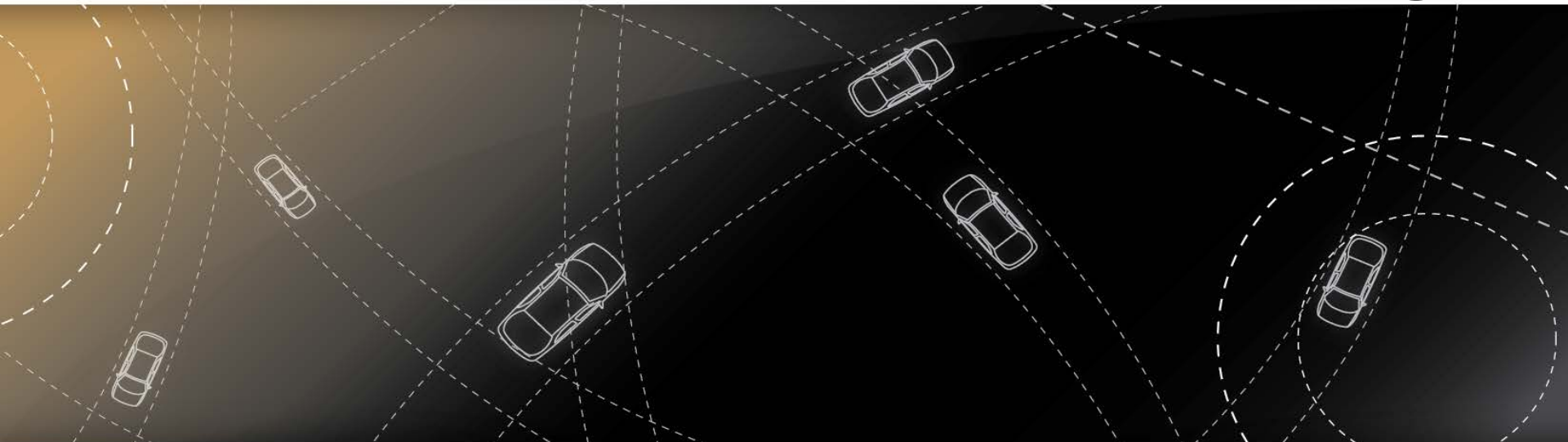


Introduction to Air Quality for Highway Planning



*Kevin Black, Paul Heishman, and Mike Claggett
Federal Highway Administration
May 2016*



Introduction

- Today's webinar will cover three topics important for understanding how vehicles contribute to air pollution
- The topics will include
 - Atmospheric and air quality science
 - Transportation concepts used in accounting for the vehicles and fleets contributing to air pollution
 - Analysis methods and models that estimate the impacts of vehicles operating on highways



Introduction

- The presentations will be conducted by:
 - Atmospheric and air quality science (Kevin Black, FHWA Air Quality Team)
 - Transportation concepts (Paul Heishman, FHWA Air Quality Team)
 - Analysis methods (Mike Claggett, FHWA Air Quality Team)
- These topics represent a short summary of FHWA's course titled "Air Quality Fundamentals" which is a two-day course available as both a web-based and an in-person, instructor lead course

Introduction

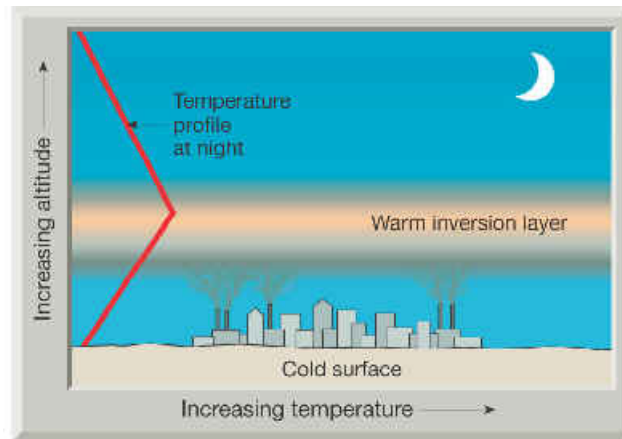
- Courses on Air Quality for Transportation Planners is important since it is the law
- Legal Authority: The 1970 CAA, amended in 1990, required USEPA to establish the National Ambient Air Quality Standards and conduct periodic review of both the standards and basis for the standards
- This course discusses some aspects that result from the regulation of air quality as it relates to highway mobile sources



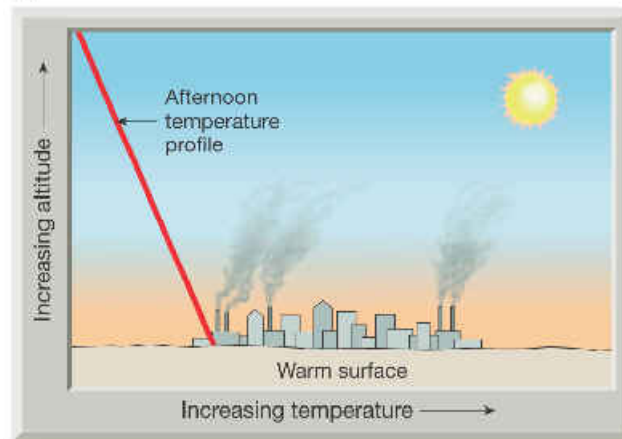
Introduction

- The first presentation today will discuss the science behind transportation-related air quality issues and cover such topics as:
 - Atmospheric science (physics, chemistry concepts)
 - Meteorological principles
 - Emissions
 - Health Impacts
 - Monitoring of air quality

The Science of Air Quality – Meteorology



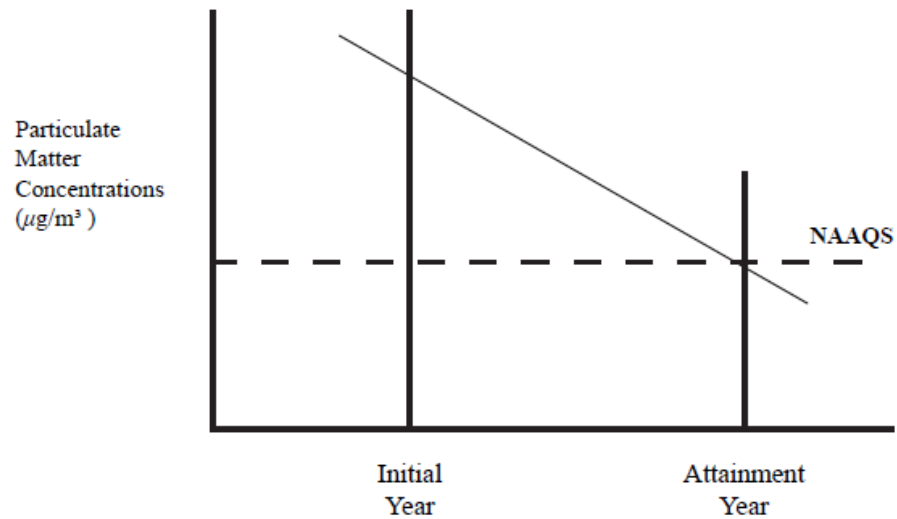
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(b)

The Science of Air Quality – Emissions

Emission and Concentration Relationships

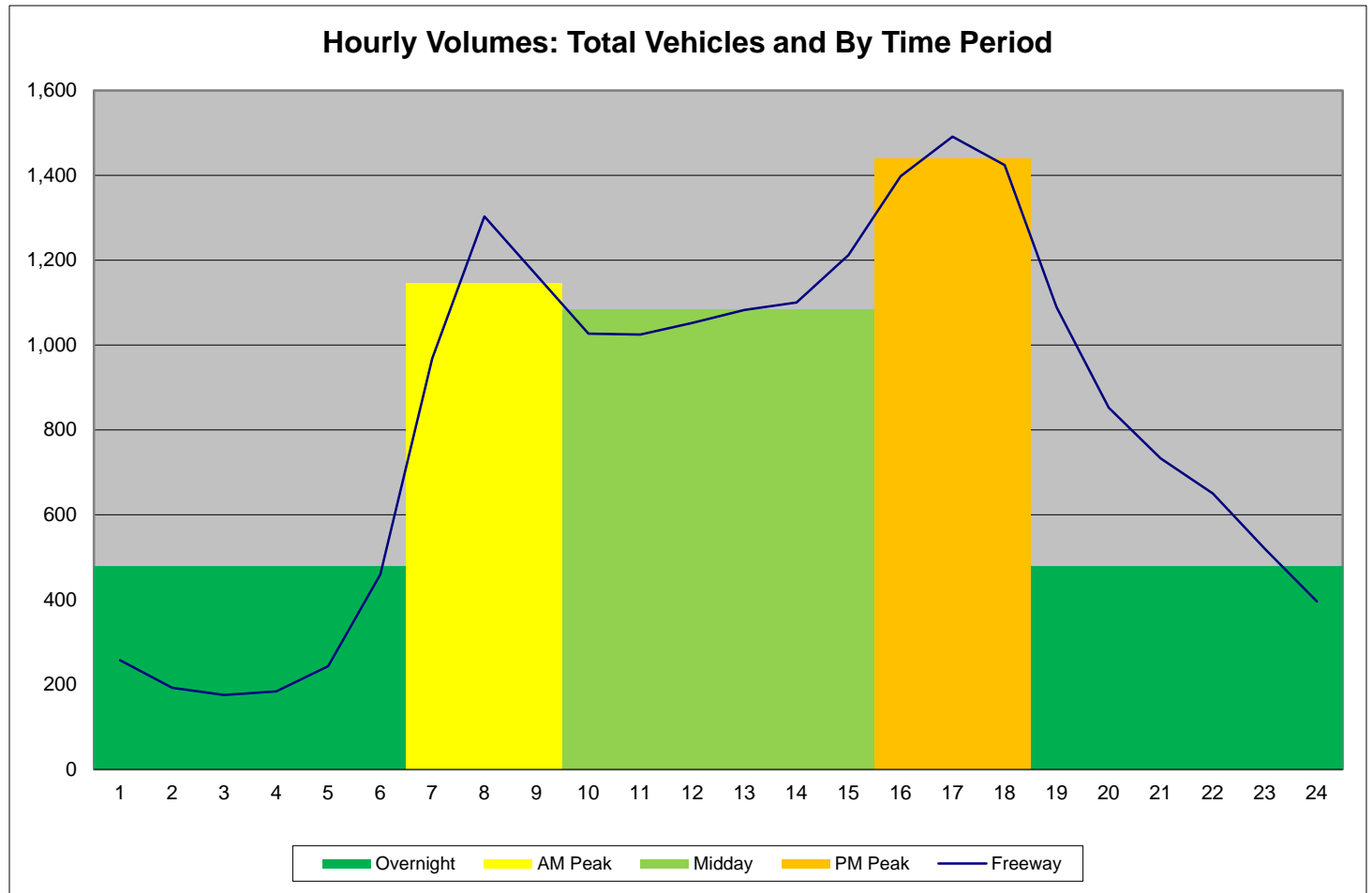




Introduction

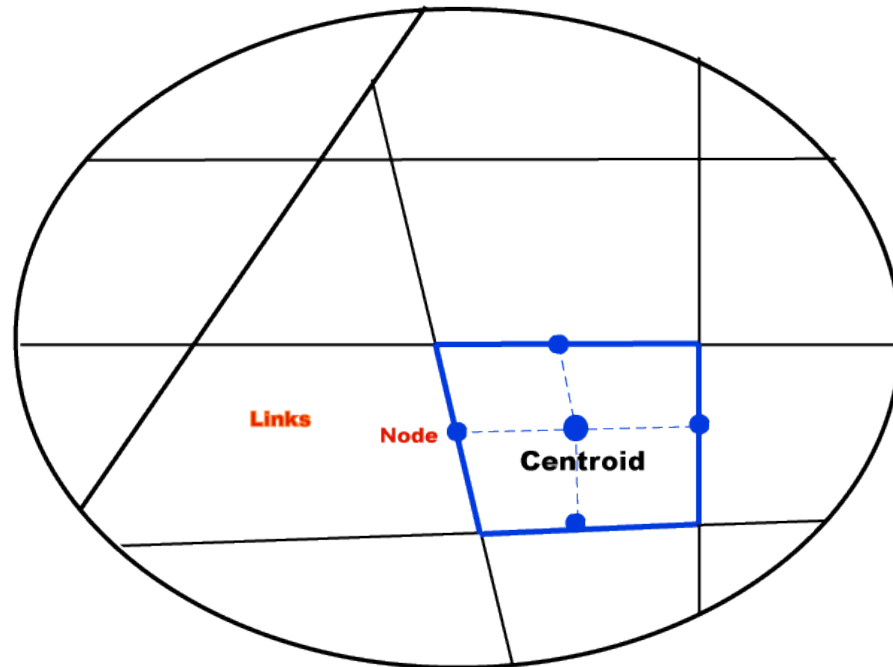
- The second presentation today will discuss transportation and traffic related concepts that those working in air quality need to be familiar with including:
 - The Highway Capacity Manual
 - Travel Demand Models
 - Traffic forecasting the 4-Step Process
 - Regional Traffic Data Concepts
 - Project-Level Traffic Concepts
 - Role of Traffic Data in Air Quality Studies

Traffic Considerations- Intro



Traffic Considerations- Regional

How is an Area Represented in Network Modeling?





Introduction

- The third and last presentation today will discuss the how air quality analysis is conducted for transportation-related air quality programs and projects and it will cover the topics:
 - Travel and traffic data used in air quality analysis
 - Emission models (rates and mass)
 - Dispersion models (concentrations)

Air Quality Impact Analysis Framework – Emissions

Fleet Characteristics

- Vehicle Activity
- Vehicle Types
- Vehicle Age
- Vehicle Fuels

Other Factors

- Scale / Geographics
- Time Spans
- State Programs
- Meteorology

Emissions Model

- Measured Rates
- Activity
- Adjustments

Inventory / Rates

Air Quality Impact Analysis Framework – Concentrations

Vehicle Emissions

- Traffic Parameters
- Highway Configuration
- Inventory / Emission Rates

Meteorology

- Wind Speed
- Wind Direction
- Atmospheric Stability
- Mixing Height

Air Quality Model

- Transport and diffusion
- Traffic-induced turbulence
- Chemical Transformation

Receptor Concentration

Introduction

- FHWA's Air Quality Team offers several courses on air quality including:
 - Air Quality Fundamentals
 - Air Quality Benefits
 - Project Level Analysis
 - Others
- For more information, participants in today's webinar can contact any of today's instructors

Introduction

Thank you for your interest. We hope our presentations may answer some questions that you may have had about air quality for highway planning



Contact Information

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Introduction to Air Quality for Highway Planning

■ Webinar outline

- Air Quality Science
 - Kevin Black
- Traffic Considerations
 - Paul Heishman
- Air Quality Impact Analysis
 - Michael Claggett



The Science of Air Quality

- In this presentation we will discuss the following topics:
 - Atmospheric Science (physics, chemistry)
 - Meteorological Principles (wind, precipitation, temperature, solar radiation)
 - Emissions (mass)
 - Air Quality Monitoring (concentrations)
 - Health Impacts
 - Analysis of Impacts
 - Emission Reduction Strategies



The Science of Air Quality

- Basis for understand air quality is the Clean Air Act and its amendments
 - Donora Valley, PA
 - Denver Brown Cloud
 - Acid Rain
 - Climate Change
 - Background concentrations
 - Upwind contributions
 - Stratospheric intrusions
 - Boundaries
 - Precursor pollutants

