 AM | 2 AM - 3 AM | 3 AM - 4 AM | 4 AM - 5 AM | 5 AM - 6 AM | 6 AM - 7 AM | 7 AM - 8 AM | 8 AM - 9 AM | 9 AM - 10 AM | 10 AM - 11 AM | 11 AM - 12 PM | 12 PM - 1 PM | 1 PM - 2 PM | 2 PM - 3 PM | 3 PM - 4 PM | 4 PM - 5 PM | 5 PM - 6 PM | 6 PM - 7 PM | 7 PM - 8 PM | 8 PM - 9 PM | 9 PM - 10 PM | 10 PM - 11 PM | 11 PM - 12 AM |
| 10 Av NB @ 39 St | 1,105 | 771 | 605 | 521 | 595 | 738 | 1,213 | 1,657 | 1,969 | 1,623 | 1,519 | 1,897 | 2,133 | 2,003 | 3,393 | 3,440 | 3,452 | 3,595 | 3,712 | 2,302 | 1,880 | 1,884 | 1,852 | 1,615 |
| 10 Av NB @ 40 St | 1,169 | 815 | 640 | 551 | 629 | 781 | 1,283 | 1,752 | 2,079 | 1,713 | 1,606 | 1,743 | 1,963 | 1,847 | 2,774 | 2,795 | 2,817 | 2,945 | 3,015 | 2,687 | 2,297 | 2,204 | 2,164 | 1,890 |
| 10 Av NB @ 41 St | 1,127 | 786 | 617 | 532 | 607 | 754 | 1,239 | 1,685 | 1,950 | 1,601 | 1,542 | 1,714 | 1,929 | 1,813 | 2,608 | 2,633 | 2,658 | 2,779 | 2,843 | 2,752 | 2,249 | 2,261 | 2,219 | 1,939 |
| 10 Av NB @ 42 St | 1,350 | 942 | 740 | 637 | 727 | 903 | 1,484 | 2,019 | 2,341 | 1,921 | 1,858 | 1,964 | 2,218 | 2,084 | 2,765 | 2,814 | 2,896 | 3,079 | 3,038 | 2,840 | 2,294 | 2,314 | 2,283 | 1,979 |
| 10 Av NB @ 43 St | 1,589 | 1,109 | 871 | 750 | 856 | 1,063 | 1,746 | 2,373 | 2,739 | 2,253 | 2,153 | 2,026 | 2,281 | 2,143 | 3,058 | 3,124 | 3,175 | 3,334 | 3,373 | 3,003 | 2,600 | 2,449 | 2,410 | 2,098 |
| 10 Av NB @ 44 St | 1,578 | 1,101 | 865 | 745 | 851 | 1,056 | 1,734 | 2,350 | 2,695 | 2,212 | 2,122 | 2,018 | 2,267 | 2,133 | 3,170 | 3,246 | 3,258 | 3,390 | 3,505 | 3,129 | 2,644 | 2,560 | 2,515 | 2,196 |
| 10 Av NB @ 45 St | 1,521 | 1,062 | 834 | 718 | 820 | 1,018 | 1,672 | 2,268 | 2,607 | 2,139 | 2,048 | 1,950 | 2,198 | 2,066 | 3,096 | 3,172 | 3,186 | 3,322 | 3,425 | 3,058 | 2,591 | 2,499 | 2,456 | 2,143 |
| 10 Av NB @ 46 St | 1,491 | 1,041 | 817 | 704 | 803 | 997 | 1,638 | 2,223 | 2,558 | 2,099 | 2,007 | 1,954 | 2,202 | 2,070 | 3,163 | 3,241 | 3,250 | 3,381 | 3,499 | 3,125 | 2,637 | 2,556 | 2,512 | 2,193 |
| 42 St EB @ 10 Av | 78 | 52 | 31 | 32 | 42 | 96 | 214 | 250 | 344 | 335 | 251 | 471 | 485 | 510 | 328 | 324 | 341 | 343 | 326 | 409 | 355 | 300 | 266 | 207 |
| 42 St EB @ 11 Av | 161 | 107 | 64 | 67 | 88 | 203 | 452 | 514 | 596 | 601 | 485 | 569 | 575 | 603 | 599 | 626 | 654 | 640 | 627 | 619 | 543 | 475 | 415 | 327 |
| 42 St EB @ 8 Av | 524 | 363 | 244 | 245 | 305 | 492 | 627 | 684 | 815 | 854 | 850 | 878 | 835 | 843 | 653 | 630 | 514 | 449 | 439 | 721 | 721 | 729 | 721 | 687 |
| 42 St EB @ 9 Av | 461 | 319 | 214 | 215 | 267 | 432 | 550 | 606 | 768 | 795 | 756 | 864 | 825 | 833 | 834 | 810 | 661 | 581 | 563 | 692 | 688 | 694 | 687 | 654 |
| 42 St EB @ YY Av | 80 | 53 | 31 | 33 | 43 | 99 | 220 | 257 | 347 | 341 | 261 | 521 | 535 | 562 | 350 | 337 | 357 | 358 | 338 | 460 | 409 | 347 | 306 | 238 |
| 42 St WB @ 10 Av | 491 | 304 | 196 | 162 | 214 | 412 | 944 | 1,182 | 1,277 | 1,339 | 1,272 | 831 | 904 | 1,030 | 2,074 | 1,817 | 1,445 | 1,291 | 1,533 | 868 | 875 | 821 | 862 | 576 |
| 42 St WB @ 11 Av | 331 | 205 | 132 | 109 | 144 | 277 | 634 | 798 | 876 | 915 | 872 | 719 | 791 | 898 | 1,532 | 1,343 | 1,101 | 1,021 | 1,141 | 763 | 762 | 711 | 750 | 497 |
| 42 St WB @ 12 Av | 204 | 126 | 81 | 67 | 88 | 170 | 389 | 496 | 557 | 580 | 540 | 324 | 370 | 416 | 850 | 737 | 603 | 559 | 628 | 668 | 671 | 630 | 664 | 441 |
| 42 St WB @ 9 Av | 411 | 295 | 219 | 207 | 220 | 369 | 558 | 693 | 707 | 707 | 692 | 634 | 654 | 725 | 820 | 824 | 751 | 713 | 784 | 708 | 680 | 647 | 577 | 520 |
| 42 St WB @ YY Av | 404 | 290 | 215 | 204 | 216 | 363 | 549 | 681 | 696 | 696 | 681 | 470 | 490 | 545 | 782 | 782 | 712 | 677 | 744 | 503 | 484 | 450 | 403 | 362 |