The Science of Air Quality



The Science of Air Quality



The Science of Air Quality



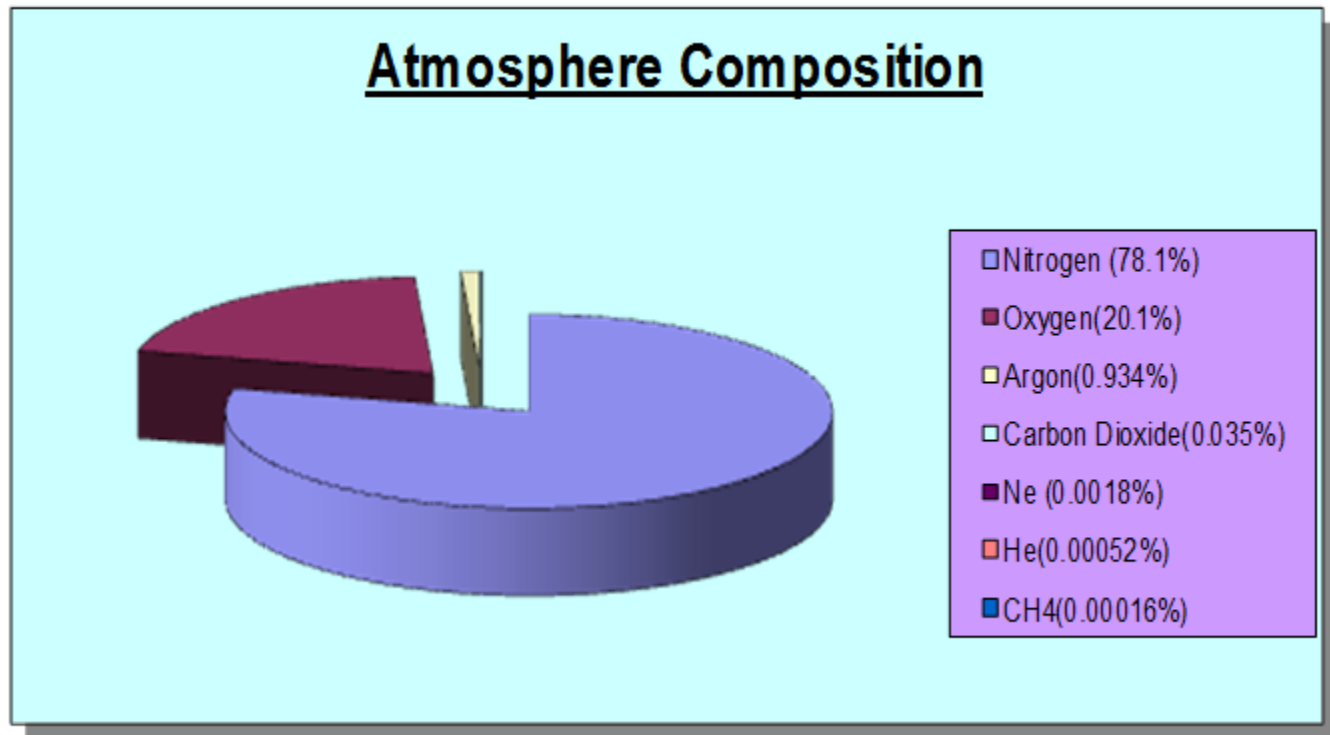
The Science of Air Quality



The Science of Air Quality



The Science of Air Quality – Atmospheric Science



The Science of Air Quality – Atmospheric Science

Periodic Table: Find Atomic Weight for MW Weight Computation

1a																0		
1 H 1.008	IIa										IIb	IVa	Va	VIa	VIIa	2 He 4.00		
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.00	8 O 15.99	9 F 18.99	10 Ne 20.18	
11 Na 22.99	12 Mg 24.31	IIb	IVb	Vb	VIb	VIII					IB	IIb	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.6	22 Ti 47.90	23 V 50.94	24 Cr 51.99	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80	
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 99	44 Ru 101.97	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30	
55 Cs 132.91	56 Ba 137.34	57-71 see below	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222	
87 Fr 223	88 Ra 226	89-103 see below	104 Rf 261	105 Ha 260	106 Sg 263													

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 147	62 Sm 150.35	63 Eu 151.96	64 Gd 157.24	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
89 Ac 227	90 Th 232.04	91 Pa 231	92 U 238.03	93 Np 237	94 Pu 242	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 254	100 Fm 253	101 Md 256	102 No 254	103 Lw 257



The Science of Air Quality – Atmospheric Science

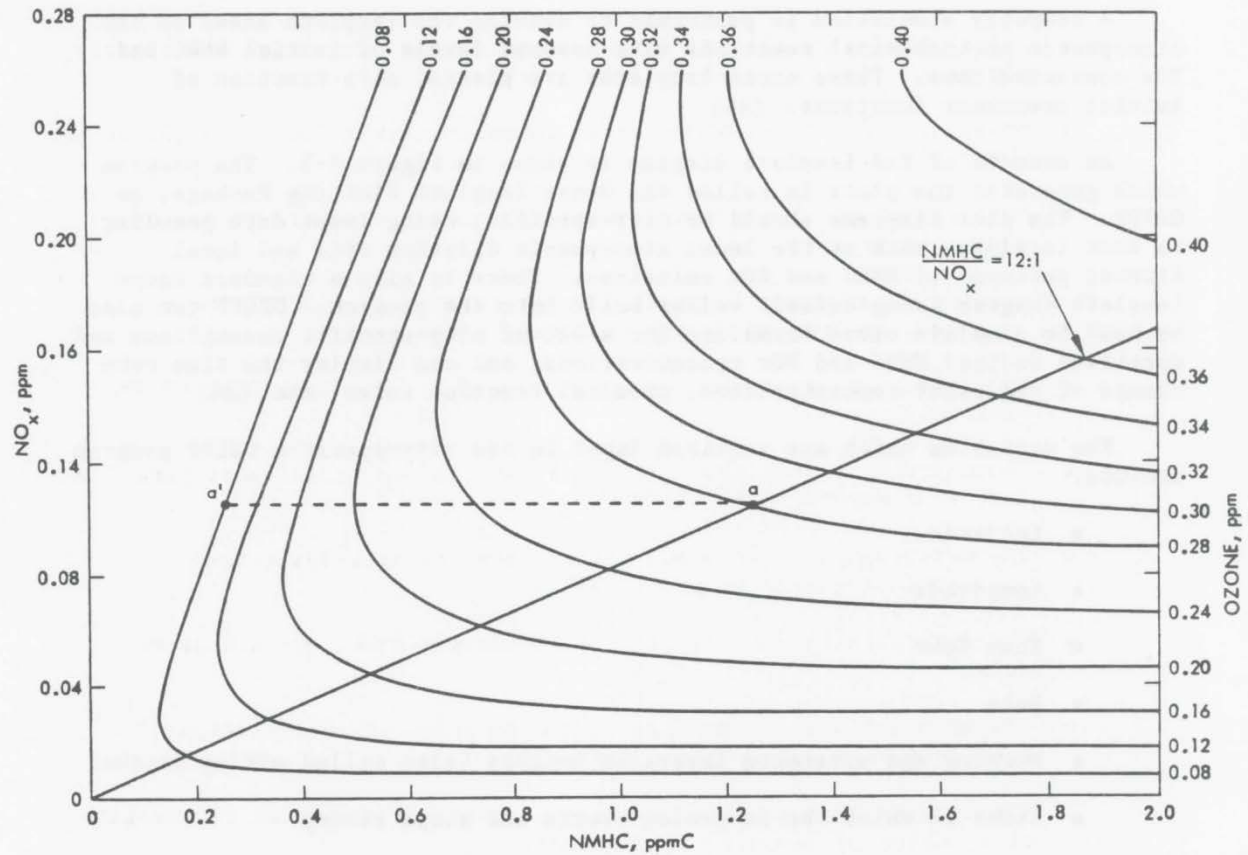
- Chemical reactivity
 - NO_x and the NO to NO₂ conversion
- Photochemical reactivity
 - Dependent on parameters such as emissions of NMHC and NO_x, meteorological conditions, reactivity, transported ozone from upwind sites, etc...
 - Empirical Kinetic Modeling Approach (EKMA) for ozone (illustration, actual calculation is by air quality dispersion models such as CAMx and CMAQ)
- Inversions (discussed in Met Section)



The Science of Air Quality – Atmospheric Science

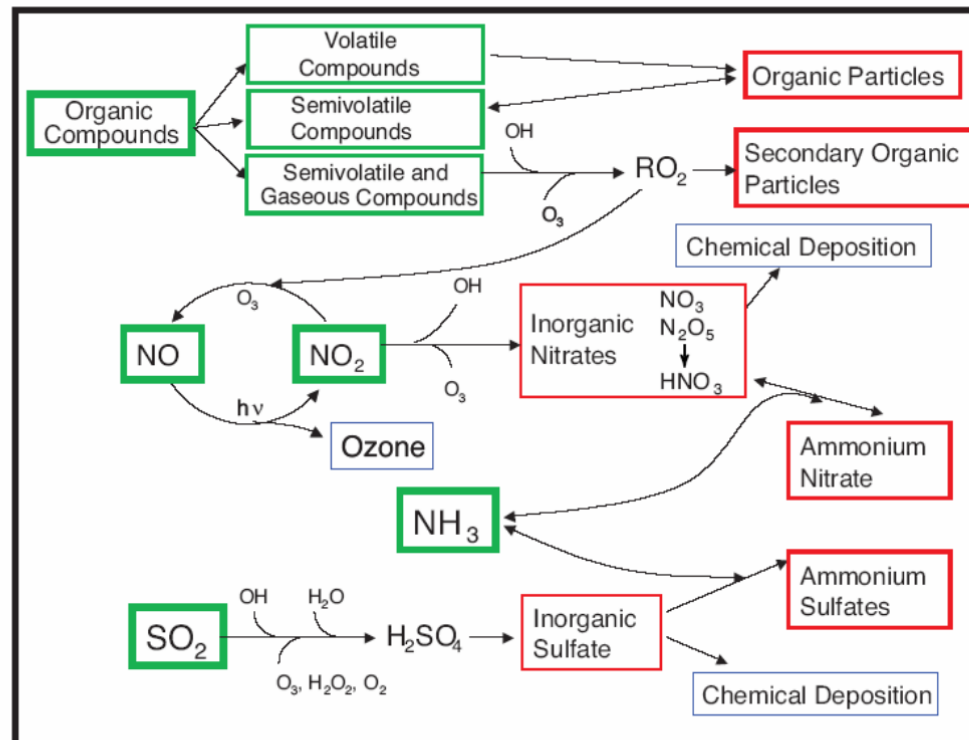
- Example of reactivity - Oxides of Nitrogen (NO_x)
 - Mainly Nitrogen Dioxide (NO₂)
 - NO₂ + Water = Nitric Acid
 - NO_x + atmosphere = PM
 - NO_x + HC + Sunlight = O₃

The Science of Air Quality – Atmospheric Science



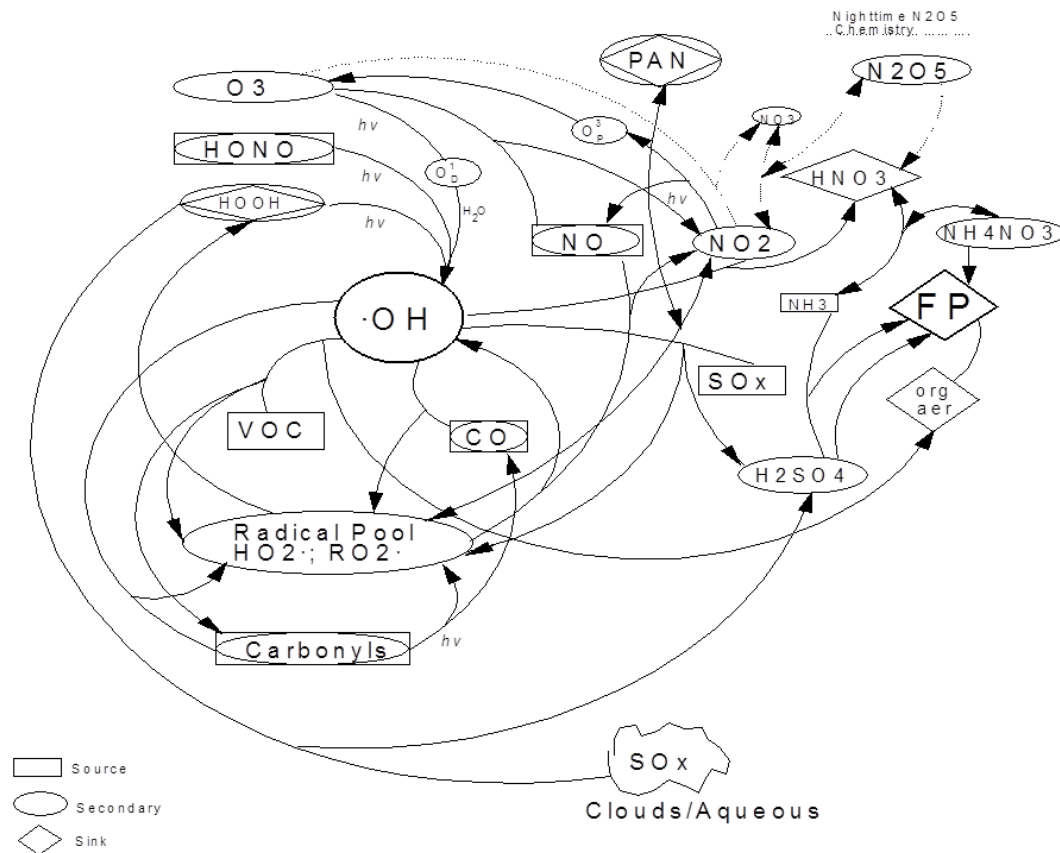
The Science of Air Quality – Atmospheric Science

The Science



The Science of Air Quality – Atmospheric Science

Figure 4. Linkage between oxidant chemistry and fine particle (FP) formation.





The Science of Air Quality – Meteorology

- “Meteorology” and “weather” are shorter term phenomena – day-to-day, week-to-week, year-to year
 - Meteorological trends are important for evaluating criteria pollutants
 - Most designations of nonattainment based on 3 years of data
- Climate, a long term phenomena, is of interest when discussing greenhouse gases
 - Atmospheric history, usually interpreted through geological records, important for examining climate trends
 - Decades, centuries, millennia geological epochs....



The Science of Air Quality – Meteorology

- Clouds: affects energy distribution and certain chemical reactions
- Wind/Mixing: dilution and transport function
- Precipitation: washes away and cleanses the air
- Relative humidity
- Temperature
- Solar radiation
- Inversions



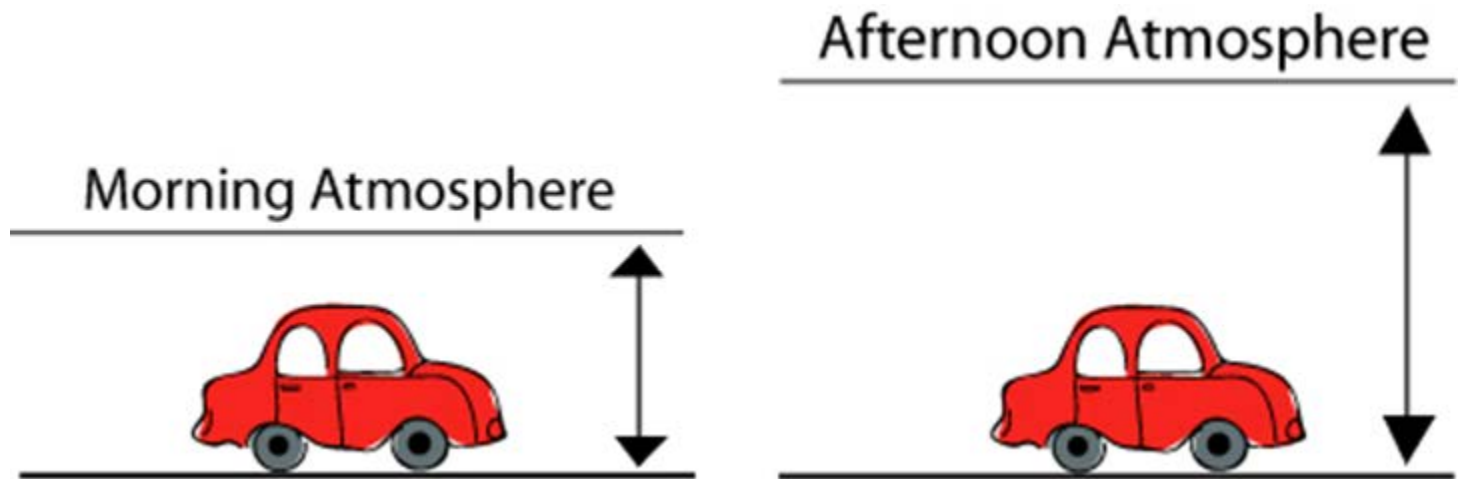
The Science of Air Quality – Meteorology

■ Temperature

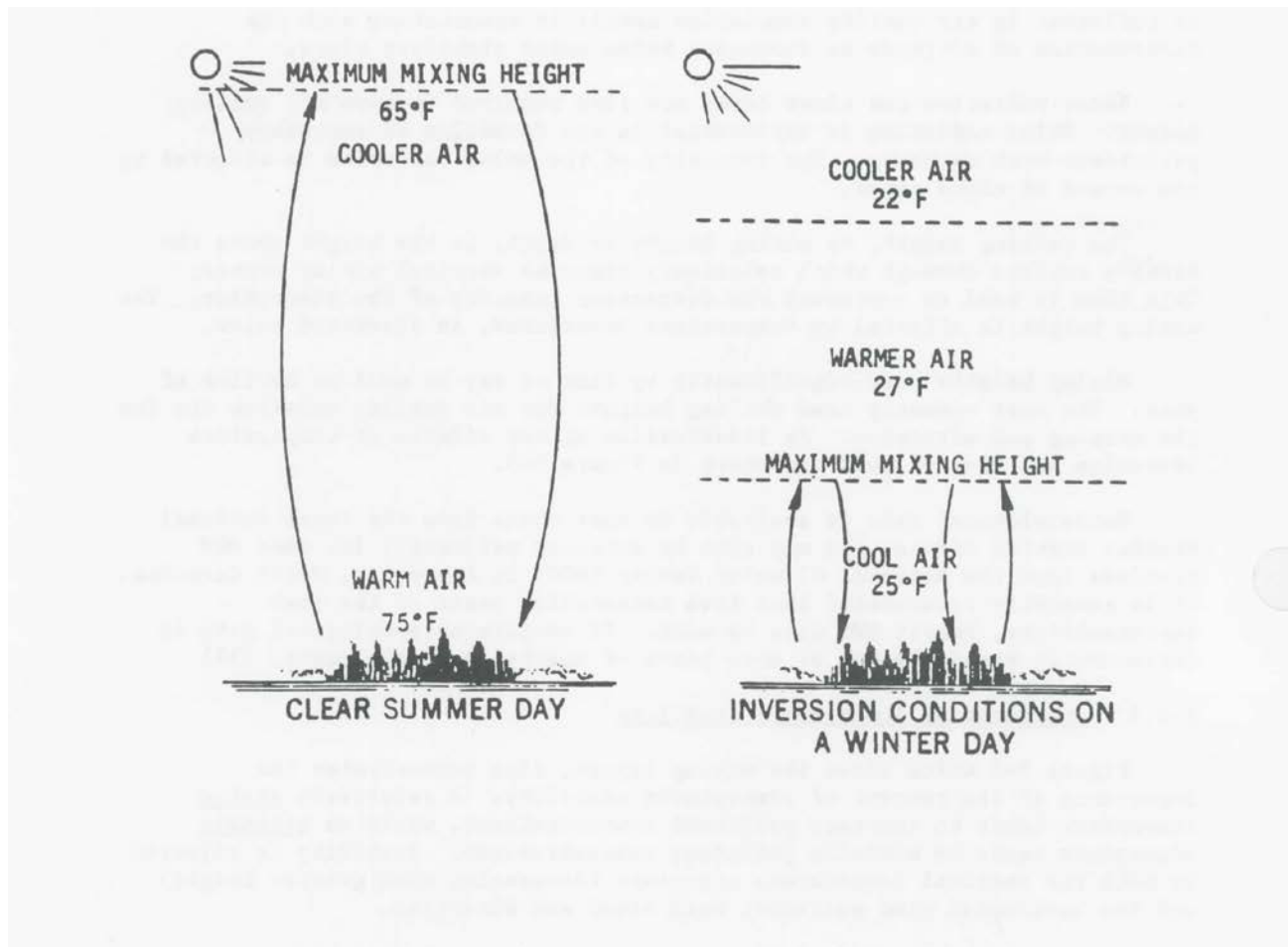
- Heating the atmosphere
- Creates instability in the ambient air
- Causes expansion of the atmosphere
- Can result in dilution due to the expansion

NOTE: ALTHOUGH FOR MET PURPOSES WE ARE DISCUSSING THE TEMPERATURE OF THE ATMOSPHERE, THERE IS ALSO AN ISSUE OF THE TEMPERATURE OF THE EXHAUST

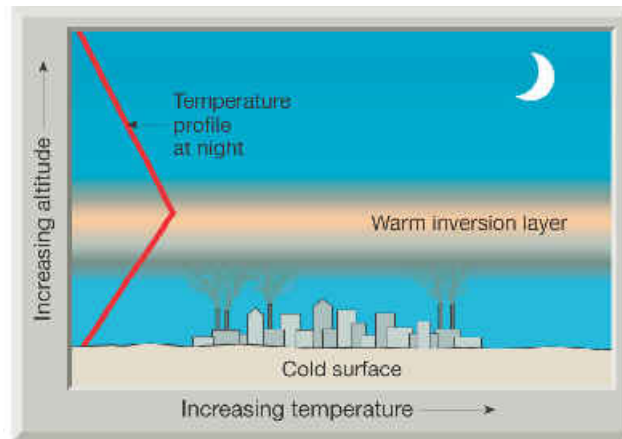
The Science of Air Quality – Meteorology



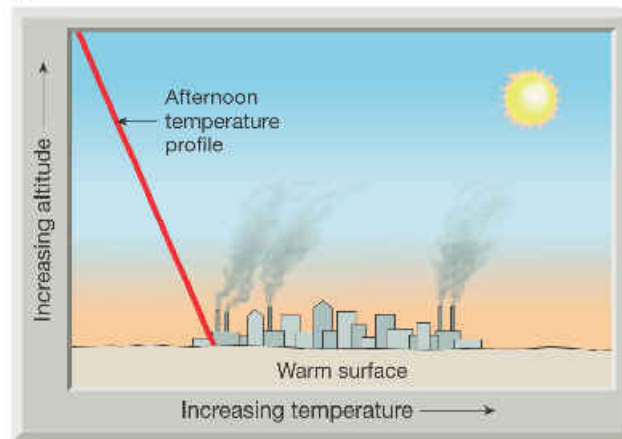
The Science of Air Quality – Meteorology



The Science of Air Quality – Meteorology



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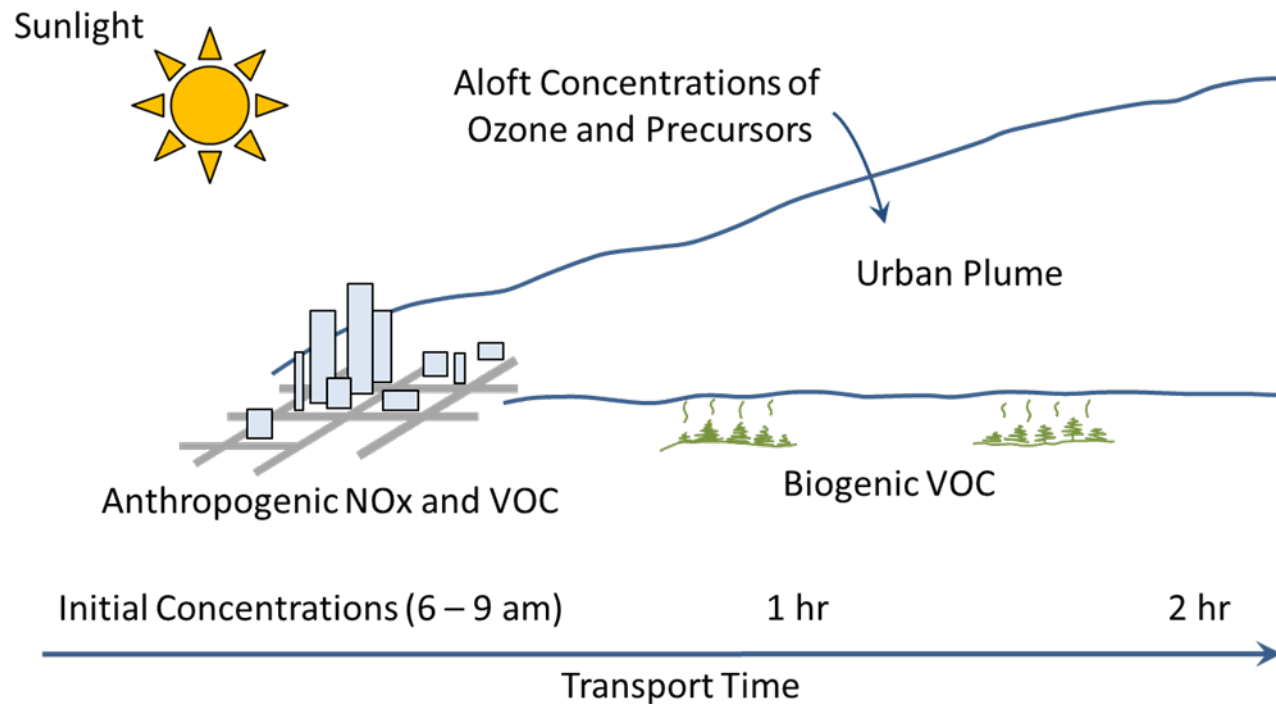
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The Science of Air Quality – Emissions

- **Emission:** A substance that is emitted into the air regardless of toxicity. However, it is often used in the same manner as pollutant
 - Can be natural (trees, wildfires, volcanoes,...)
 - Can be man-made (factories, power plants, vehicles,...)
- **Pollutant:** A substance that has the ability to affect both human and natural environment in an adverse way
 - Emitted substance that exceeds some threshold (such as the NAAQS)

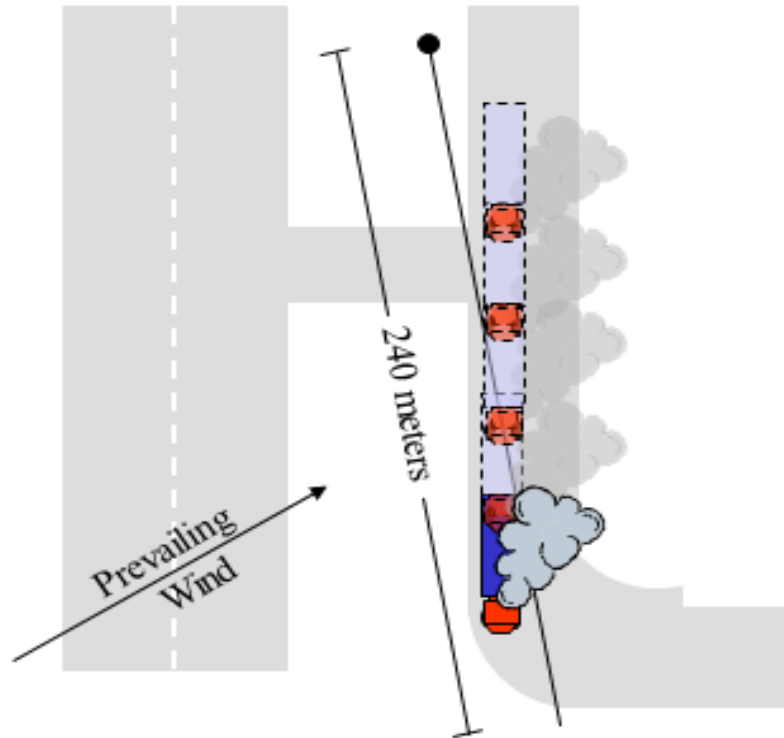
The Science of Air Quality – Emissions



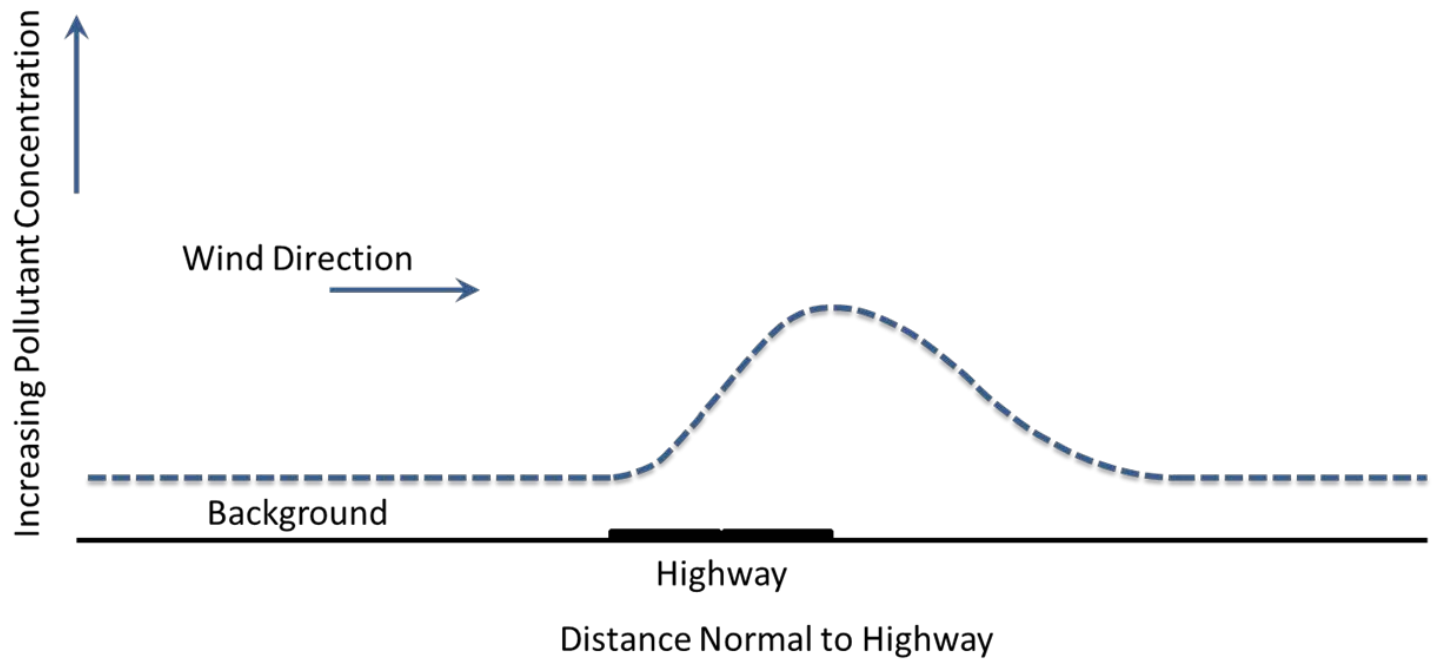
The Science of Air Quality – Emissions

- Criteria Air Pollutant (CAPs): pollutants considered harmful to public health and the environment for which EPA sets National Ambient Air Quality Standards (NAAQS). These six pollutants are CO, O₃, NO₂, SO₂, PM (PM₁₀ & PM_{2.5}), and Pb
- Hazardous Air Pollutants(HAPs): Air pollutants that cause or may cause cancer or other serious health effects, or adverse environmental and ecological effects. Currently there are 188 HAPs. The HAPs are also known as air toxics and include DPM, CH₂O,...
- Greenhouse Gas Air Pollutants (GAPs, GHG) tend to trap radiation and lead to warming and include CO₂, CH₄, N₂O...
- On-road Mobile Source emissions refers to vehicles such as cars, trucks, buses and motorcycles that are licensed to operate on public road and highway facilities. These are typically powered by internal combustion engines

The Science of Air Quality – Emissions



The Science of Air Quality – Emissions





The Science of Air Quality – Emissions

- Types of mobile source emissions
 - Running
 - Start
 - Evaporative Processes
 - Crankcase
 - Tire Wear
 - Brake Wear
 - Extended Idle
 - Life Cycle Processes



The Science of Air Quality – Emissions

- Two types of national air quality standards
 - Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly
 - Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings

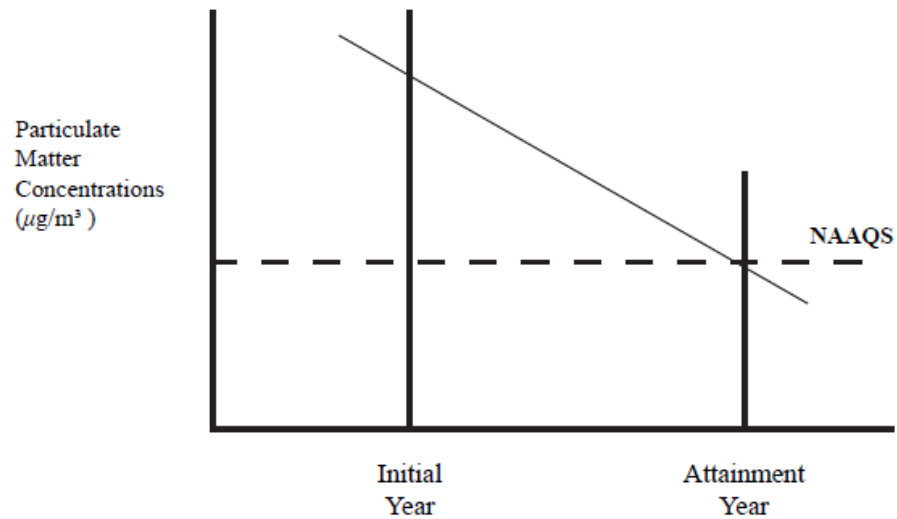


The Science of Air Quality – Emissions

- Pollutants established for NAAQS:
 - Carbon monoxide (CO)
 - Sulfur dioxide (SO₂)
 - Lead (Pb)
 - Ozone (O₃)
 - Nitrogen Dioxide (NO₂)
 - Particulate Matter 2.5 μm and less (PM_{2.5})
 - Particulate Matter 10 μm and less (PM₁₀)

The Science of Air Quality – Emissions

Emission and Concentration Relationships



The Science of Air Quality – Emissions

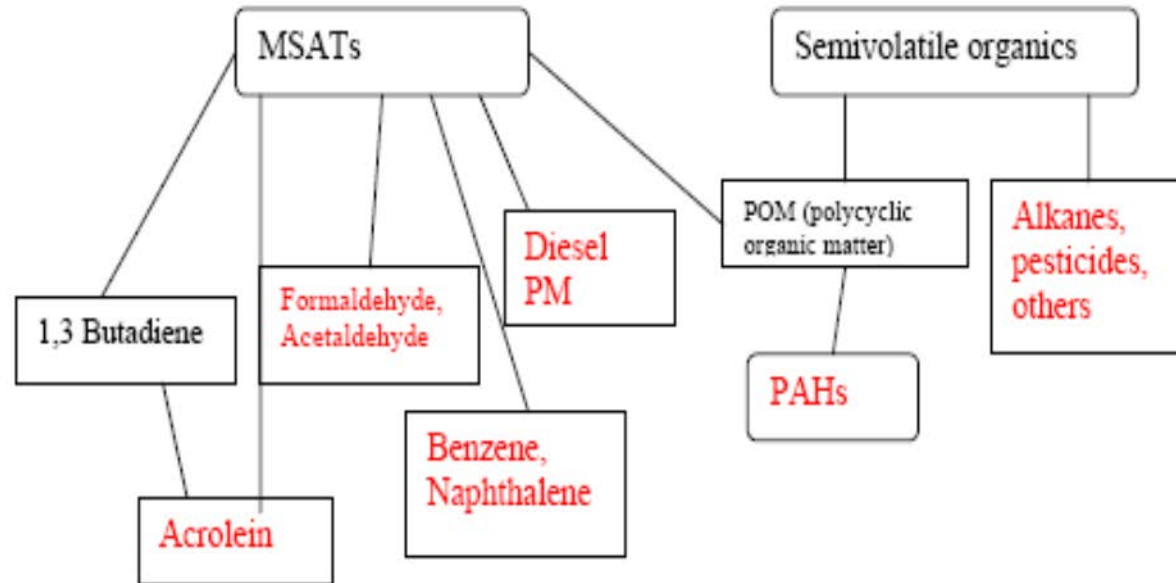
Pollutant [links to historical tables of NAAQS reviews]	Primary/ Secondary	Averaging Time	Level	Form	
Carbon Monoxide (CO)	primary	8 hours	9 ppm	Not to be exceeded more than once per year	
		1 hour	35 ppm		
Lead (Pb)	primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	Not to be exceeded	
Nitrogen Dioxide (NO₂)	primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years	
	primary and secondary	1 year	53 ppb ⁽²⁾	Annual Mean	
Ozone (O₃)	primary and secondary	8 hours	0.070 ppm ⁽³⁾	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years	
Particle Pollution (PM)	PM _{2.5}	primary	1 year	12.0 µg/m ³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	annual mean, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
		primary and secondary	24 hours	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO₂)	primary	1 hour	75 ppb ⁽⁴⁾	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years	
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year	