*Source: WSP*

### *Example of 24-hour Speeds at Intersections by Approach*

| | Total 2025 Projected Build Volumes | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Link Description | 12 AM - 1 AM | 1 AM - 2 AM | 2 AM - 3 AM | 3 AM - 4 AM | 4 AM - 5 AM | 5 AM - 6 AM | 6 AM - 7 AM | 7 AM - 8 AM | 8 AM - 9 AM | 9 AM - 10 AM | 10 AM - 11 AM | 11 AM - 12 PM | 12 PM - 1 PM | 1 PM - 2 PM | 2 PM - 3 PM | 3 PM - 4 PM | 4 PM - 5 PM | 5 PM - 6 PM | 6 PM - 7 PM | 7 PM - 8 PM | 8 PM - 9 PM | 9 PM - 10 PM | 10 PM - 11 PM | 11 PM - 12 AM |
| 10 Av NB @ 39 St | 2,278 | 800 | 615 | 520 | 594 | 734 | 1,219 | 1,743 | 2,545 | 2,109 | 1,886 | 2,127 | 2,585 | 2,347 | 3,841 | 3,740 | 4,201 | 4,962 | 3,997 | 2,492 | 2,496 | 1,899 | 1,843 | 1,985 |
| 10 Av NB @ 40 St | 2,057 | 836 | 648 | 550 | 628 | 777 | 1,290 | 1,816 | 2,328 | 2,006 | 1,911 | 1,931 | 2,269 | 2,125 | 3,126 | 3,043 | 3,470 | 4,086 | 3,256 | 2,823 | 3,165 | 2,216 | 2,156 | 2,175 |
| 10 Av NB @ 41 St | 2,192 | 813 | 627 | 531 | 607 | 750 | 1,246 | 1,744 | 2,133 | 1,842 | 1,887 | 1,921 | 2,263 | 2,115 | 2,992 | 2,915 | 3,432 | 4,140 | 3,123 | 2,894 | 2,428 | 2,274 | 2,208 | 2,276 |
| 10 Av NB @ 42 St | 2,516 | 971 | 750 | 636 | 727 | 899 | 1,492 | 2,085 | 2,638 | 2,181 | 2,222 | 2,185 | 2,837 | 2,404 | 3,166 | 3,124 | 3,753 | 4,702 | 3,349 | 2,995 | 2,527 | 2,328 | 2,270 | 2,347 |
| 10 Av NB @ 43 St | 2,618 | 1,134 | 880 | 750 | 856 | 1,060 | 1,754 | 2,428 | 2,899 | 2,450 | 2,436 | 2,201 | 2,592 | 2,408 | 3,370 | 3,377 | 3,907 | 4,639 | 3,640 | 3,129 | 3,596 | 2,462 | 2,401 | 2,426 |
| 10 Av NB @ 44 St | 2,061 | 1,111 | 868 | 745 | 851 | 1,055 | 1,741 | 2,392 | 2,833 | 2,375 | 2,314 | 2,159 | 2,502 | 2,341 | 3,390 | 3,411 | 3,646 | 4,069 | 3,657 | 3,220 | 3,152 | 2,571 | 2,514 | 2,363 |
| 10 Av NB @ 45 St | 2,015 | 1,071 | 837 | 718 | 820 | 1,017 | 1,679 | 2,309 | 2,747 | 2,303 | 2,229 | 2,085 | 2,422 | 2,264 | 3,302 | 3,329 | 3,548 | 3,952 | 3,568 | 3,144 | 3,060 | 2,509 | 2,455 | 2,312 |
| 10 Av NB @ 46 St | 1,982 | 1,050 | 821 | 704 | 804 | 997 | 1,645 | 2,264 | 2,699 | 2,262 | 2,187 | 2,089 | 2,429 | 2,266 | 3,368 | 3,397 | 3,607 | 4,013 | 3,641 | 3,211 | 3,108 | 2,566 | 2,510 | 2,361 |
| 42 St EB @ 10 Av | 145 | 53 | 32 | 32 | 42 | 96 | 219 | 274 | 440 | 422 | 288 | 504 | 564 | 577 | 385 | 357 | 409 | 447 | 367 | 448 | 367 | 306 | 270 | 231 |
| 42 St EB @ 11 Av | 340 | 112 | 66 | 67 | 88 | 202 | 455 | 540 | 871 | 735 | 535 | 602 | 747 | 679 | 686 | 653 | 713 | 825 | 660 | 646 | 714 | 479 | 418 | 386 |
| 42 St EB @ 8 Av | 600 | 365 | 245 | 245 | 305 | 492 | 629 | 703 | 895 | 940 | 899 | 919 | 901 | 901 | 713 | 678 | 602 | 598 | 479 | 753 | 726 | 732 | 722 | 712 |
| 42 St EB @ 9 Av | 678 | 325 | 217 | 215 | 267 | 431 | 554 | 639 | 908 | 937 | 844 | 932 | 941 | 936 | 941 | 881 | 794 | 799 | 626 | 746 | 699 | 700 | 689 | 722 |
| 42 St EB @ YY Av | 208 | 56 | 33 | 33 | 43 | 98 | 224 | 289 | 485 | 482 | 347 | 588 | 650 | 663 | 455 | 408 | 488 | 570 | 401 | 513 | 420 | 353 | 308 | 280 |
| 42 St WB @ 10 Av | 655 | 307 | 197 | 162 | 215 | 412 | 949 | 1,202 | 1,356 | 1,395 | 1,303 | 872 | 992 | 1,104 | 2,120 | 1,851 | 1,508 | 1,400 | 1,575 | 913 | 947 | 828 | 866 | 636 |
| 42 St WB @ 11 Av | 565 | 210 | 134 | 109 | 144 | 277 | 639 | 820 | 1,049 | 980 | 923 | 766 | 1,151 | 983 | 1,601 | 1,394 | 1,226 | 1,343 | 1,204 | 819 | 884 | 718 | 753 | 578 |
| 42 St WB @ 12 Av | 301 | 129 | 82 | 67 | 88 | 170 | 391 | 503 | 713 | 601 | 566 | 340 | 684 | 445 | 882 | 758 | 665 | 846 | 655 | 685 | 730 | 633 | 664 | 471 |
| 42 St WB @ 9 Av | 499 | 296 | 220 | 207 | 220 | 370 | 561 | 710 | 806 | 786 | 734 | 678 | 731 | 794 | 881 | 865 | 800 | 789 | 818 | 758 | 755 | 652 | 580 | 557 |
| 42 St WB @ YY Av | 569 | 293 | 217 | 204 | 216 | 364 | 554 | 701 | 778 | 754 | 714 | 513 | 581 | 623 | 834 | 819 | 777 | 784 | 788 | 556 | 558 | 457 | 408 | 423 |