The Science of Air Quality – Emissions

- More recently, two other classes of emissions have garnered greater attention:
 - Mobile Source Air Toxics (MSATs)
 - Greenhouse Gases (GHG, climate change emissions)
- MSATs are as their name implies, “toxic”
 - Although this is the case, most MSATs do not have ambient air concentration standards that have been agreed upon as having toxicological effects
- GHG are generally not toxic but appear to cause warming of the atmosphere. This can result in damaging weather conditions which can cause harm to people and the environment

The Science of Air Quality – Emissions



The Science of Air Quality – Emissions

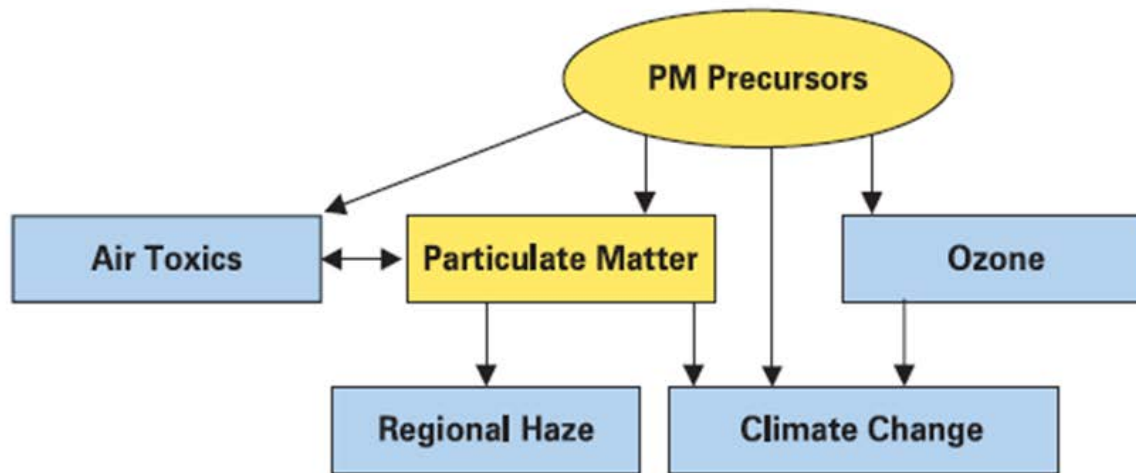
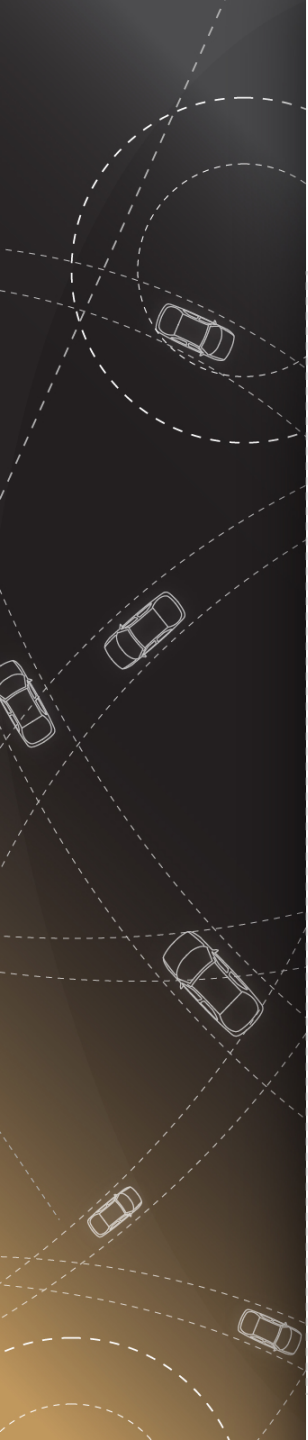


Figure 1. Relationship of PM to Other Atmospheric Concerns



The Science of Air Quality - Air Quality Monitoring/Concentrations

- Types of Monitoring
 - Ambient air quality monitoring
 - Source monitoring
 - Background monitoring



The Science of Air Quality - Air Quality Monitoring/Concentrations

- Air quality monitoring – located at sites which are not unduly influenced by any one source
- Source Monitoring – located to capture the emissions from a specific source (i.e. power plant)
- Background monitoring – provides “typical” baseline concentrations for various chemicals and compounds found in the atmosphere
- The transportation community is really only concerned about air quality monitoring since this is the monitoring used to designate areas as to their attainment or nonattainment status



The Science of Air Quality - Air Quality Monitoring/Concentrations

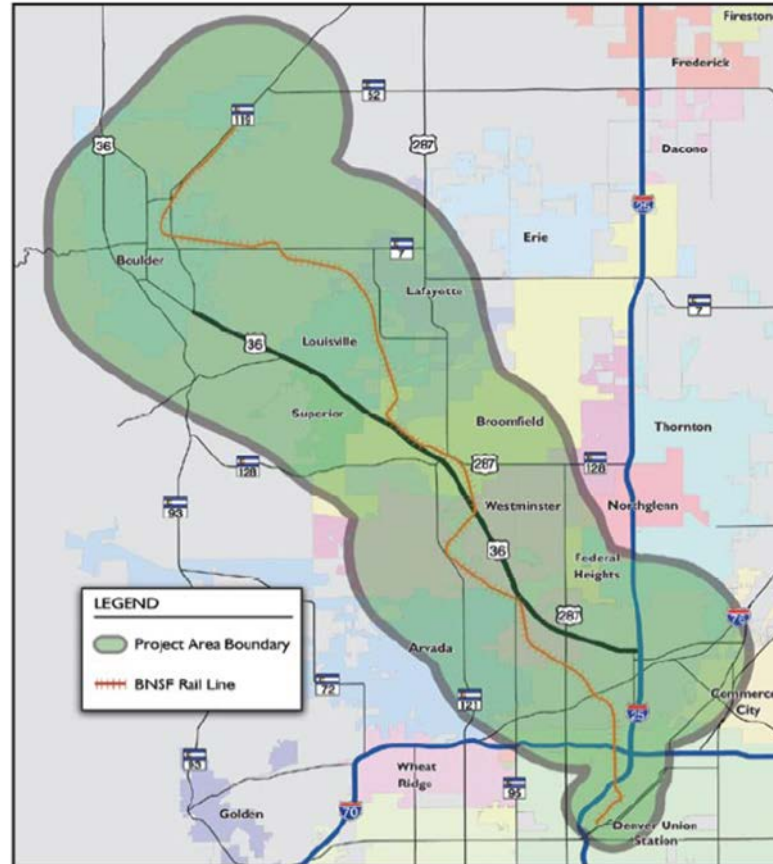
- There are several monitoring networks that EPA has established to determine whether an area is attaining the standards or not. These monitoring systems consist of:
- SLAMS: State and Local Air Monitoring System
- NAMS: National Air Monitoring System
- PAMS: Photochemical Air Monitoring System



The Science of Air Quality - Air Quality Monitoring/Concentrations

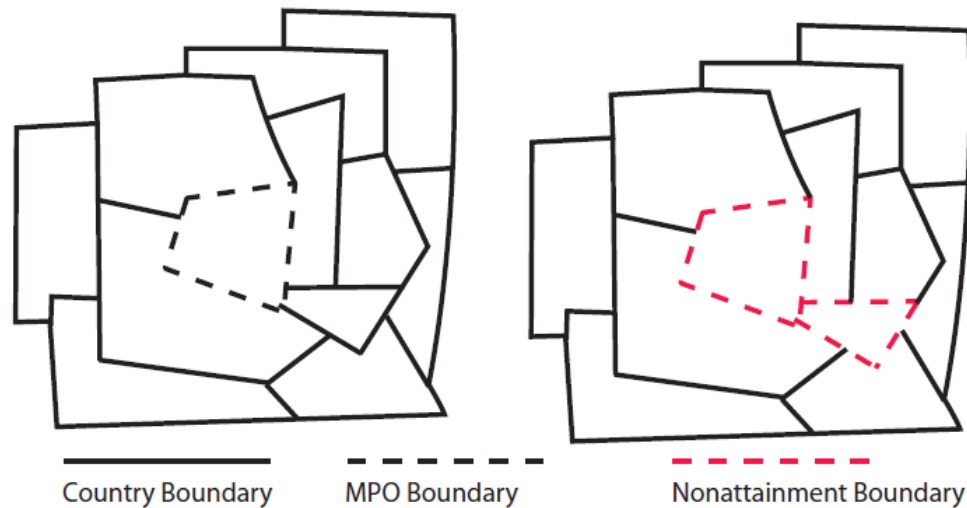
- There are other monitoring systems that can have an influence on the transportation and these are:
 - SPMS: Special Purpose Monitoring Stations
 - Near-Road: network established for CO, NO_x, PM
- Special Purpose Monitors can be established for a specific purpose but if they are allowed to operate for 24 months or longer, the measurements they record can be used to determine an area's attainment or nonattainment status
- More recently, a new monitoring system has been established with the purpose of determining vehicle emission and ambient concentrations resulting from them. This monitor system is effectively source monitoring since the monitors are located adjacent to highways where vehicle emissions are the only source

The Science of Air Quality - Air Quality Monitoring/Concentrations

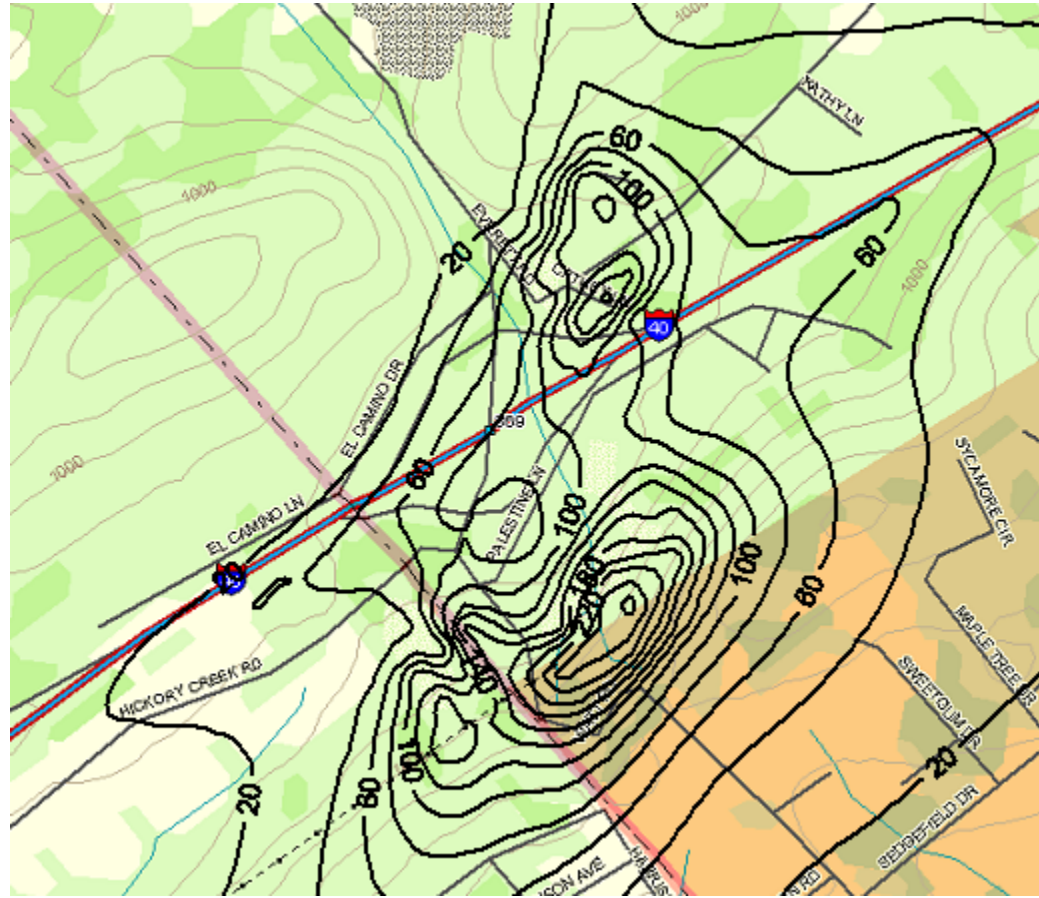


The Science of Air Quality - Air Quality Monitoring/Concentrations

Boundary Relationships



The Science of Air Quality - Air Quality Monitoring/Concentrations





The Science of Air Quality – Health Impacts

■ Chemical Exposure

- ***Acute*** exposure: contact with a substance that occurs once or for only a time period which is less than 14 days
- Intermediate exposure: contact with a substance that occurs for more than 14 days and less than a year
- ***Chronic*** exposure: contact with a substance that occurs more than 1 year

The Science of Air Quality – Health Impacts

■ Chemical Odor

- For most of the time, human noses can pick up an odor before it reaches acute toxic level with few exceptions
- CO: No odor
- NO/NO₂: Very strong irritant
- O₃: Strong
- VOC: Very strong

The Science of Air Quality – Health Impacts

Pollutant	Pollutant Impact		
	Primary/Health	Secondary/Environment	Other
CO	impairs visual perception, thoughts, reflexes, drowsiness, cardiovascular functions		inert, non-reactive
NOx	respiratory irritant, coughing, wheezing and shortness of breath may occur, can also increase the risk of respiratory illness in children	may adversely affect terrestrial and aquatic ecosystems through regional transport and deposition	reactive
O3 (ground level), smog	affects respiratory system, chest pain, coughing, throat irritation, and congestion, can worsen bronchitis, emphysema, can reduce lung function and inflame the linings of the lungs, may permanently scar lung tissue	may reduce yield of agricultural crops and damages forests and other vegetation	formed by reaction of NOx and sunlight
O3 (upper atmosphere)	depletion will reduce sunlight, increases possibility of skin cancer	reduces sunlight	formed by reaction of NOx and sunlight
PM (10, 2.5), soot	aggravation of existing respiratory and cardiovascular disease, alteration of body's defense system, carcinogenic, premature mortality (infant mortality)	serves as a carrier for toxic metals, damages human-made materials, and is a major cause of reduced visibility in many parts of the U.S	formed by reaction of NOx and sunlight, can be inert or reactive
VOC	affects respiratory system, coughing, throat irritation	toxic compounds may damage certain materials	reactive



Science of Air Quality – Analysis of Impacts

- Analysis of Mobile Source Impacts
- Emissions (mass)
 - Emissions = Vehicle Miles Traveled (VMT) x Emission factor (EF)
 - VMT is from regional transportation modeling and EF is from either MOVES2014 or EMFAC2011
- Concentrations (mass/volume)
 - Concentrations \equiv Emissions / volume of ambient air
- Analysis is the subject of following sessions



Science of Air Quality – Emission Reduction Strategies

- Emission reductions strategies not covered in this course however some strategies that are discussed in another course we offer include:
 - Fleet (vehicle) turnover
 - Reduced vehicle use (transit, park-and-ride,...)
 - Traffic control systems (signal synchronization)
 - Fuels (ethanol, electric, ...)
 - Engine improvements and after-treatment device
 - Diesel replacement programs
 - Idle reduction policies

References

- FHWA Air Quality Websites
 - http://www.fhwa.dot.gov/environment/air_quality/
 - <http://www.fhwa.dot.gov/resourcecenter/teams/airquality/index.cfm>
- EPA Air Quality Websites
 - <https://www3.epa.gov/otaq/>
 - <https://www3.epa.gov/airquality/>
- Many, many other references can be found in your library or on the web using a search engine and entering terms such as “transportation and air quality”

Contact Information



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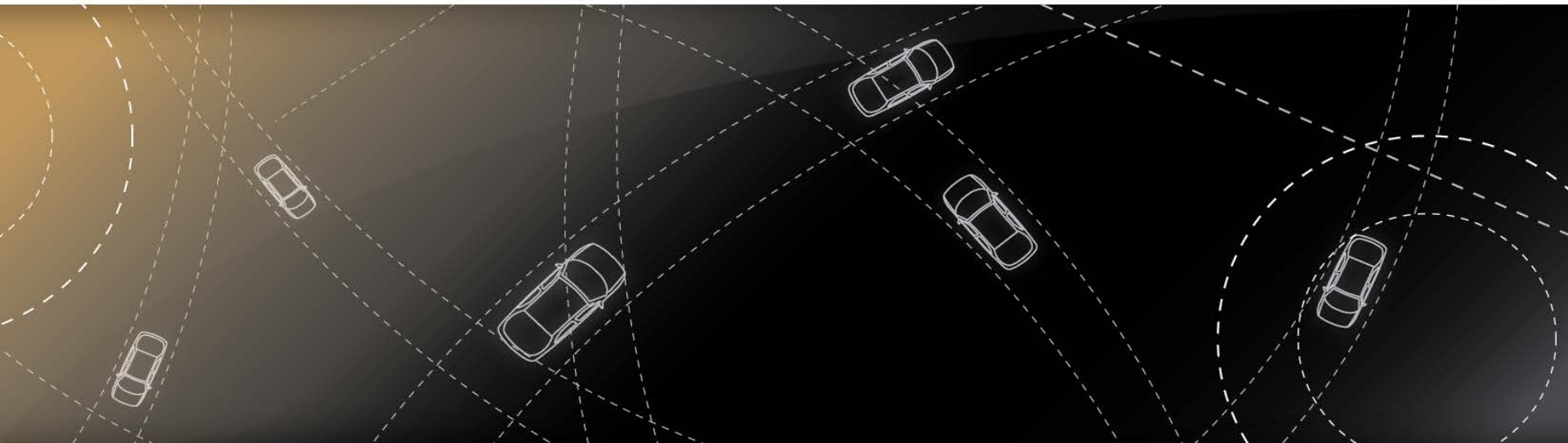
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Introduction to Air Quality for Highway Planning

Traffic Considerations

Paul Heishman



Introduction to Air Quality for Highway Planning

■ Webinar Outline

- Air Quality Science
 - Kevin Black
- Traffic Considerations
 - Paul Heishman
- Air Quality Impact Analysis
 - Michael Claggett



Traffic Considerations

■ Training Objectives

- Introduce Regional Traffic Data Concepts
- Introduce Project-Level Traffic Concepts
- Introduce the Role of Traffic Data in Air Quality Studies

Traffic Considerations- Intro

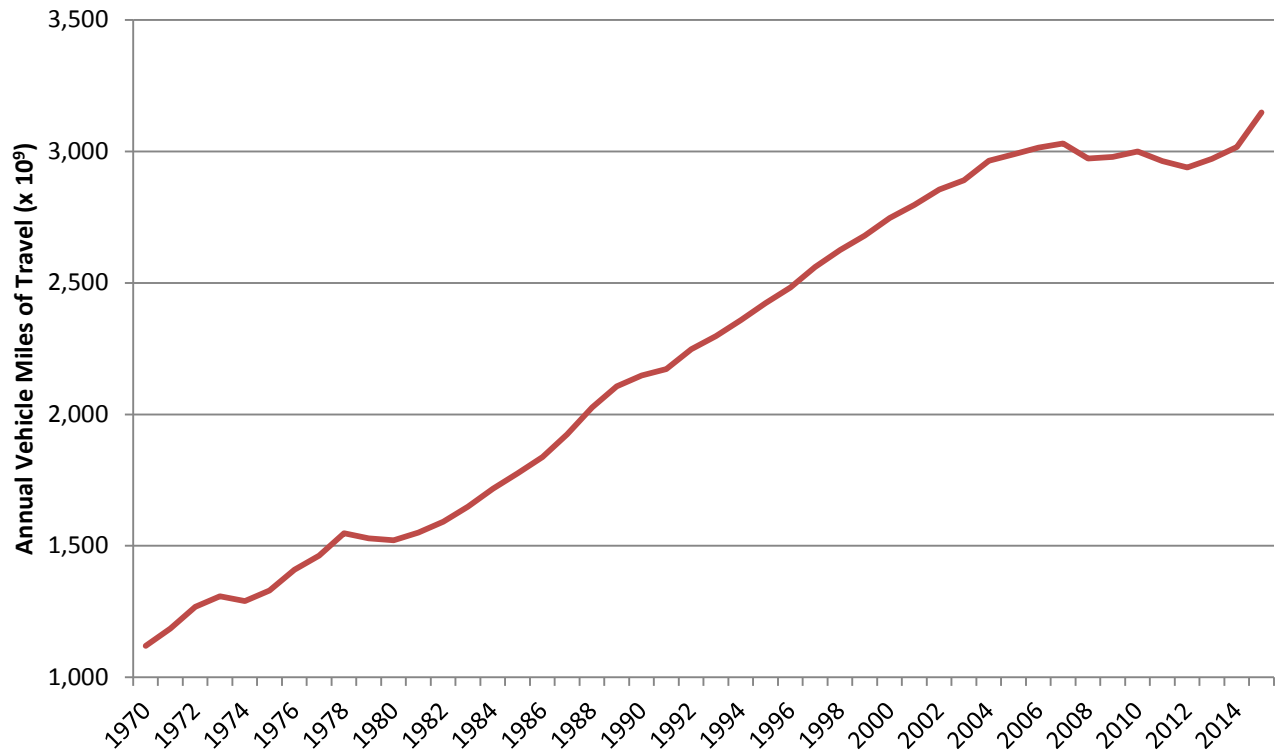
- How is the traffic?
 - When?
 - Where?



- The answer is a moving target!

Traffic Considerations- Intro

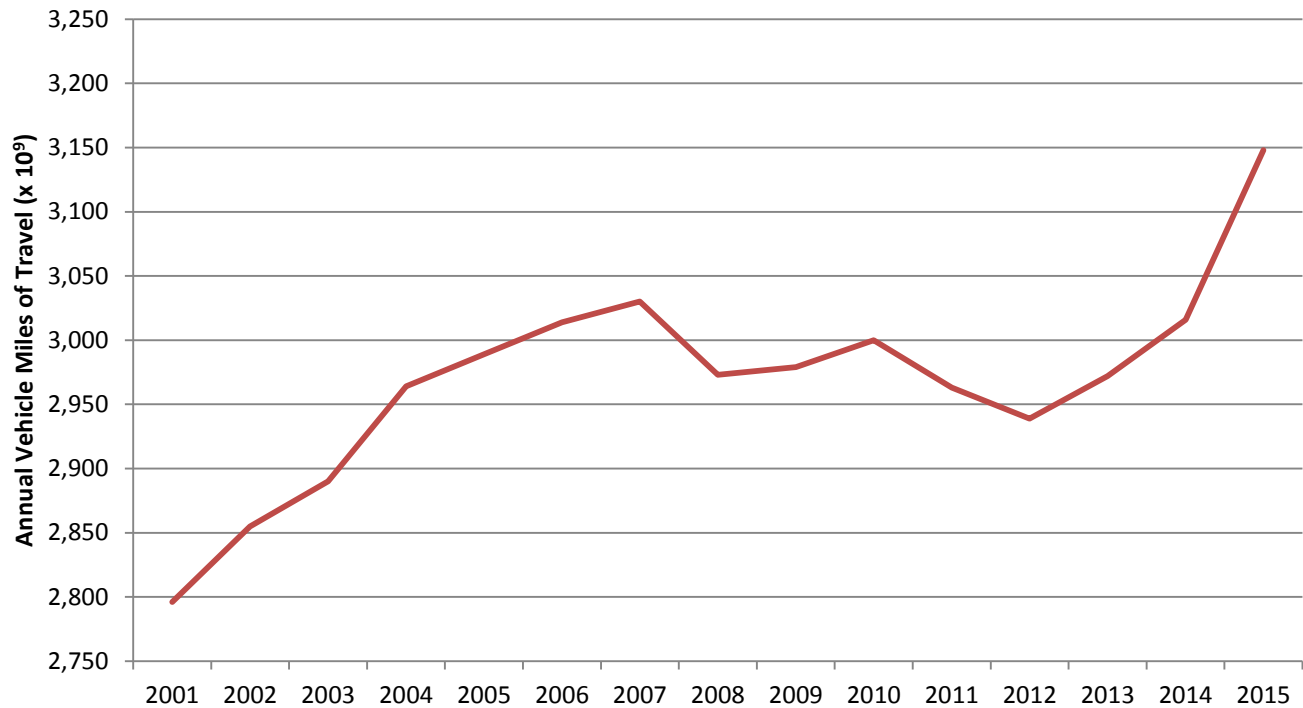
Annual Vehicle Miles of Travel (1970-2015)



http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Traffic Considerations- Intro

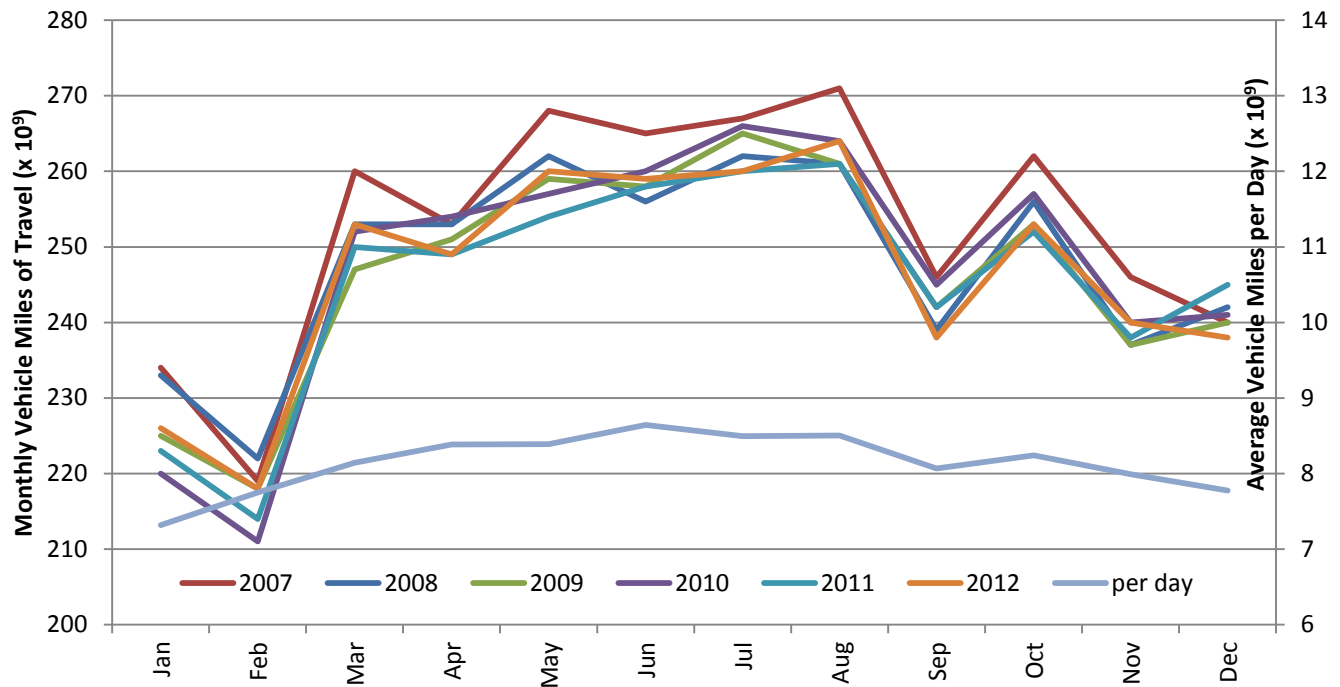
Annual Vehicle Miles of Travel (2001-2015)



http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

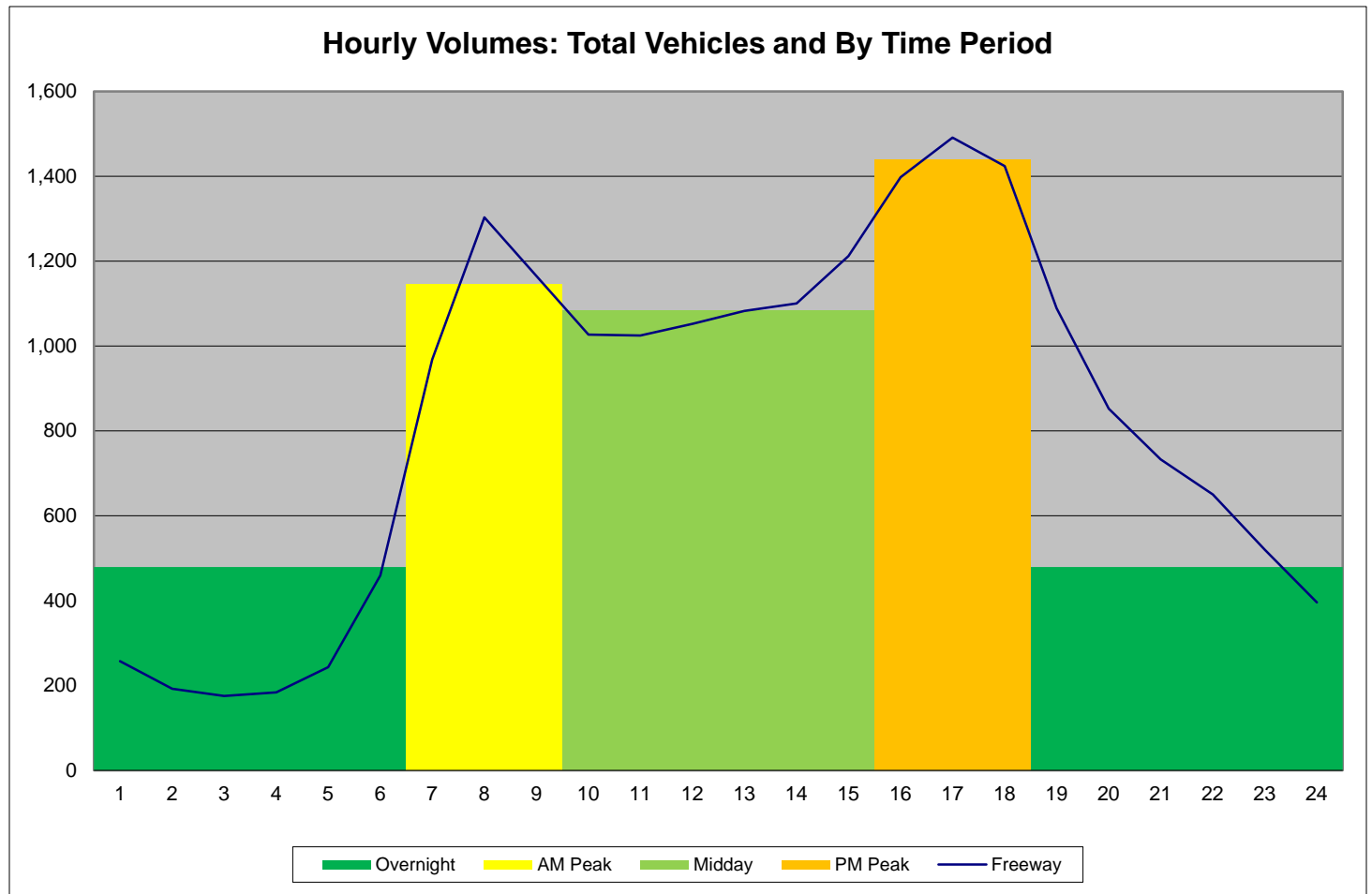
Traffic Considerations- Intro

Monthly Vehicle Miles of Travel (2007-2012)



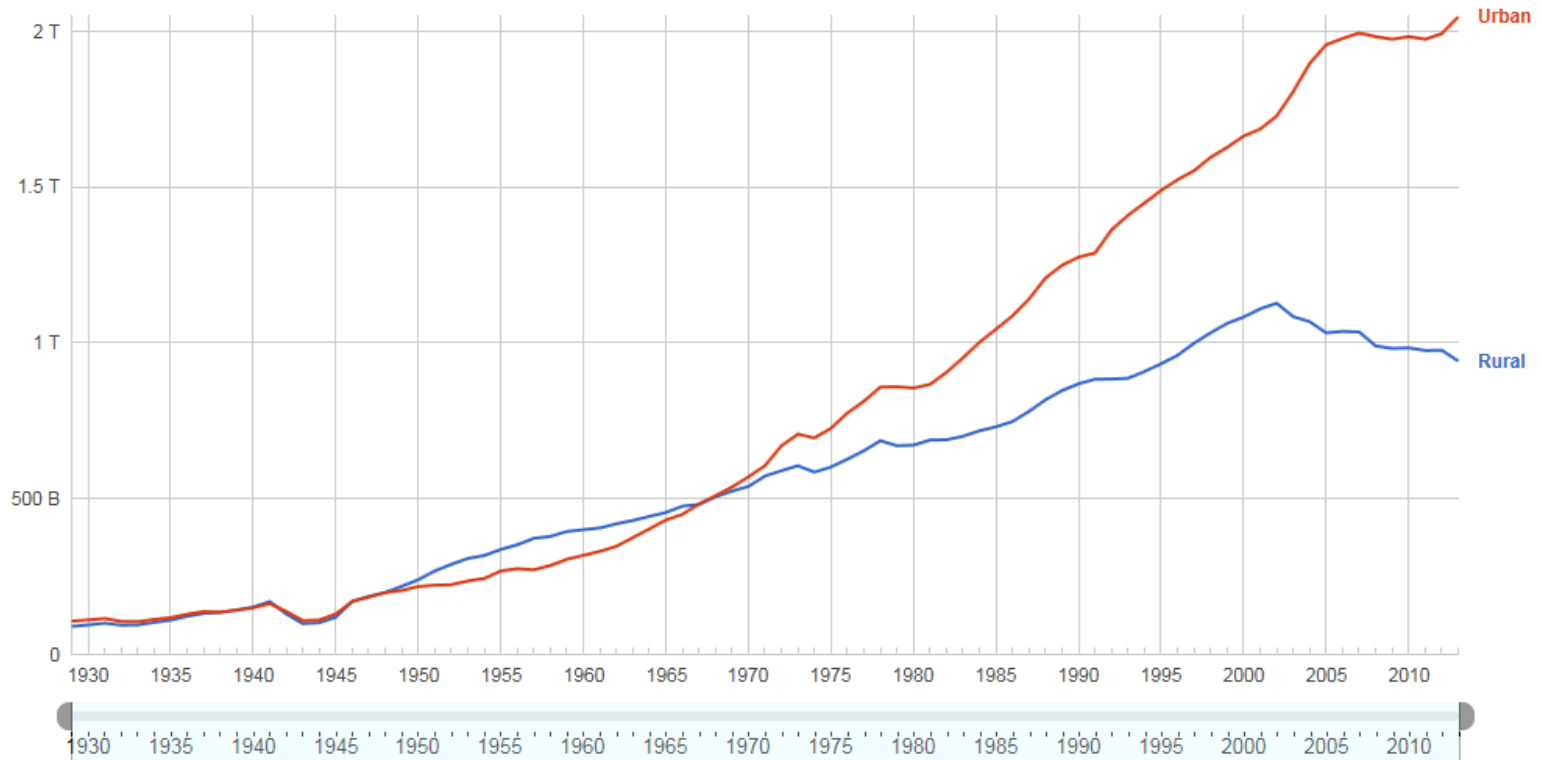
http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Traffic Considerations- Intro



Traffic Considerations- Intro

Vehicle Miles Traveled ?