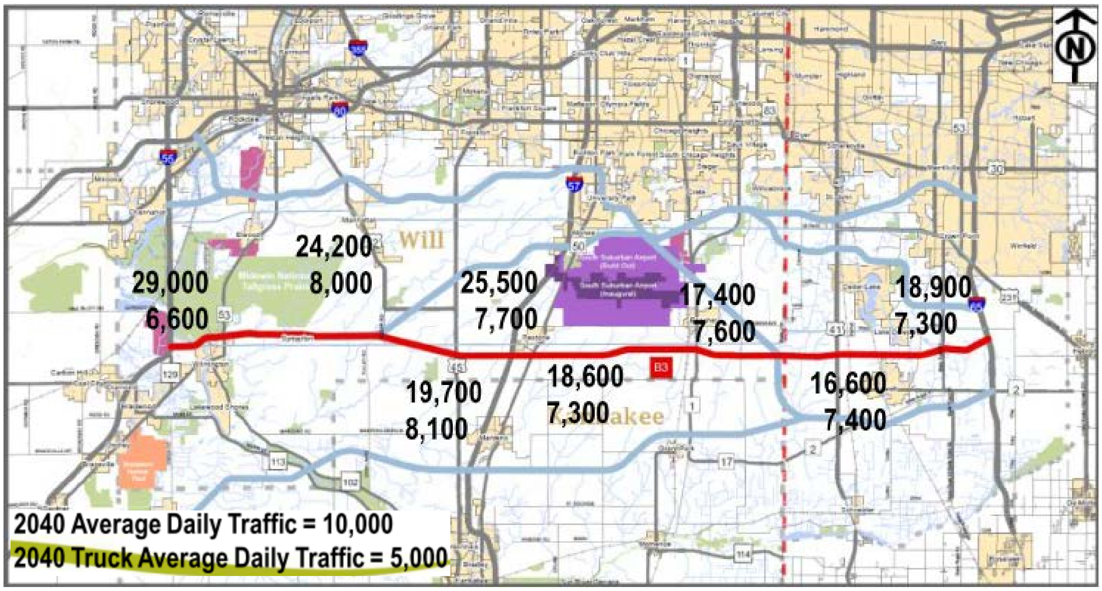
*Source: WSP*

# PM Analysis

## SCREENING ANALYSIS

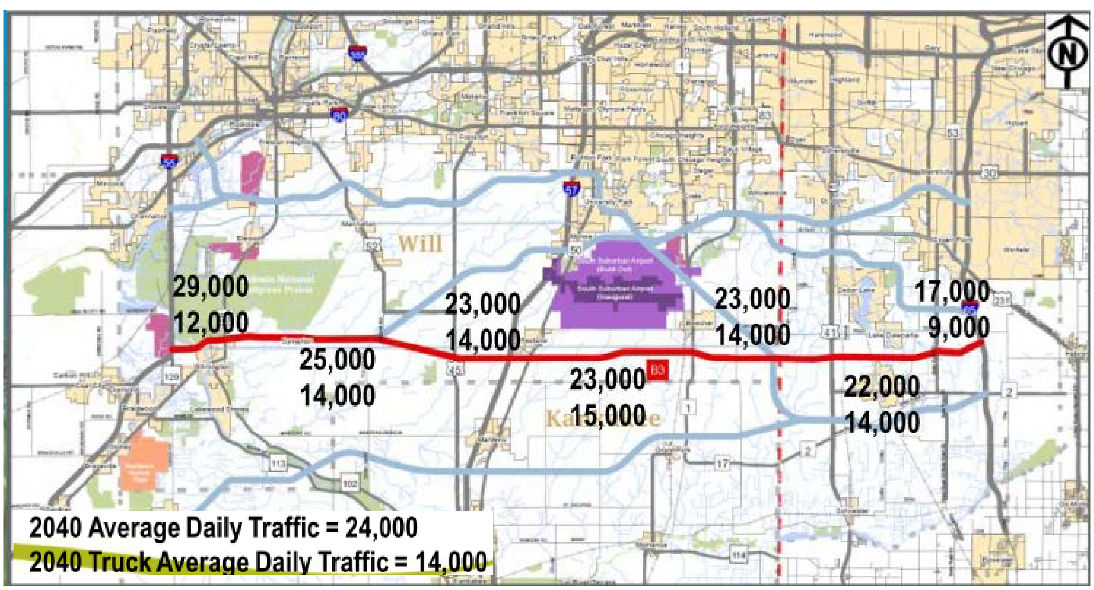
The maps below provided in the traffic report show significant increase in the number of diesel trucks as a result of the proposed project:

***No Build Alternative***




*Source: WSP*

***Build Alternative***




*Source: WSP*

# REFINED ANALYSIS

## *Link Volumes on a 24-Hour Basis*

| Start Time | Roadway Links | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EB I-XX | WB I-XX | CCS | CCSD | CCNE | CBNE | CCSW | CCSWD | CBN | CBND | CBNED | CBSW |
| | veh/h | veh/h | veh/h | | veh/h | | veh/h | veh/h | veh/h | veh/h | veh/h | veh/h |
| 0:00 | 479 | 705 | 100 | 47 | 59 | 36 | 46 | 72 | 135 | 130 | 40 | 57 |
| 1:00 | 277 | 344 | 72 | 34 | 43 | 34 | 33 | 52 | 130 | 124 | 38 | 55 |
| 2:00 | 195 | 197 | 47 | 22 | 28 | 25 | 21 | 33 | 96 | 92 | 28 | 41 |
| 3:00 | 283 | 222 | 21 | 10 | 13 | 13 | 10 | 15 | 49 | 47 | 14 | 21 |
| 4:00 | 863 | 440 | 31 | 15 | 19 | 21 | 14 | 23 | 81 | 78 | 24 | 35 |
| 5:00 | 2389 | 1,400 | 93 | 44 | 55 | 71 | 43 | 67 | 269 | 258 | 79 | 114 |
| 6:00 | 4809 | 3,226 | 212 | 99 | 125 | 119 | 98 | 152 | 453 | 434 | 134 | 192 |
| 7:00 | 6131 | 5,132 | 400 | 149 | 253 | 174 | 174 | 310 | 781 | 781 | 188 | 312 |
| 8:00 | 6713 | 5,115 | 514 | 241 | 303 | 243 | 236 | 368 | 923 | 884 | 272 | 391 |
| 9:00 | 5877 | 3,450 | 523 | 245 | 309 | 203 | 241 | 375 | 774 | 741 | 228 | 328 |
| 10:00 | 4613 | 3,389 | 415 | 156 | 176 | 176 | 173 | 287 | 518 | 562 | 216 | 325 |
| 11:00 | 3815 | 3,314 | 459 | 181 | 250 | 221 | 211 | 340 | 619 | 619 | 239 | 328 |
| 12:00 | 3713 | 3,460 | 550 | 207 | 232 | 194 | 229 | 380 | 571 | 595 | 213 | 358 |
| 13:00 | 3818 | 3,755 | 532 | 200 | 225 | 154 | 222 | 367 | 453 | 491 | 189 | 284 |
| 14:00 | 4260 | 4,589 | 569 | 263 | 261 | 283 | 266 | 365 | 605 | 652 | 281 | 400 |
| 15:00 | 4695 | 5,111 | 556 | 257 | 255 | 296 | 260 | 357 | 635 | 684 | 295 | 419 |
| 16:00 | 5225 | 4,827 | 620 | 287 | 334 | 309 | 310 | 430 | 641 | 732 | 321 | 493 |
| 17:00 | 5237 | 5,460 | 724 | 335 | 332 | 365 | 338 | 465 | 783 | 843 | 363 | 517 |
| 18:00 | 4592 | 5,186 | 717 | 332 | 329 | 350 | 335 | 460 | 750 | 809 | 348 | 495 |
| 19:00 | 3309 | 4,065 | 573 | 265 | 263 | 295 | 268 | 368 | 632 | 682 | 294 | 418 |
| 20:00 | 2389 | 3,376 | 186 | 56 | 113 | 198 | 120 | 173 | 382 | 459 | 188 | 228 |
| 21:00 | 2034 | 2,798 | 157 | 47 | 96 | 139 | 102 | 146 | 268 | 322 | 132 | 160 |
| 22:00 | 1560 | 1,921 | 274 | 82 | 167 | 219 | 178 | 255 | 423 | 508 | 208 | 253 |
| 23:00 | 921 | 1,262 | 220 | 64 | 147 | 142 | 116 | 160 | 263 | 335 | 143 | 243 |