Data from [Office of Highway Policy Information, FHWA](#) Last updated: Oct 9, 2015

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<http://www.google.com/publicdata/explore>

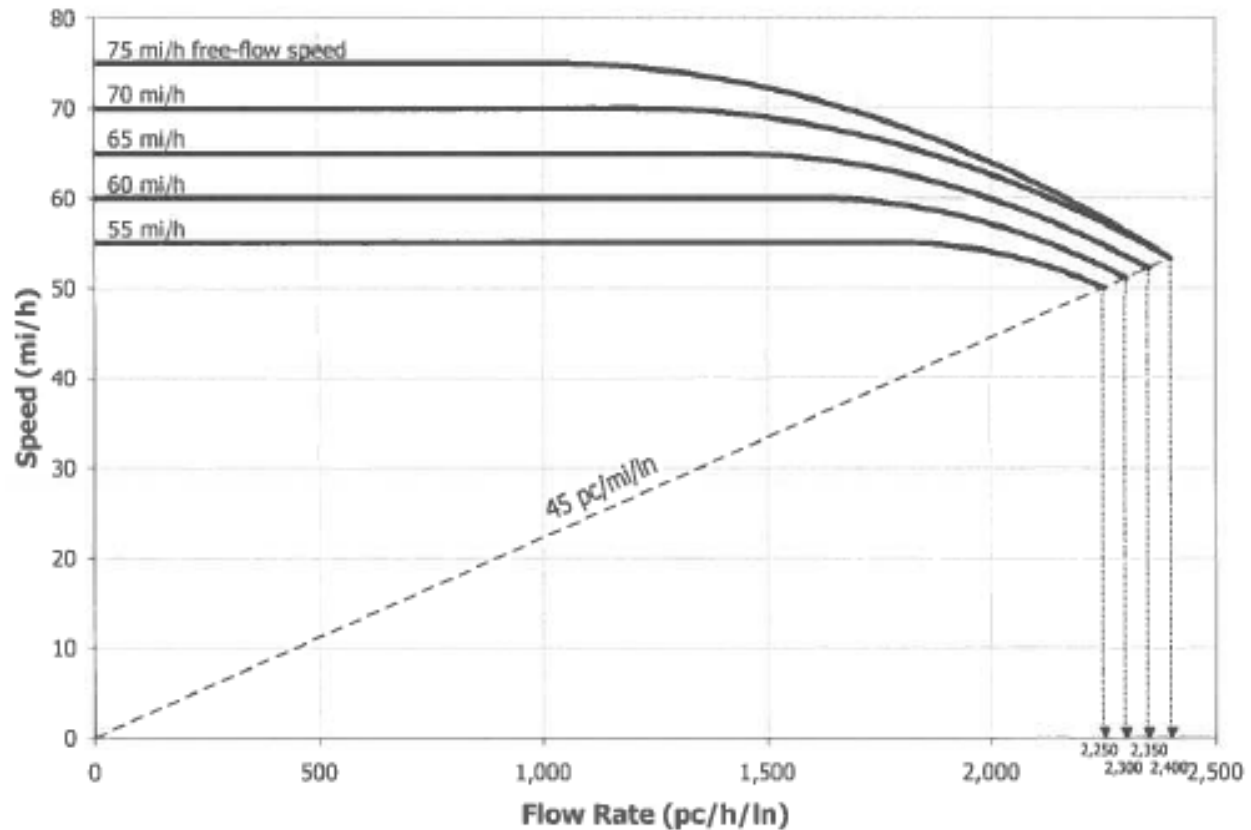


Traffic Considerations- Intro

■ A Couple Underlying Fundamentals

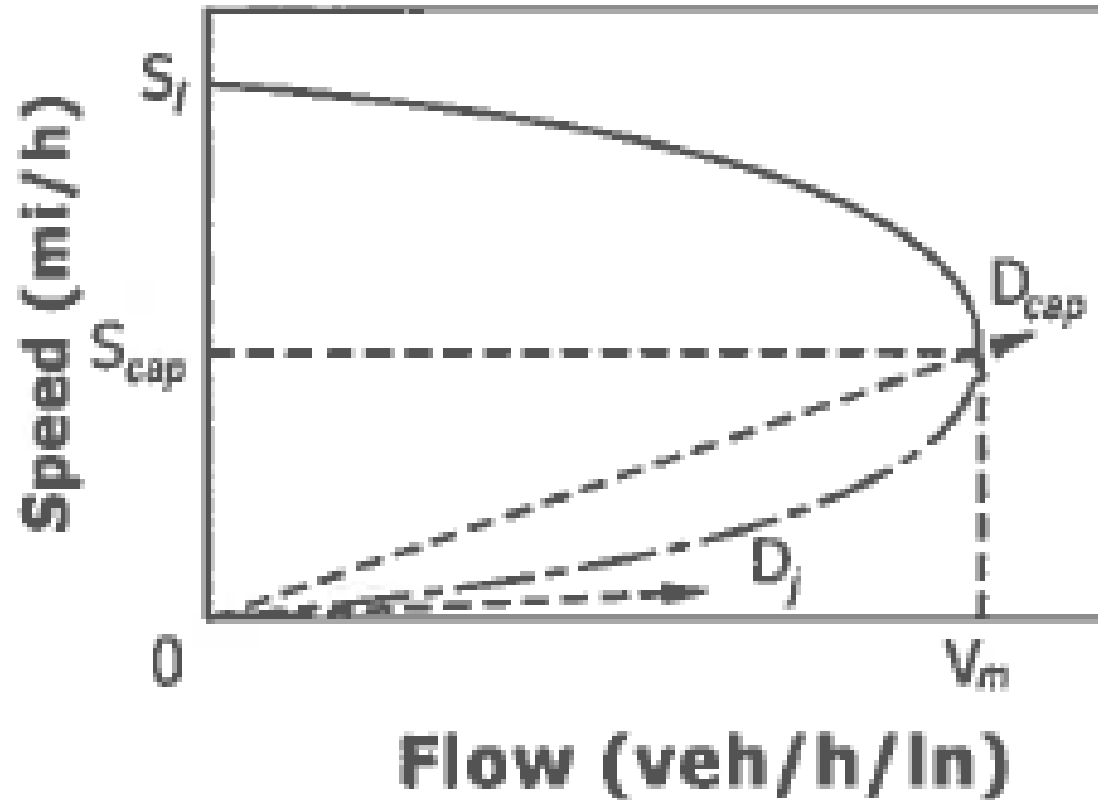
- Travel is a “derived demand”
 - People don’t travel just to travel
 - Travel with intention of completing a task at another location (e.g., go to work or shop)
 - Travel is a “cost” of that other task
- Travel time is a big factor in that cost
 - Speeds are affected by a variety of factors
- Reliability is a growing concern

Traffic Considerations- Intro



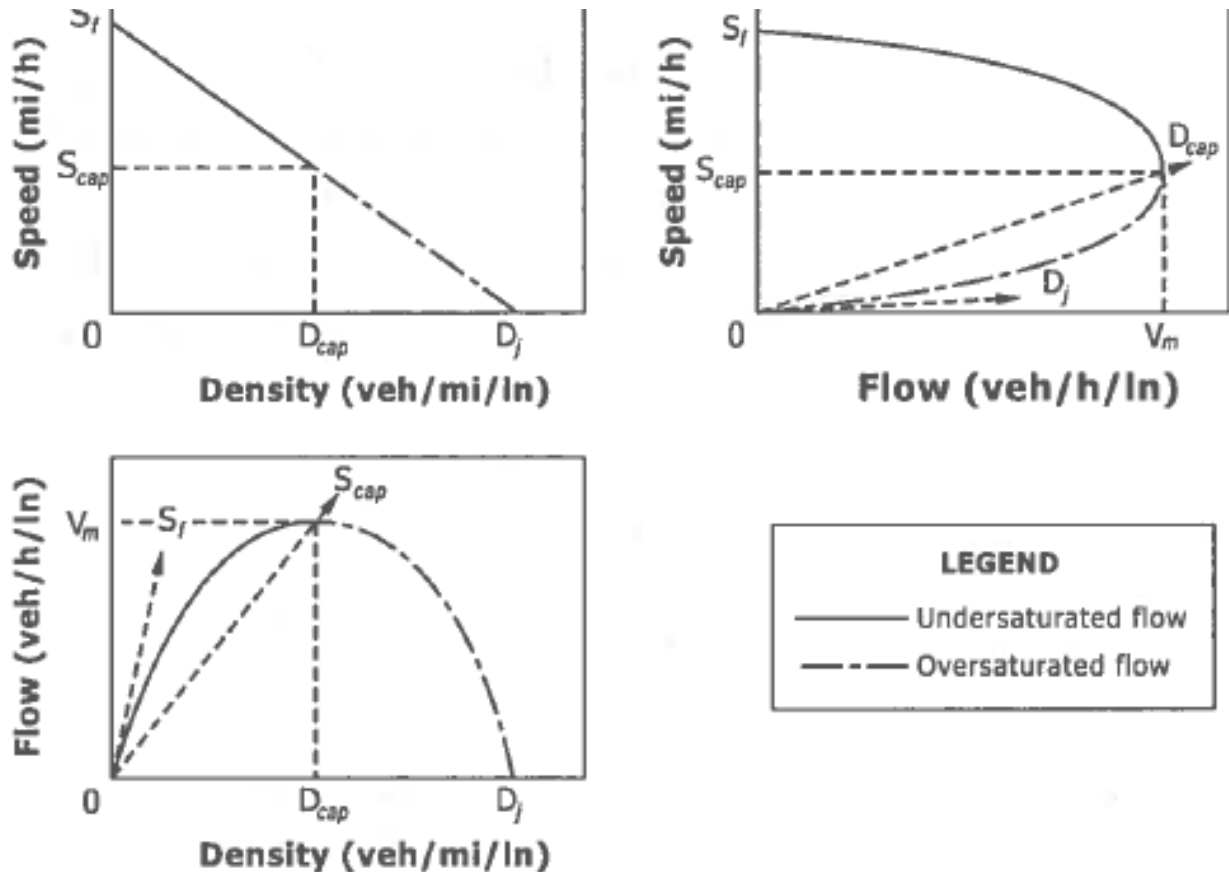
Highway Capacity Manual 2010, Exhibit 11-2

Traffic Considerations- Intro



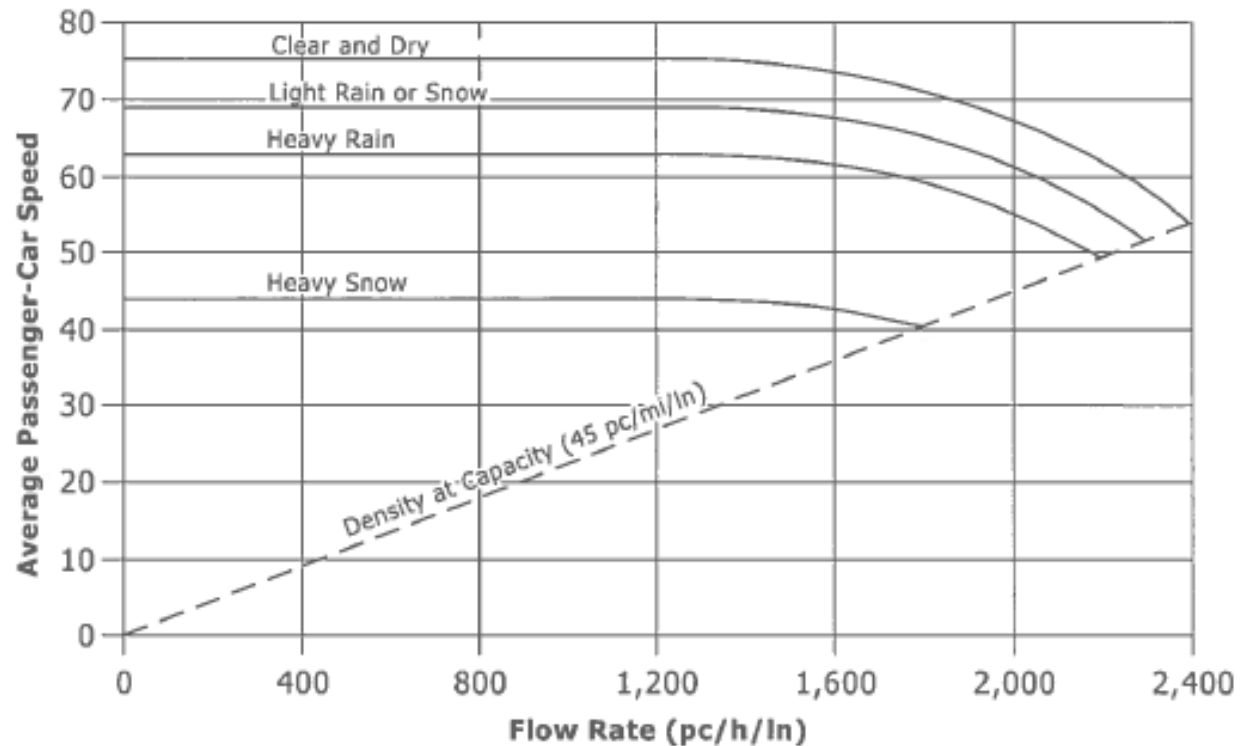
Highway Capacity Manual 2010, Exhibit 4-3

Traffic Considerations- Intro



Highway Capacity Manual 2010, Exhibit 4-3

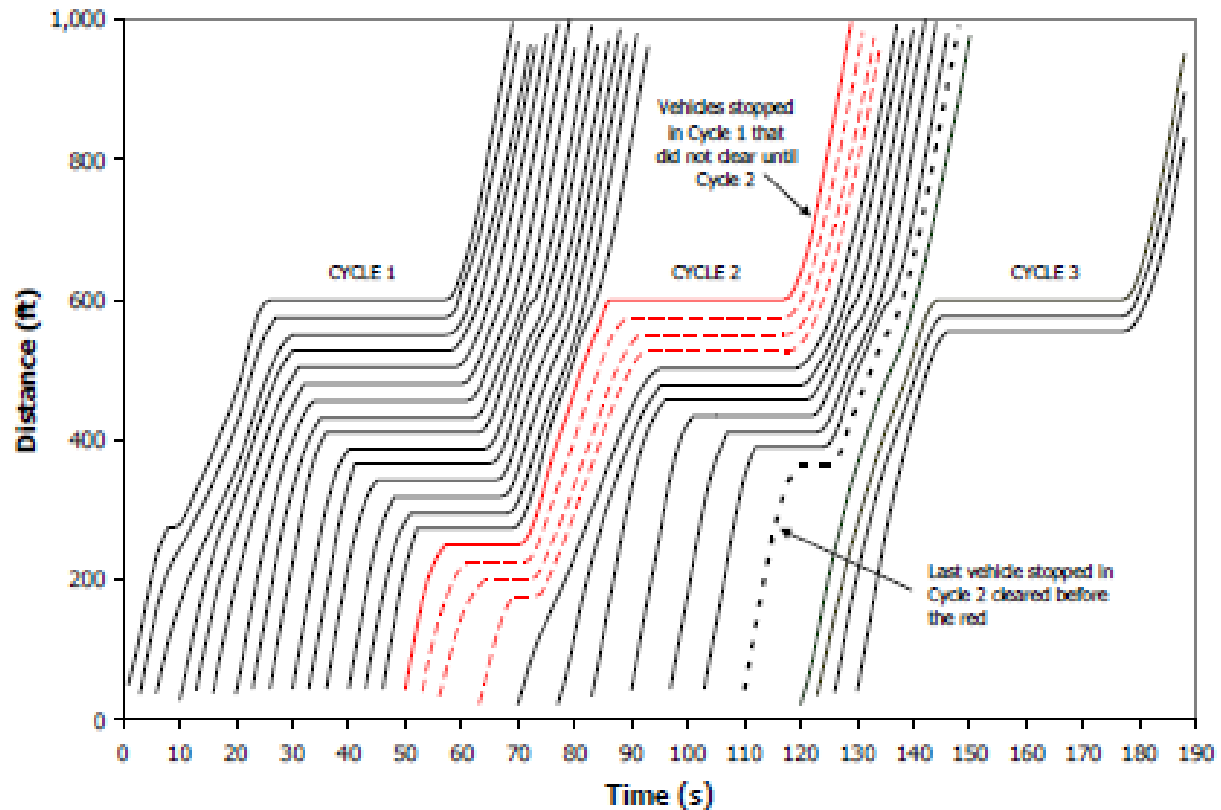
Traffic Considerations- Intro



Note: Free-flow speed = 75 mi/h (base conditions).