*Source: WSP*

## *Link Speed Data on a 24-Hour Basis*

| Start Time | Roadway Links | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EB I-XX | WB I-XX | CCS | CCSD | CCNE | CBNE | CCSW | CCSWD | CBN | CBND | CBNED | CBSW |
| | mph | mph | mph | mph | mph | mph | mph | mph | mph | mph | mph | mph |
| 0:00 | 42 | 48 | 25 | 25 | 25 | 30 | 25 | 25 | 11 | 11 | 30 | 31 |
| 1:00 | 41 | 46 | 25 | 25 | 25 | 30 | 25 | 25 | 21 | 21 | 30 | 30 |
| 2:00 | 43 | 51 | 25 | 25 | 25 | 30 | 25 | 25 | 22 | 22 | 30 | 30 |
| 3:00 | 43 | 56 | 25 | 25 | 25 | 29 | 25 | 25 | 25 | 25 | 29 | 30 |
| 4:00 | 60 | 63 | 25 | 25 | 25 | 31 | 25 | 25 | 28 | 28 | 31 | 31 |
| 5:00 | 60 | 60 | 25 | 25 | 25 | 31 | 25 | 25 | 28 | 28 | 31 | 28 |
| 6:00 | 57 | 62 | 25 | 25 | 25 | 30 | 25 | 25 | 26 | 26 | 30 | 30 |
| 7:00 | 53 | 62 | 25 | 25 | 25 | 28 | 25 | 15 | 23 | 23 | 28 | 28 |
| 8:00 | 46 | 63 | 15 | 25 | 15 | 28 | 15 | 15 | 23 | 23 | 28 | 27 |
| 9:00 | 47 | 62 | 15 | 15 | 15 | 26 | 15 | 15 | 21 | 21 | 26 | 27 |
| 10:00 | 53 | 63 | 15 | 15 | 15 | 27 | 15 | 15 | 21 | 21 | 27 | 27 |
| 11:00 | 57 | 60 | 15 | 15 | 15 | 28 | 25 | 15 | 22 | 22 | 28 | 26 |
| 12:00 | 58 | 63 | 15 | 15 | 15 | 28 | 25 | 15 | 22 | 22 | 28 | 26 |
| 13:00 | 58 | 62 | 15 | 15 | 15 | 28 | 25 | 15 | 23 | 23 | 28 | 28 |
| 14:00 | 58 | 61 | 15 | 15 | 15 | 28 | 25 | 15 | 24 | 24 | 28 | 28 |
| 15:00 | 57 | 61 | 15 | 15 | 15 | 25 | 15 | 15 | 27 | 27 | 25 | 28 |
| 16:00 | 55 | 57 | 15 | 25 | 15 | 23 | 25 | 15 | 25 | 25 | 23 | 28 |
| 17:00 | 54 | 58 | 15 | 15 | 15 | 23 | 15 | 15 | 23 | 23 | 23 | 27 |
| 18:00 | 53 | 57 | 15 | 15 | 15 | 23 | 15 | 15 | 26 | 26 | 23 | 26 |
| 19:00 | 55 | 57 | 15 | 15 | 15 | 27 | 15 | 15 | 26 | 26 | 27 | 26 |
| 20:00 | 57 | 57 | 15 | 25 | 15 | 27 | 15 | 15 | 24 | 24 | 27 | 25 |
| 21:00 | 52 | 59 | 15 | 25 | 15 | 27 | 15 | 15 | 26 | 26 | 27 | 26 |
| 22:00 | 46 | 50 | 15 | 25 | 15 | 28 | 15 | 15 | 27 | 27 | 28 | 27 |
| 23:00 | 40 | 48 | 15 | 25 | 25 | 27 | 15 | 15 | 27 | 27 | 27 | 27 |

*Source: WSP*

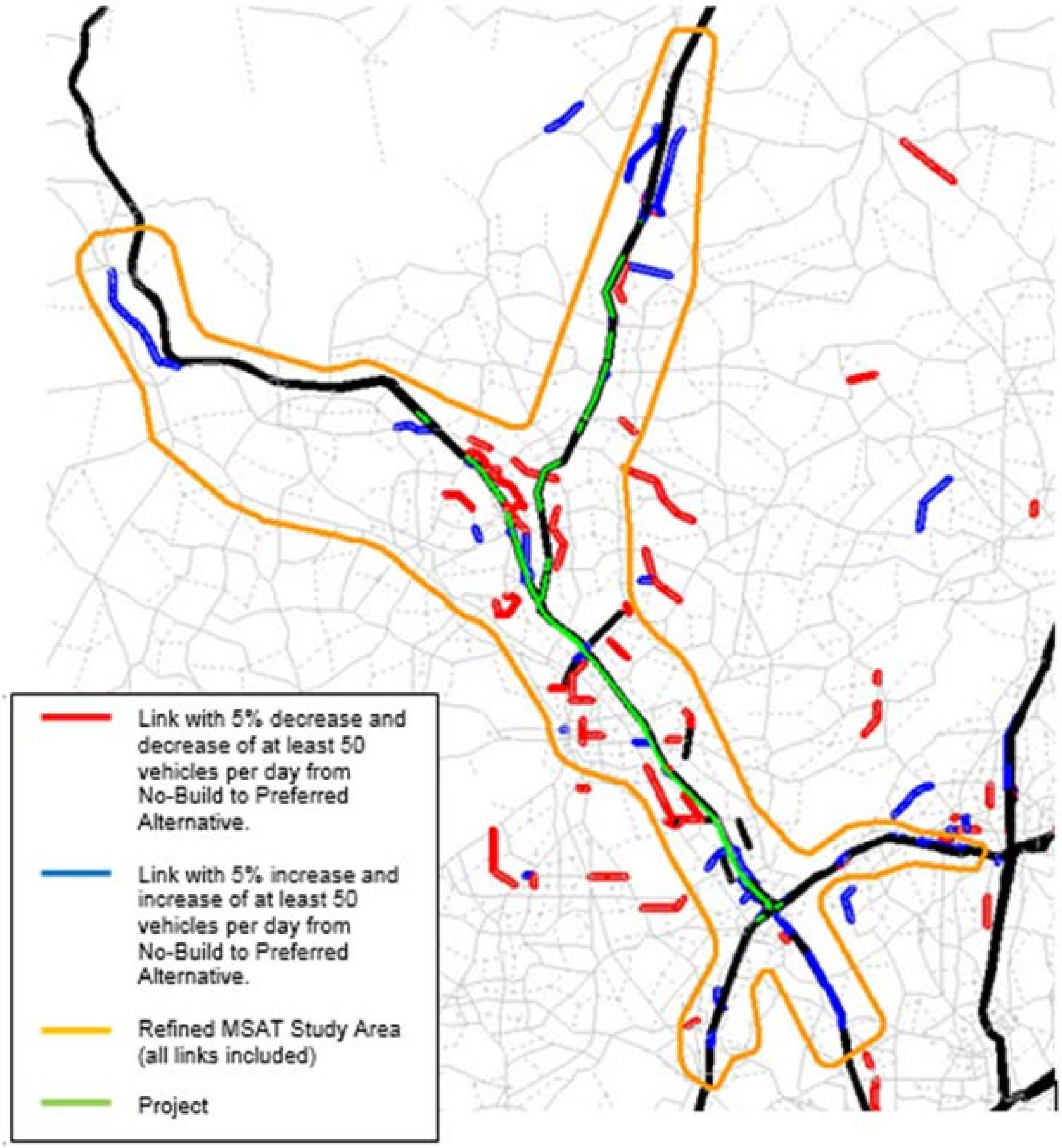
## *Vehicle Mix on One Link on a 24-Hour Basis*

| | WB I-XX before M. Ave entrance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Start Time** | Motor Cycle | Passenger Car | Passenger Truck | Commercial Trucks | Bus | Single Unit Truck | Combination Truck | Total |
| | | | | | | | | |
| 0:00 | 0.00% | 83.64% | 11.11% | 1.94% | 0.61% | 0.71% | 1.99% | 100% |
| 1:00 | 0.10% | 77.62% | 11.53% | 3.49% | 0.58% | 2.52% | 4.17% | 100% |
| 2:00 | 0.00% | 71.07% | 10.15% | 5.25% | 1.02% | 5.92% | 6.60% | 100% |
| 3:00 | 0.00% | 54.80% | 13.21% | 11.11% | 0.60% | 8.71% | 11.56% | 100% |
| 4:00 | 0.00% | 65.40% | 13.32% | 9.39% | 0.45% | 6.13% | 5.30% | 100% |
| 5:00 | 0.00% | 67.83% | 19.31% | 6.50% | 0.50% | 3.33% | 2.52% | 100% |
| 6:00 | 0.05% | 72.39% | 16.31% | 5.99% | 0.27% | 3.04% | 1.94% | 100% |
| 7:00 | 0.06% | 82.46% | 10.68% | 3.79% | 0.25% | 1.51% | 1.25% | 100% |
| 8:00 | 0.03% | 84.67% | 9.38% | 3.44% | 0.24% | 1.06% | 1.18% | 100% |
| 9:00 | 0.13% | 80.29% | 11.59% | 4.22% | 0.39% | 1.38% | 2.01% | 100% |
| 10:00 | 0.01% | 77.31% | 13.69% | 4.15% | 0.42% | 1.69% | 2.72% | 100% |
| 11:00 | 0.01% | 77.43% | 14.52% | 4.02% | 0.38% | 1.57% | 2.06% | 100% |
| 12:00 | 0.02% | 76.83% | 14.53% | 4.34% | 0.28% | 1.72% | 2.27% | 100% |
| 13:00 | 0.02% | 77.41% | 14.42% | 4.41% | 0.38% | 1.48% | 1.88% | 100% |
| 14:00 | 0.00% | 78.90% | 15.31% | 3.34% | 0.28% | 1.02% | 1.14% | 100% |
| 15:00 | 0.03% | 82.06% | 13.65% | 2.30% | 0.32% | 0.63% | 1.00% | 100% |
| 16:00 | 0.01% | 87.31% | 8.89% | 1.82% | 0.30% | 0.77% | 0.91% | 100% |
| 17:00 | 0.02% | 90.30% | 6.91% | 1.43% | 0.26% | 0.51% | 0.57% | 100% |
| 18:00 | 0.03% | 90.22% | 6.88% | 1.38% | 0.19% | 0.53% | 0.76% | 100% |
| 19:00 | 0.01% | 89.59% | 7.47% | 1.38% | 0.28% | 0.40% | 0.88% | 100% |
| 20:00 | 0.03% | 90.14% | 7.59% | 0.97% | 0.19% | 0.46% | 0.62% | 100% |
| 21:00 | 0.00% | 89.20% | 7.56% | 1.12% | 0.27% | 0.54% | 1.31% | 100% |
| 22:00 | 0.00% | 87.89% | 8.57% | 1.02% | 0.42% | 0.64% | 1.46% | 100% |
| 23:00 | 0.00% | 86.27% | 9.32% | 1.74% | 0.37% | 0.69% | 1.61% | 100% |