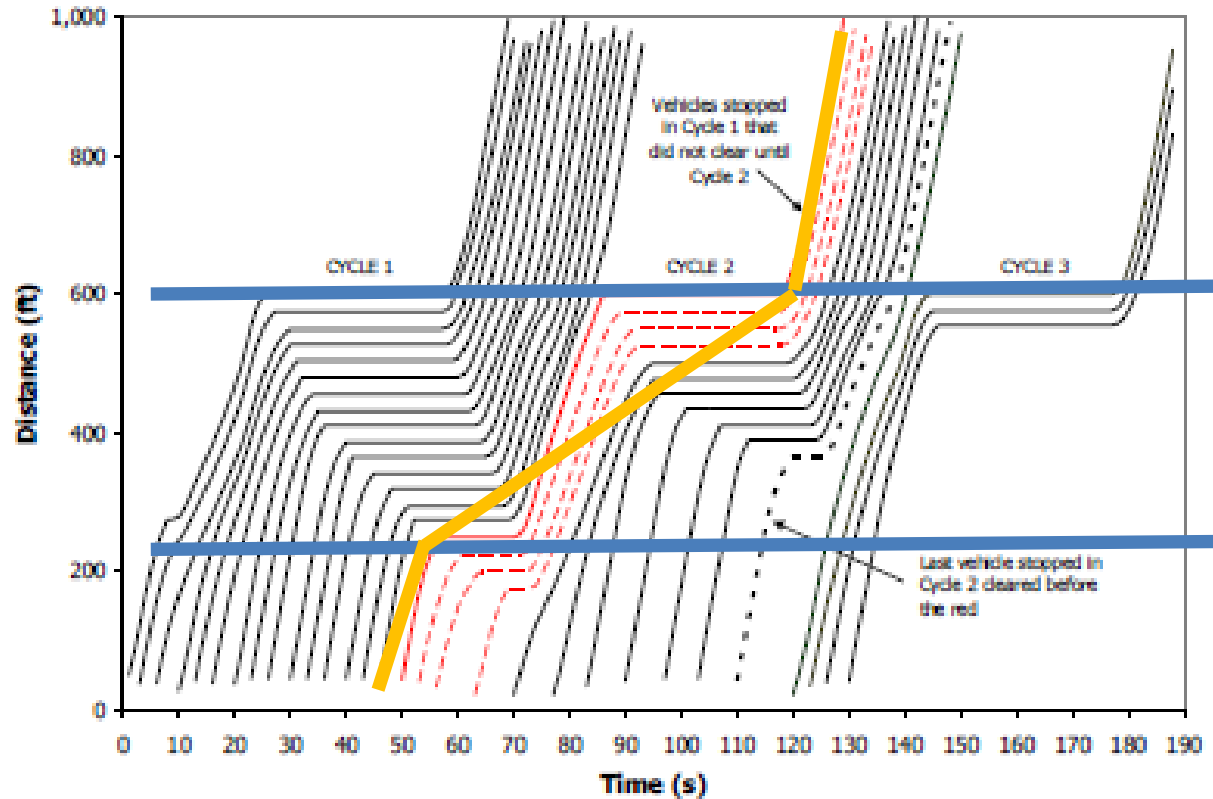
Highway Capacity Manual 2010, Exhibit 10-18

Traffic Considerations- Intro



Highway Capacity Manual 2010, Exhibit 24-5

Traffic Considerations- Intro



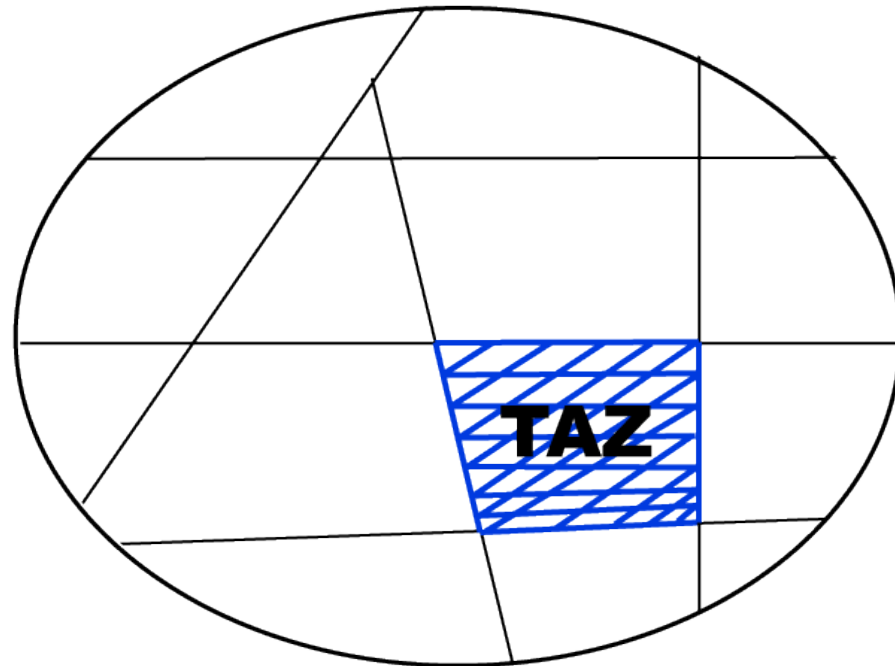
Highway Capacity Manual 2010, Exhibit 24-5

Traffic Considerations- Regional

- In Urban Areas, Metropolitan Planning Organization (MPO) develops a regional Travel Demand Model (TDM)
- The area is divided into Traffic Analysis Zones (TAZs)
 - TAZs contain land use data (homes, jobs)
 - TDM represents travel between TAZs

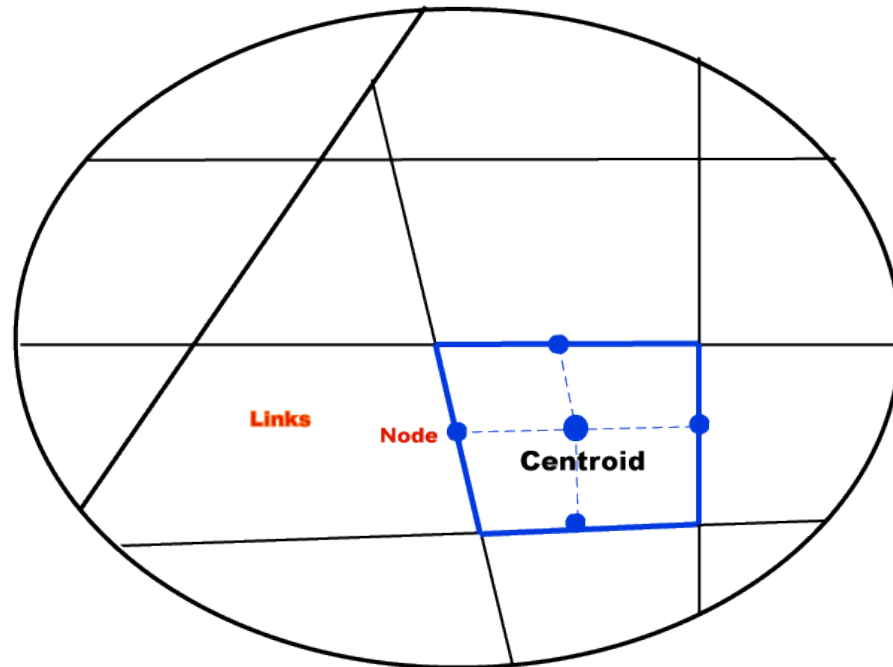
Traffic Considerations- Regional

How is an Area Represented in Network Modeling?



Traffic Considerations- Regional

How is an Area Represented in Network Modeling?





Traffic Considerations- Regional

- Typical TDM Concept: 4 Step Model
 - Trip Generation
 - Trip Distribution
 - Mode Choice
 - Route Assignment
- Example Trip: Go to work; Go from TAZ 21 to TAZ 441; Drive alone; Use SR 12.
- Model at aggregate level over full area
- Different Model Structures Available

Traffic Considerations- Regional

- In typical application, MPO uses TDM volumes and speeds to complete regional conformity analysis
- Use TDM to assess viability of large scale projects (highway and transit) to set Transportation Improvement Program (TIP) and Long-range Plan
- Plan within financial constraints



Traffic Considerations- Project

- Regional TDM provides basic volumes
 - Speeds typically must be adjusted
 - Still reflect relative congestion effects
 - Do not normally treat intersection delay
 - Can forecast future year conditions
- Need project-level analysis for details
 - Typically calculate Levels of Service
 - Refine details (e.g., speed) along routes



Traffic Considerations- Project

- In looking at a Project, consider:
 - How will it affect where people go?
 - How will it affect who goes by what mode?
 - How will it affect what routes they use?
 - How will it affect their time of travel?
 - How will it affect on-road operations?
 - How will it affect land use & future travel?
- Apply the same considerations for all alternatives



Traffic Considerations- Review

- Traffic has generally grown in recent years
 - However, not uniformly or absolutely
- Need Travel Demand Models for forecasts
 - Based on related factors (e.g., income)
 - Developed at regional scale
- Use traffic engineering principles to adapt for project-level analyses
- Variability at various scales
 - Temporally and spatially, volumes and speeds
- Use the right tools for the job- models, data

Traffic Considerations- References

Traffic Tools:

<http://ops.fhwa.dot.gov/trafficanalysistools/>

Interim Guidance-Travel & Land Use Forecasting in NEPA

http://environment.fhwa.dot.gov/projdev/travel_landUse.asp

Guide on Consistent Traffic Analysis:

www.fhwa.dot.gov/publications/research/operations/11064/index.cfm

Travel Trends:

www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Traffic Flow Theory:

www.fhwa.dot.gov/publications/research/operations/tft/index.cfm

NCHRP Reports: (<http://www.trb.org/Publications/Publications.aspx>)

535-Predicting Air Quality Effects of Traffic-Flow Improvements

716-Travel Demand Forecasting: Parameters and Techniques

765-Analytical Travel Forecasting Approaches for Project-Level Planning and Design

Travel Model Improvement Project:

<http://www.fhwa.dot.gov/planning/tmip/>

Highway Capacity Manual 2010:

<http://www.hcm2010.org/>

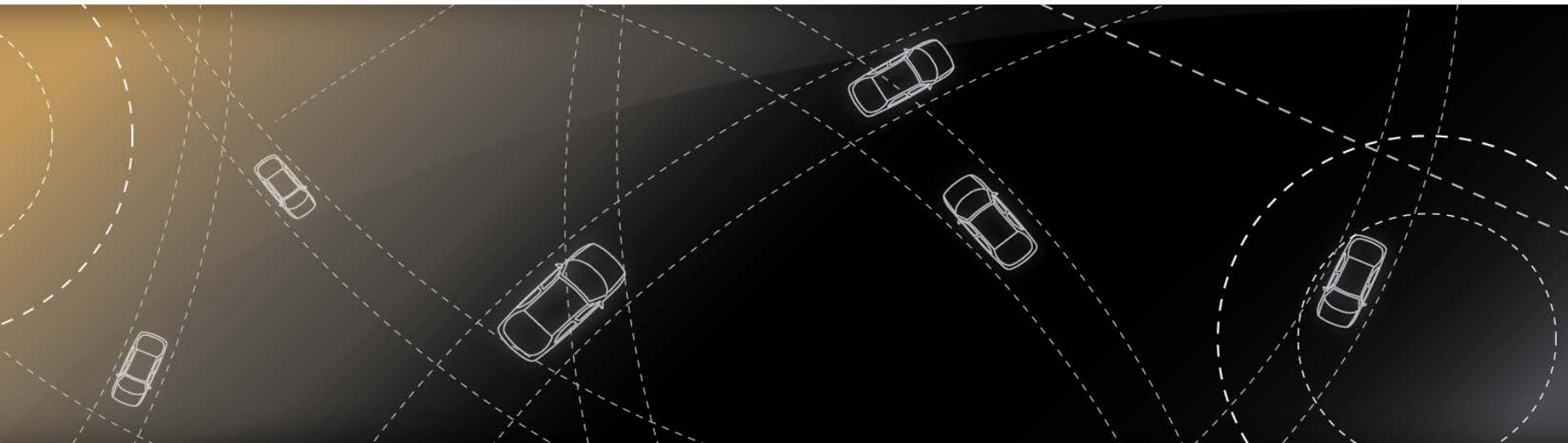
Contact Information



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Baltimore, MD 21201
Phone: 410-962-2362
Cell: 410-746-0483

paul.heishman@dot.gov
www.fhwa.dot.gov/resourcecenter



Introduction to Air Quality for Highway Planning

Air Quality Impact Analysis

Michael Claggett



Introduction to Air Quality for Highway Planning

■ Webinar outline

- Air Quality Science
 - Kevin Black
- Traffic Considerations
 - Paul Heishman
- Air Quality Impact Analysis
 - Michael Claggett



Air Quality Impact Analysis

- Need for highway air quality impact analysis
- Air quality impact analysis framework
- Vehicle emissions models
- Air quality models for highway applications
- Training opportunities
- List of web resources
- Contact information



Need for Highway Air Quality Impact Analysis

■ Policy and guidance

– Vehicle emissions modeling

- National Environmental Policy Act (NEPA) of 1969
- Interim Guidance Update on Mobile Source Air Toxic (MSAT) Analysis in NEPA
- Regional analysis for transportation conformity determinations
- Congestion Mitigation and Air Quality Improvement (CMAQ) Program



Need for Highway Air Quality Impact Analysis

■ Policy and guidance

– Air quality modeling

- National Environmental Policy Act (NEPA) of 1969
- FHWA Technical Advisory T6640.8A
- Hot-spot analysis of carbon monoxide (CO) and particulate matter (PM) for project-level conformity determinations
- 40 CFR Part 51 Appendix W, Guideline on Air Quality Models

Air Quality Impact Analysis Framework – Emissions

Fleet Characteristics

- Vehicle Activity
- Vehicle Types
- Vehicle Age
- Vehicle Fuels

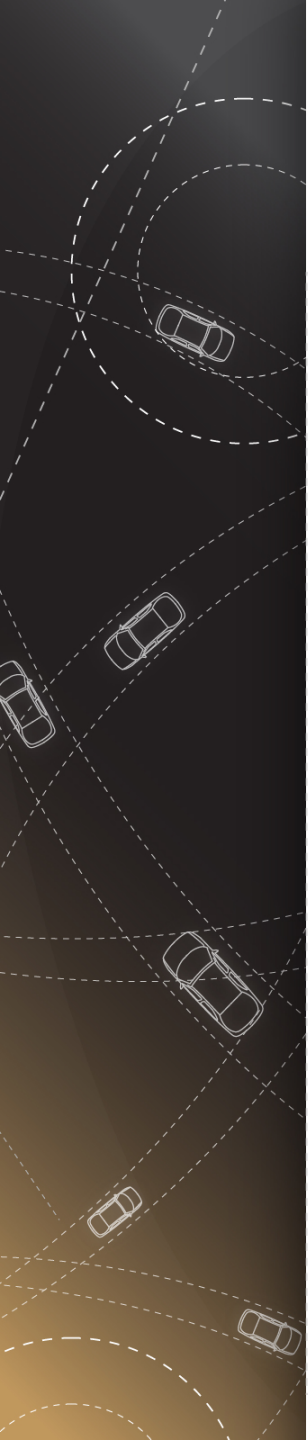
Other Factors

- Scale / Geographics
- Time Spans
- State Programs
- Meteorology

Emissions Model

- Measured Rates
- Activity
- Adjustments

Inventory / Rates





Vehicle Emissions Models

- U.S. EPA's MOtor Vehicle Emission Simulator (MOVES) Model

<https://www3.epa.gov/otaq/models/moves/index.htm>

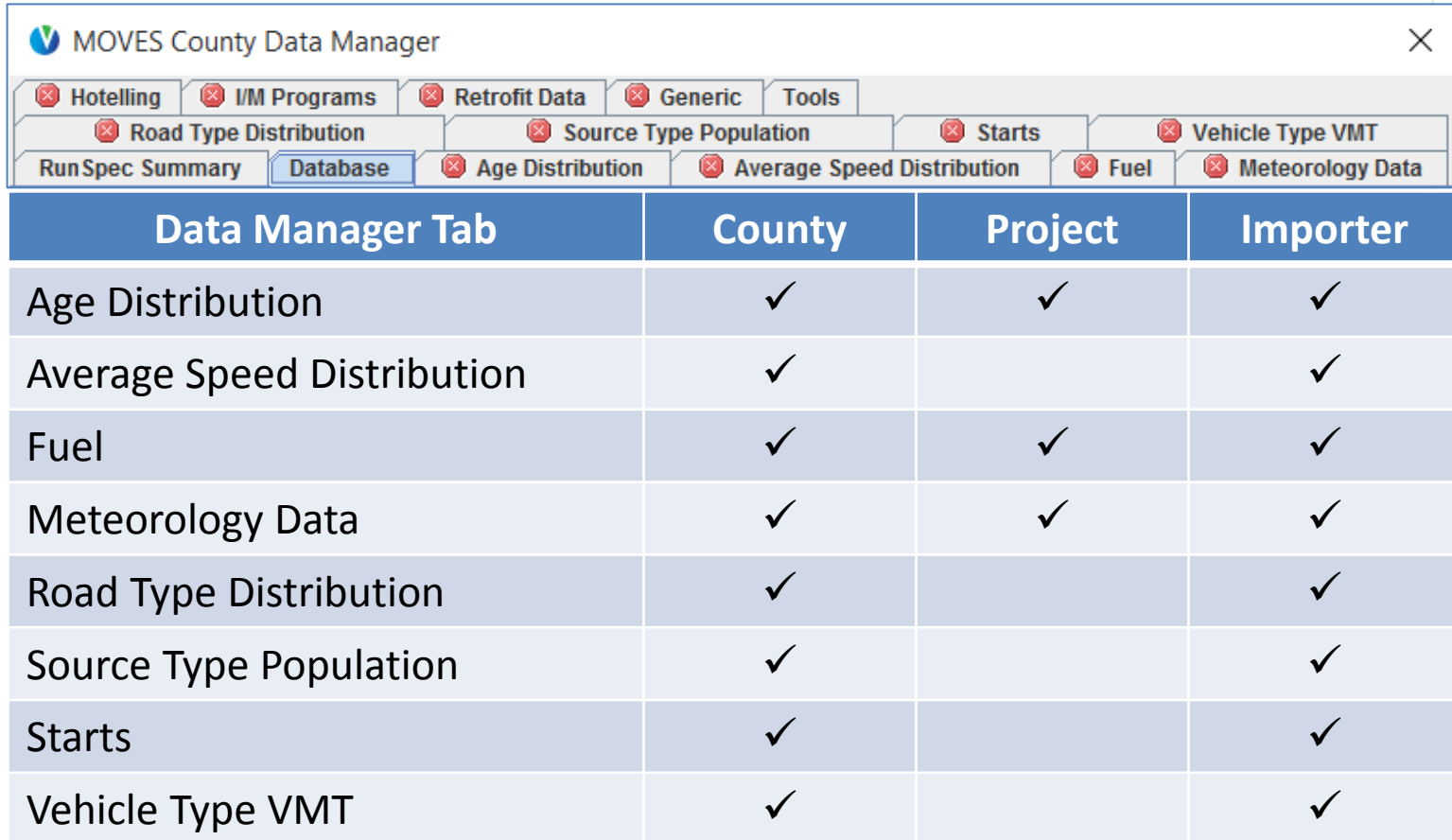
– for applications in all parts of the U.S.,
except California