*Source: WSP*

# MSAT Analysis

## DETERMINE AFFECTED NETWORK SEGMENTS




A sample map with affected network links and a project study area for MSAT analysis.

*Source: WSP*

# INPUTS TO MOVES ON A COUNTY SCALE

## *Typical Transportation Demand Management Inputs to a County Scale MOVES Analysis (will need postprocessing before input into MOVES)*

**Build Condition**

| | |
|---|---|
| **ETC Year =** | 2030 |
| **Link Average Grade =** | 0 |

| Link No. | Link Description | Road Type | Speed (5 mph incr) | X1 (ft) | Y1 (ft) | X2 (ft) | Y2 (ft) | **Peak Hr (veh/hr)** | Length (ft) | Length (mi) | **VMT (veh*mi/hr)** | **Annual VMT (Multiplied by 365.25) (veh*mi/year)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | XXX-2 | 5 | 40 | 324525 | 325458 | 324650 | 325593 | 2963 | 183.98 | 0.035 | 103.25 | 37711 |
| 3 | XXX-3 | 5 | 40 | 324650 | 325593 | 324823 | 325937 | 2963 | 385.05 | 0.073 | 216.08 | 78924 |
| 4 | XXX-4 | 5 | 40 | 324823 | 325937 | 324868 | 325981 | 2963 | 62.94 | 0.012 | 35.32 | 12900 |
| 5 | XXX-5 | 5 | 40 | 324868 | 325981 | 324981 | 326090 | 2963 | 157.00 | 0.030 | 88.11 | 32181 |
| 6 | XXX-6 | 5 | 40 | 324981 | 326090 | 325053 | 326157 | 2603 | 98.35 | 0.019 | 48.49 | 17710 |
| 7 | XXX-7 | 5 | 35 | 325053 | 326157 | 325152 | 326226 | 2603 | 120.67 | 0.023 | 59.49 | 21729 |
| 8 | XXX-8 | 5 | 35 | 325152 | 326226 | 325298 | 326260 | 2710 | 149.91 | 0.028 | 76.94 | 28103 |
| 9 | XXX-9 | 5 | 35 | 325298 | 326260 | 325461 | 326251 | 2710 | 163.25 | 0.031 | 83.79 | 30604 |
| 10 | XXX-10 | 5 | 35 | 325461 | 326251 | 325704 | 326151 | 2710 | 262.77 | 0.050 | 134.87 | 49261 |
| 11 | XXX-11 | 5 | 35 | 325704 | 326151 | 325755 | 326063 | 2710 | 101.71 | 0.019 | 52.20 | 19067 |
| 12 | XXX-12 | 5 | 35 | 325755 | 326063 | 325815 | 325986 | 2966 | 97.62 | 0.018 | 54.84 | 20029 |
| 13 | XXX-13 | 5 | 35 | 325815 | 325986 | 325974 | 325906 | 2966 | 177.99 | 0.034 | 99.99 | 36520 |
| 14 | XXX-14 | 5 | 35 | 325974 | 325906 | 326045 | 325894 | 2966 | 72.01 | 0.014 | 40.45 | 14774 |
| 15 | XXX-15 | 5 | 35 | 326045 | 325894 | 326144 | 325875 | 2966 | 100.81 | 0.019 | 56.63 | 20683 |
| 16 | XXX-16 | 5 | 35 | 326144 | 325875 | 326365 | 325930 | 3105 | 227.74 | 0.043 | 133.93 | 48917 |
| 17 | XXX-17 | 5 | 35 | 326365 | 325930 | 326501 | 325948 | 3015 | 137.19 | 0.026 | 78.34 | 28612 |
| 18 | XXX-18 | 5 | 35 | 326501 | 325948 | 326728 | 325876 | 3015 | 238.14 | 0.045 | 135.99 | 49669 |
| 19 | XXX-19 | 5 | 35 | 326728 | 325876 | 326784 | 325881 | 3015 | 56.22 | 0.011 | 32.10 | 11726 |
| 20 | XXX-20 | 5 | 35 | 326784 | 325881 | 326850 | 325889 | 3015 | 66.48 | 0.013 | 37.96 | 13866 |
| 21 | XXX-21 | 5 | 35 | 326850 | 325889 | 326934 | 325899 | 3015 | 84.59 | 0.016 | 48.30 | 17643 |
| 22 | XXX-22 | 5 | 35 | 326934 | 325899 | 327025 | 325888 | 3015 | 91.66 | 0.017 | 52.34 | 19118 |
| 23 | XXX-23 | 5 | 35 | 327025 | 325888 | 327115 | 325863 | 3015 | 93.41 | 0.018 | 53.34 | 19482 |
| 24 | XXX-24 | 5 | 35 | 327115 | 325863 | 327221 | 325837 | 3543 | 109.14 | 0.021 | 73.24 | 26750 |
| 25 | XXX-25 | 5 | 35 | 327221 | 325837 | 327571 | 325771 | 3543 | 356.17 | 0.067 | 239.00 | 87294 |
| 26 | XXX-26 | 5 | 35 | 327571 | 325771 | 327679 | 325686 | 3543 | 137.44 | 0.026 | 92.22 | 33685 |
| 27 | XXX-27 | 5 | 35 | 327679 | 325686 | 327842 | 325451 | 3543 | 286.00 | 0.054 | 191.91 | 70095 |
| 28 | XXX-28 | 5 | 35 | 327842 | 325451 | 327928 | 325375 | 4621 | 114.77 | 0.022 | 100.44 | 36688 |
| 29 | XXX-29 | 5 | 35 | 327928 | 325375 | 327981 | 325335 | 4226 | 66.40 | 0.013 | 53.15 | 19411 |
| 30 | XXX-30 | 5 | 40 | 327981 | 325335 | 328137 | 325206 | 4226 | 202.43 | 0.038 | 162.02 | 59177 |
| 31 | XXX-31 | 5 | 45 | 328137 | 325206 | 328403 | 324992 | 4226 | 341.40 | 0.065 | 273.25 | 99803 |
| 32 | XXX-32 | 5 | 40 | 328403 | 324992 | 328564 | 324860 | 5908 | 208.19 | 0.039 | 232.96 | 85088 |

*Source: WSP*

***Example of Hour VHT Distribution (for one AM peak hour) by Vehicle Type, Road Functional Class and Speed from an MPO Model for Input Into MOVES (will need postprocessing before input into MOVES)***

| FCLASS | speed_bin | SOV | HOV2 | HOV3+ | TAXI | MEDTRUC | HEATRUC | BUS | COMM | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Arterial | 1 | 0.48 | 0.22 | 0.09 | 0.07 | 0.04 | 0.03 | 0.04 | 0.03 | 1.00 |
| Arterial | 2 | 0.59 | 0.18 | 0.08 | 0.04 | 0.03 | 0.02 | 0.03 | 0.03 | 1.00 |
| Arterial | 3 | 0.47 | 0.22 | 0.09 | 0.07 | 0.04 | 0.03 | 0.05 | 0.03 | 1.00 |
| Arterial | 4 | 0.47 | 0.22 | 0.10 | 0.07 | 0.04 | 0.03 | 0.04 | 0.03 | 1.00 |
| Arterial | 5 | 0.46 | 0.22 | 0.10 | 0.08 | 0.04 | 0.03 | 0.04 | 0.03 | 1.00 |
| Arterial | 6 | 0.51 | 0.20 | 0.09 | 0.07 | 0.03 | 0.02 | 0.04 | 0.03 | 1.00 |
| Arterial | 7 | 0.52 | 0.21 | 0.09 | 0.07 | 0.03 | 0.02 | 0.03 | 0.04 | 1.00 |
| Arterial | 8 | 0.71 | 0.13 | 0.04 | 0.02 | 0.04 | 0.02 | 0.02 | 0.02 | 1.00 |
| Arterial | 9 | | | | | | | | | |
| Arterial | 10 | 0.39 | 0.28 | 0.11 | 0.07 | 0.07 | 0.03 | 0.00 | 0.05 | 1.00 |
| Arterial | 11 | | | | | | | | | |
| Arterial | 12 | | | | | | | | | |
| Arterial | 13 | | | | | | | | | |
| Arterial | 14 | | | | | | | | | |
| Arterial | 15 | | | | | | | | | |
| Arterial | 16 | | | | | | | | | |
| Highway Facilities | 1 | 0.60 | 0.19 | 0.07 | 0.03 | 0.04 | 0.04 | 0.00 | 0.01 | 1.00 |
| Highway Facilities | 2 | 0.68 | 0.15 | 0.06 | 0.01 | 0.05 | 0.04 | 0.00 | 0.01 | 1.00 |
| Highway Facilities | 3 | 0.57 | 0.23 | 0.07 | 0.03 | 0.04 | 0.04 | 0.00 | 0.01 | 1.00 |
| Highway Facilities | 4 | 0.60 | 0.20 | 0.07 | 0.03 | 0.04 | 0.04 | 0.00 | 0.01 | 1.00 |
| Highway Facilities | 5 | 0.58 | 0.19 | 0.07 | 0.03 | 0.05 | 0.05 | 0.01 | 0.01 | 1.00 |
| Highway Facilities | 6 | 0.52 | 0.23 | 0.07 | 0.05 | 0.06 | 0.05 | 0.00 | 0.02 | 1.00 |
| Highway Facilities | 7 | 0.45 | 0.19 | 0.07 | 0.04 | 0.08 | 0.15 | 0.00 | 0.02 | 1.00 |
| Highway Facilities | 8 | 0.47 | 0.21 | 0.07 | 0.05 | 0.10 | 0.08 | 0.01 | 0.02 | 1.00 |
| Highway Facilities | 9 | | | | | | | | | |
| Highway Facilities | 10 | 0.42 | 0.31 | 0.07 | 0.06 | 0.07 | 0.01 | 0.00 | 0.04 | 1.00 |
| Highway Facilities | 11 | | | | | | | | | |
| Highway Facilities | 12 | | | | | | | | | |
| Highway Facilities | 13 | | | | | | | | | |
| Highway Facilities | 14 | | | | | | | | | |
| Highway Facilities | 15 | | | | | | | | | |
| Highway Facilities | 16 | | | | | | | | | |
| Local Roadways | 1 | 0.50 | 0.22 | 0.10 | 0.06 | 0.03 | 0.02 | 0.04 | 0.03 | 1.00 |
| Local Roadways | 2 | 0.51 | 0.20 | 0.09 | 0.06 | 0.05 | 0.04 | 0.03 | 0.03 | 1.00 |
| Local Roadways | 3 | 0.51 | 0.22 | 0.09 | 0.05 | 0.03 | 0.02 | 0.05 | 0.03 | 1.00 |
| Local Roadways | 4 | 0.43 | 0.25 | 0.11 | 0.08 | 0.03 | 0.02 | 0.05 | 0.03 | 1.00 |
| Local Roadways | 5 | 0.44 | 0.23 | 0.11 | 0.08 | 0.03 | 0.02 | 0.06 | 0.03 | 1.00 |
| Local Roadways | 6 | 0.51 | 0.24 | 0.10 | 0.07 | 0.02 | 0.01 | 0.02 | 0.03 | 1.00 |
| Local Roadways | 7 | 0.36 | 0.26 | 0.10 | 0.15 | 0.03 | 0.00 | 0.00 | 0.09 | 1.00 |
| Local Roadways | 8 | 0.48 | 0.28 | 0.13 | 0.08 | 0.00 | 0.00 | 0.00 | 0.02 | 1.00 |
| Local Roadways | 9 | | | | | | | | | |
| Local Roadways | 10 | | | | | | | | | |
| Local Roadways | 11 | | | | | | | | | |
| Local Roadways | 12 | | | | | | | | | |
| Local Roadways | 13 | | | | | | | | | |
| Local Roadways | 14 | | | | | | | | | |
| Local Roadways | 15 | | | | | | | | | |
| Local Roadways | 16 | | | | | | | | | |

1) SOV- single occupancy vehicle, HOV2 or 3 -high occupancy w/1 or 2 passengers; COMM - light commercial truck
2) Speed bins are per MOVES speed rangers in Appendix C Table 4
*Source: WSP*

# Appendix C MOVES Input Definitions and Data Classes

This appendix defines MOVES terminology and provides tables of MOVES input classes and their crosswalk to common traffic data classes. The tables are applicable to MOVES2014a; when future versions of MOVES are released the analyst should check the latest user guidance from EPA to determine whether any input structures have changed.

### Table 1. Terms and Explanations

| MOVES Terminology | Traffic Terminology | Description |
|---|---|---|
| **General Terms** | | |
| Activity | Traffic Characteristics | A term that describes various vehicle activities that affect emissions, such as VMT, speeds, and temporal patterns of traffic. |
| Acceleration, Deceleration, Cruise and Idle Links | | Road segments determined by the air quality analysts to identify links with different speeds/operating conditions, to develop geographically-specific emissions estimates for use in dispersion modeling of intersections and highways. |
| **MOVES Inputs for County-Level and Project-Level Runs** | | |
| Source Type Population | Number of Vehicles | Number of vehicles by 13 source types (vehicle types). See below for a list of the 13 source types. |
| **MOVES Inputs for Project-Level Runs** | | |
| Link Source Type Hour | Vehicle Mix on Each Link | VHT fraction of each source type (vehicle class) on each link for each hour – equals to vehicle mix (see below). |
| Link Average Speed[b] | | The average speed of all vehicles traversing the link. |
| Link Drive Schedule[b] | Vehicle Traces, Drive Cycles | Second-by-second speed profile for each vehicle (or representative vehicle type) traversing the link. |
| Operating Mode Distribution[b] | | Fraction of time by source (vehicle) type spent in each of the 25 MOVES vehicle-specific power (VSP) and speed ranges (VSP is a function of second-by-second speed values and vehicle type). |
| Start Fraction | | Fraction of total vehicles that start in each hour of the day |
| Hotelling Fraction | | Fraction of time spent in hoteling mode (extended idle or auxiliary power unit operation) by hour (long-haul combo trucks) |
| Parked Fraction | | Fraction of time vehicles spend parked in an hour |
| Grade | | Average grade of each link (percent) |
| **MOVES Inputs for County-Scale Runs** | | |
| Road Type Distribution | Facility Type, Road Class, Highway Functional Classification | Fraction of VMT occurring by 5 road types, for 13 source (vehicle) types. Road types include off-network, rural restricted access, rural unrestricted access, urban restricted access, and urban unrestricted access; off-network VMT can be included only for project-scale analysis.[a] |
| VMT by Vehicle Class | | Annual VMT by 5 HPMS vehicle types. See Appendix C for the list of vehicle types used in MOVES. |
| Month, Day, and Hour VMT Fractions | Temporal VMT Adjustments | Fraction of VMT occurring by month of year for 13 source types; fraction of VMT occurring by hour of day and weekday versus weekend for 5 road types and 13 source types. |
| Average Speed Distribution | | Fraction of VHT in each speed range (bin), by road type, hour and source (vehicle) type. There are 16 speed ranges used by MOVES from 2.5 to 75 mph (see below). |
| Ramp Fraction | | Fraction of restricted access road type VHT occurring on ramps. |

[a] See NCHRP WOD 210, Vol. 2, Section 4.7 for a discussion of when to use the “off-network” road type.
[b] Only one of these three inputs—link average speed, drive schedule, or operating mode distribution—needs to be provided.

### *Table 2: MOVES Source Types and Corresponding FHWA/HPMS Classes*

| MOVES | | FHWA/HPMS Class | | |
|---|---|---|---|---|
| **MOVES Source Type ID** | **MOVES Source Type** | **MOVES Vehicle Type ID** | **HPMS Vehicle Type** | **FHWA 13-Class Groups** |
| 11 | Motorcycle | 10 | Motorcycle | Class 1 |
| 21 | Passenger Car | 25 | Light Duty Vehicles | Class 2 |
| 31 | Passenger Truck | 25 | Light Duty Vehicles | Class 3 |
| 32 | Light Commercial Truck | 25 | Light Duty Vehicles | Class 3 |
| 41 | Intercity Bus | 40 | Buses | Class 4 |
| 42 | Transit Bus | 40 | Buses | Class 4 |
| 43 | School Bus | 40 | Buses | Class 4 |
| 51 | Refuse truck | 50 | Single Unit Trucks | Class 5 – 6 |
| 52 | Single Unit Short-Haul Truck | 50 | Single Unit Trucks | Class 5 – 7 |
| 53 | Single Unit Long-Haul Truck | 50 | Single Unit Trucks | Class 5 – 7 |
| 54 | Motor Home | 50 | Single Unit Trucks | Class 5 – 6 |
| 61 | Combination Unit Short-Haul Truck | 60 | Combination Trucks | Class 8 – 13 |
| 62 | Combination Unit Long-Haul Truck | 60 | Combination Trucks | Class 8 – 13 |

### *Table 3: MOVES2014a Roadway Types and Corresponding HPMS Functional Classes*

| MOVES Road Type ID | MOVES Road Type Description | HPMS Code | HPMS Functional Class Description |
|---|---|---|---|
| 1 | Off-Network | N/A | N/A |
| 2 | Rural Restricted Access | 1 | Rural Interstate |
| 3 | Rural Unrestricted Access | 2 | Rural Principal Arterial |
| | | 6 | Rural Minor Arterial |
| | | 7 | Rural Major Collector |
| | | 8 | Rural Minor Collector |
| | | 9 | Rural Local |
| 4 | Urban Restricted Access | 11 | Urban Interstate |
| | | 12 | Urban Freeway |
| 5 | Urban Unrestricted Access | 14 | Urban Other Arterial |
| | | 16 | Urban Minor Arterial |
| | | 17 | Urban Collector |
| | | 19 | Urban Local |

Note: The HPMS Functional Classifications no longer distinguish between urban and rural roadways. However, the MOVES model still requires this distinction. However, the urban and rural designations of the roadway can be obtained from the urban code in HPMS.

### *Table 4: MOVES2014a Average Speed Ranges*

| Bin | Average Speed (mph) | Average Speed Range (mph) |
|---|---|---|
| 1 | 2.5 | speed < 2.5 mph |
| 2 | 5 | 2.5 mph <= speed < 7.5 mph |
| 3 | 10 | 7.5 mph <= speed < 12.5 mph |
| 4 | 15 | 12.5 mph <= speed < 17.5 mph |
| 5 | 20 | 17.5 mph <= speed < 22.5 mph |
| 6 | 25 | 22.5 mph <= speed < 27.5 mph |
| 7 | 30 | 27.5 mph <= speed < 32.5 mph |
| 8 | 35 | 32.5 mph <= speed < 37.5 mph |
| 9 | 40 | 37.5 mph <= speed < 42.5 mph |
| 10 | 45 | 42.5 mph <= speed < 47.5 mph |
| 11 | 50 | 47.5 mph <= speed < 52.5 mph |
| 12 | 55 | 52.5 mph <= speed < 57.5 mph |
| 13 | 60 | 57.5 mph <= speed < 62.5 mph |
| 14 | 65 | 62.5 mph <= speed < 67.5 mph |
| 15 | 70 | 67.5 mph <= speed < 72.5 mph |
| 16 | 75 | 72.5 mph <= speed |

# Appendix D Link Definition in Air Quality vs Traffic Analysis

Roadways can be segmented to differentiate modes of vehicle operation, to make both emission estimates and dispersion modeling more accurate. For a project that requires dispersion modeling, most likely for PM but possibly also for CO analysis, the segmentation approach will be driven by EPA guidance specific to the modeling of that pollutant, as summarized below. Links for project-scale analysis in MOVES can be defined to correspond to the links required for dispersion modeling.

If dispersion modeling is not required, links can be defined for emissions analysis purposes that correspond to roadway segments with a uniform traffic volume, mix of vehicles, speed conditions, and grade. In this case, it is not necessary to define separate acceleration, deceleration, cruise, and queue links as may be needed for dispersion modeling. This is because MOVES incorporates assumptions about variations in speed that occur over a typical link accounting for interruptions in flow due to signalized or not signalized intersections (on unrestricted access roads).

A running link in MOVES is a stretch of road of a certain length where vehicles are moving at the same speed (among other parameters). If some vehicle classes move on this roadway segment at a different speed, this segment of traffic volume needs to be defined as a separate link. Because of this definition, the time fraction that each class of vehicles spends on the link is equal to the volume fraction of this vehicle class on this link.

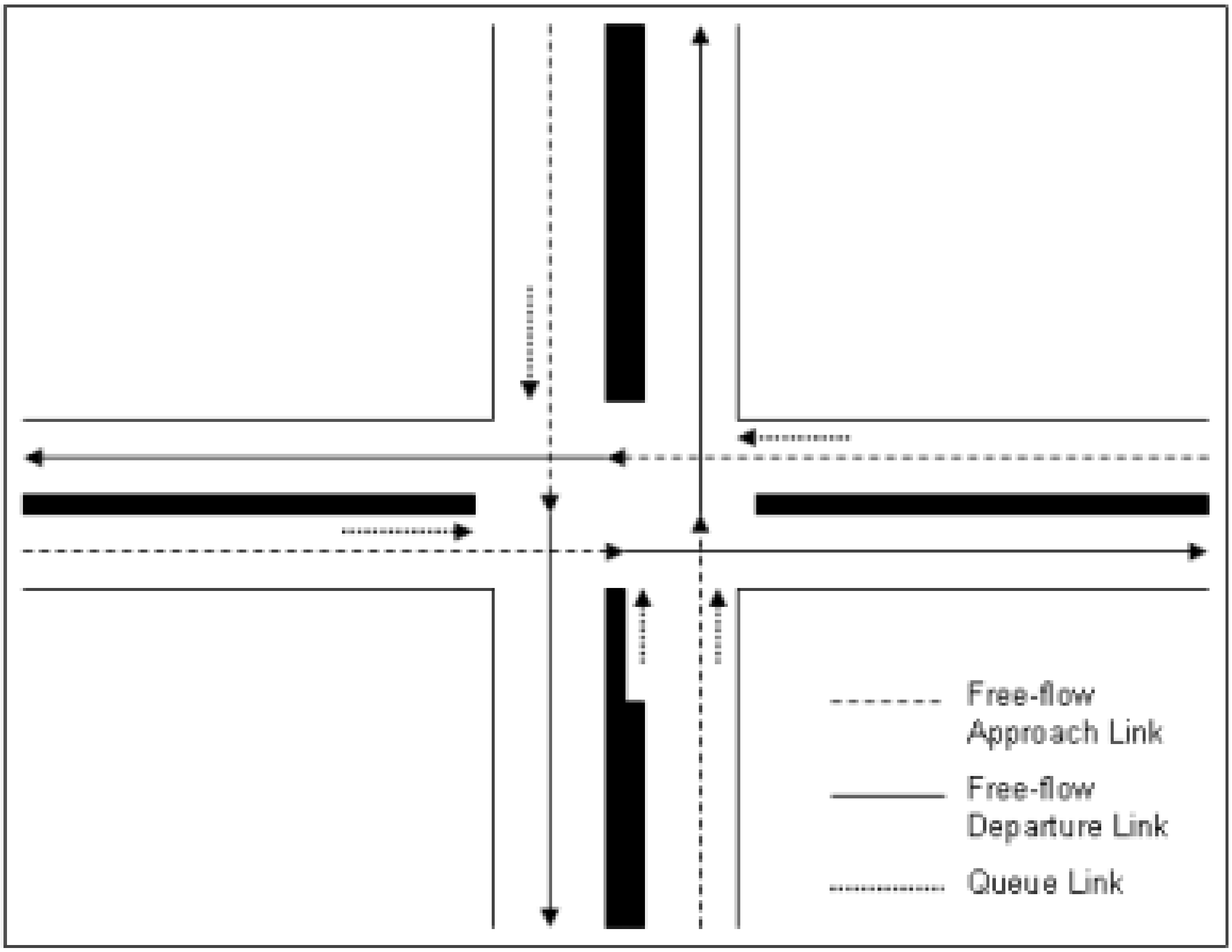
More sophisticated analysis may break up the traffic flow into multiple links if needed to represent different traffic conditions. For instance, separate links could be created on one physical segment of the road to represent faster moving passenger cars and passenger trucks versus slower moving combination trucks. There is no limit to the number of links in MOVES. Each link would have a separate emission factor for the traffic represented on it.

## LINKS IN DISPERSION MODELING

This section provides a summary of guidance on link definitions for CO and PM dispersion modeling. More detailed guidance is provided in FHWA Resource Center training materials (FHWA, 2015).

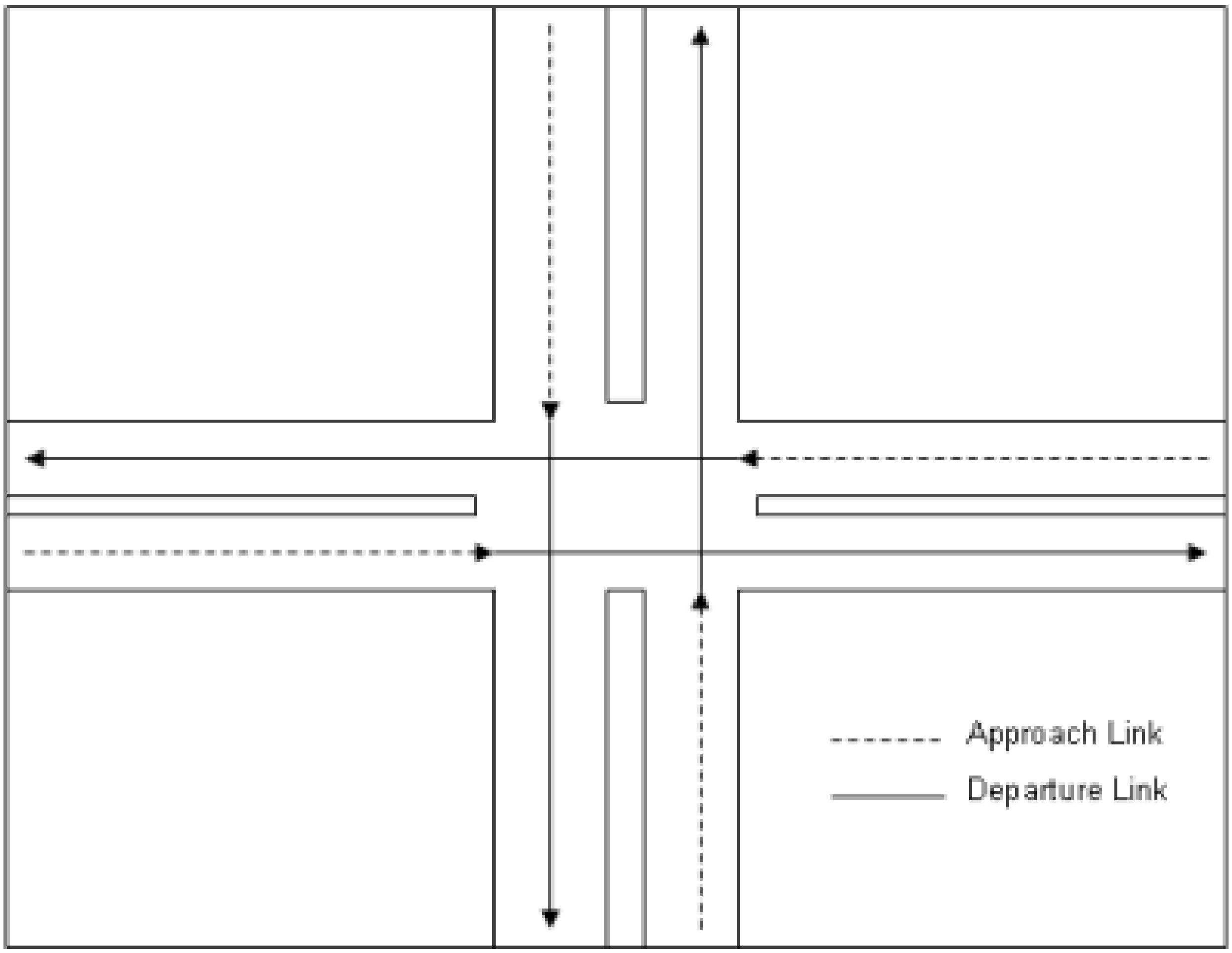
Modeling of carbon monoxide (CO) for the intersections on screening or refined levels using CAL3QHC/R model includes modeling of free-flow links and queue links. Free-flow links represent approach and departure links, while queue links represent idling traffic. Uncongested speeds (speeds that do not include intersection stop time) are used in the CO modeling on the free-flow links.

A simple intersection with suggested links is presented in the following diagram for **CO analysis**:



Modeling procedures for particulate matter (PM) are different. The analysts are asked to use congested speeds (speeds that include intersection stop time) and, therefore, not to include separate links for idling traffic (queue links) in their models. A simple intersection for PM dispersion modeling is presented below. This model will include only approach and departure links:

## PM ANALYSIS




In both cases an average speed (or a number of speeds for several vehicle classes, should they have different speeds) on each approach and departure link will be used as input to the MOVES model.