- California Air Resources Board
EMFAC2011

<http://www.arb.ca.gov/msei/modeling.htm>

– for applications in California

Summary of Data Manager Input Requirements – MOVES



The screenshot shows the MOVES County Data Manager application window. The title bar reads "MOVES County Data Manager". The interface includes a menu bar with options: Hotelling, I/M Programs, Retrofit Data, Generic, and Tools. Below the menu bar are several tabs, some of which are active: Road Type Distribution, Source Type Population, Starts, and Vehicle Type VMT. At the bottom of the window, there is a table summarizing input requirements for various data manager tabs. The table has four columns: Data Manager Tab, County, Project, and Importer. Checkmarks indicate which requirements are met for each tab.

Data Manager Tab	County	Project	Importer
Age Distribution	✓	✓	✓
Average Speed Distribution	✓		✓
Fuel	✓	✓	✓
Meteorology Data	✓	✓	✓
Road Type Distribution	✓		✓
Source Type Population	✓		✓
Starts	✓		✓
Vehicle Type VMT	✓		✓

Summary of Data Manager Input Requirements – MOVES

MOVES County Data Manager

Hotelling I/M Programs Retrofit Data Generic Tools
 Road Type Distribution Source Type Population Starts Vehicle Type VMT
 RunSpec Summary Database Age Distribution Average Speed Distribution Fuel Meteorology Data

Data Manager Tab	County	Project	Importer
Hotelling	✓	✓	✓
I/M Programs	✓	✓	✓
Retrofit Data	✓	✓	✓
Generic	✓	✓	✓
Links		✓	
Link Source Types		✓	
Link Drive Schedules		✓	
Off-Network		✓	
Operating Mode Distribution		✓	



Vehicle Emissions Model Results

- County scale inventory
 - Mass within a region and time span
 - Regional conformity analysis
 - Projected Emissions \leq Emission Budgets?
 - NEPA quantitative MSAT analysis
 - Emission trends over time of the project alternatives



Vehicle Emissions Model Results

■ Project scale

- Inventory (mass) or emission rates (mass per unit activity) for a time span
 - NEPA air quality analysis
 - Hot-spot analysis of CO and PM for project-level conformity determinations
 - FHWA CMAQ project assessments

Air Quality Impact Analysis Framework – Concentrations

Vehicle Emissions

- Traffic Parameters
- Highway Configuration
- Inventory / Emission Rates

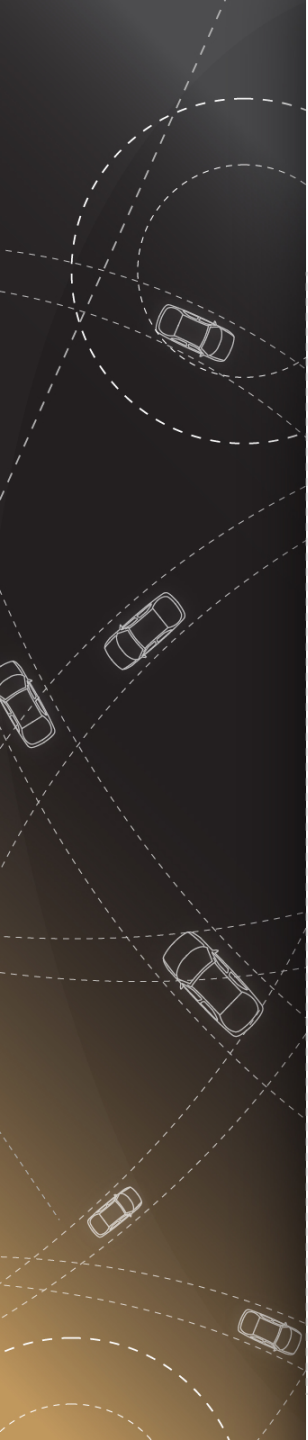
Meteorology

- Wind Speed
- Wind Direction
- Atmospheric Stability
- Mixing Height

Air Quality Model

- Transport and diffusion
- Traffic-induced turbulence
- Chemical Transformation

Receptor Concentration





Air Quality Models for Highway Applications

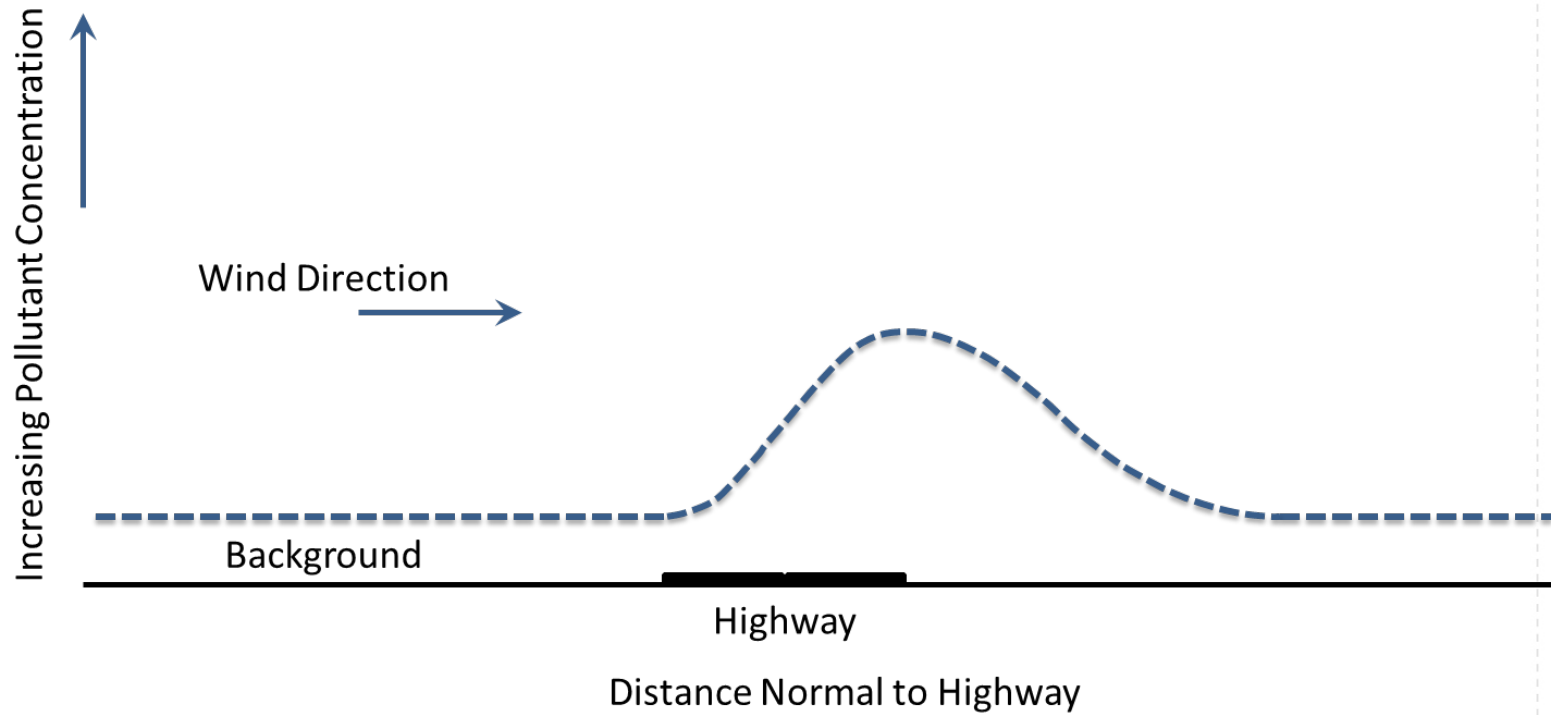
- Spatial regimes
- Air quality model features
- Summary of input data requirements
- Air quality model results
 - Determining ambient concentrations
 - Computing design values



Spatial Regimes

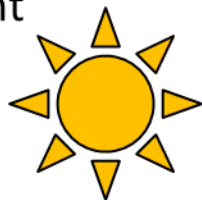
- Project scale / microscale:
 - Concentrations $> \pm 20\%$ for distances ≤ 100 m
- Urban scale / mesoscale:
 - Concentrations $< \pm 20\%$ for distances between 100 m and 10,000 m
- Regional scale / macroscale:
 - Concentrations $< \pm 20\%$ for distances $> 10,000$ m

Project Scale



Urban Scale

Sunlight



Aloft Concentrations of
Ozone and Precursors

Urban Plume

Anthropogenic NO_x and VOC

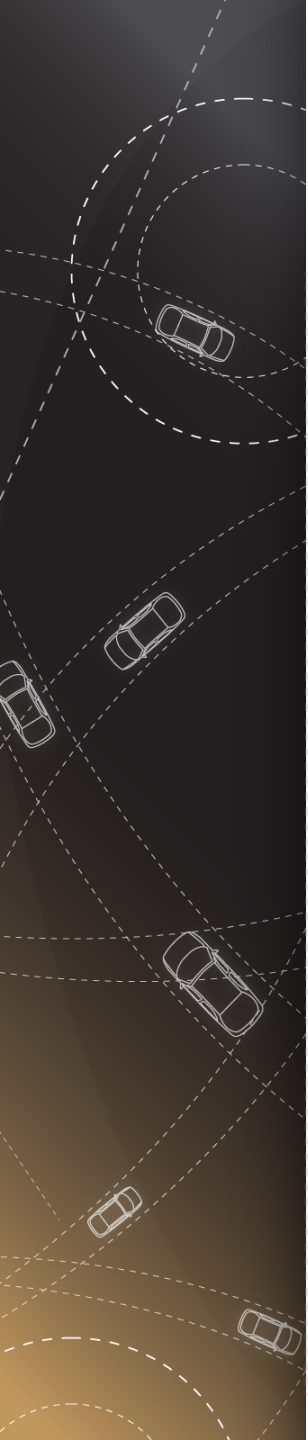
Biogenic VOC

Initial Concentrations (6 – 9 am)

1 hr

2 hr

Transport Time



Air Quality Model Features

Feature	Atmospheric Scale						
	Project Scale					Urban Scale	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE	CMAQ	UAM
<i>Exposure Scale</i>							
Acute	•	•	•	•	•	•	•
Chronic			•	•	•	•	•
<i>Source Characterization</i>							
Free-flow Highways	•	•	•	•	Not recommended for regulatory applications		
Signalized Intersections		•	•				
Transportation Terminals				•			
Urban Areas						•	•
<i>Pollutant Applicability</i>							
Inert Pollutants	•	•	•	•	•	•	•
Reactive Pollutants				NO ₂		•	
<i>Mathematical Class</i>							
Dispersion / Gaussian	•	•	•	•	•		
Photochemical / Numerical						•	•
Receptor							
Statistical, Empirical, Physical							
<i>Level of Sophistication</i>							
Screening							
Refined	•	•	•	•	•	•	•

Air Quality Model Features

Feature	Atmospheric Scale						
	Project Scale					Urban Scale	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE	CMAQ	UAM
<i>Exposure Scale</i>							
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Reactive Pollutants				NO ₂		•	
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Dispersion / Gaussian	•	•	•	•	•		
Photochemical / Numerical						•	•
Receptor							
Statistical, Empirical, Physical							
<i>Level of Sophistication</i>							
Screening							
Refined	•	•	•	•	•	•	•

Air Quality Model Features

Feature	Atmospheric Scale						
	Project Scale					Urban Scale	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE	CMAQ	UAM
<i>Exposure Scale</i>							
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Chronic			•	•	•	•	•
<i>Source Characterization</i>							
Free-flow Highways	•	•	•	•	Not recommended for regulatory applications		
Signalized Intersections		•	•				
Transportation Terminals				•			
Urban Areas						•	•
<i>Pollutant Applicability</i>							
Inert Pollutants	•	•	•	•	•	•	•
Reactive Pollutants				NO ₂		•	
<i>Mathematical Class</i>							
Dispersion / Gaussian	•	•	•	•	•		
Photochemical / Numerical						•	•
Receptor							
Statistical, Empirical, Physical							
<i>Level of Sophistication</i>							
Screening							
Refined	•	•	•	•	•	•	•

Air Quality Model Features

Feature	Atmospheric Scale						
	Project Scale					Urban Scale	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE	CMAQ	UAM
<i>Exposure Scale</i>							
Acute	•	•	•	•	•	•	•
Chronic			•	•	•	•	•
<i>Source Characterization</i>							
Free-flow Highways	•	•	•	•	Not recommended for regulatory applications		
Signalized Intersections		•	•				
Transportation Terminals				•			
Urban Areas						•	•
<i>Pollutant Applicability</i>							
Inert Pollutants	•	•	•	•	•	•	•
Reactive Pollutants				NO ₂		•	
<i>Mathematical Class</i>							
Dispersion / Gaussian	•	•	•	•	•		
Photochemical / Numerical						•	•
Receptor							
Statistical, Empirical, Physical							
<i>Level of Sophistication</i>							
Screening							
Refined	•	•	•	•	•	•	•

Air Quality Model Features

Feature	Atmospheric Scale						
	Project Scale					Urban Scale	
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE	CMAQ	UAM
<i>Exposure Scale</i>							
Acute	•	•	•	•	•	•	•
Chronic			•	•	•	•	•
<i>Source Characterization</i>							
Free-flow Highways	•	•	•	•	Not recommended for regulatory applications		
Signalized Intersections		•	•				
Transportation Terminals				•			
Urban Areas						•	•
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<i>Level of Sophistication</i>							
Screening							
Refined	•	•	•	•	•	•	•

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Technology Transfer Network Support Center for Regulatory Atmospheric Modeling

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This website is maintained by EPA's Air Quality Modeling Group (AQMG). The AQMG conducts modeling analyses to support policy and regulatory decisions in the Office of Air and Radiation (OAR) and provides leadership and direction on the full range of air quality models and other mathematical simulation techniques used in assessing control strategies and source impacts. Documentation and guidance for these air quality models can be found on this website, including downloadable computer code, input data, and model processors.

This site contains the following sections.

[Air Quality Models](#) - Provides descriptions and documentation for three types of air quality models: dispersion, photochemical, and receptor models. Also provided with the dispersion modeling section are source code and associated user's guides and documentation for preferred/recommended models, screening models, and alternative models.

[Modeling Applications and Tools](#) - Provides more detailed information on modeling analyses AQMG has conducted to support policy and regulatory decisions in OAR including assessment of control strategies and source culpability. In addition, this site provides access to EPA developed tools for use in State Implementation Plan (SIP) demonstrations and other air quality modeling assessments.

[Modeling Guidance & Support](#) - Provides current guidance for applying air quality models for regulatory applications for both State Implementation Plans (SIP) demonstrations and revisions, as well as permit applications for new source reviews including Prevention of Significant Deterioration (PSD) regulations. Included is the Model Clearinghouse which is designed to help record the interpretation of modeling guidance for specific regulatory applications. Also included in this area are links to modeling contacts within the EPA Regional Offices and State environmental agencies.

[Meteorological Data & Processors](#) - Provides information on Meteorological data used in air quality models as derived from both ambient measurements and meteorological models. Processors based on these two main sources of meteorological data are also provided.

[Conferences & Workshops](#) - Provides announcements and related information for upcoming meetings, conferences, and workshops including agendas, review materials, and links.

[Reports & Journal Articles](#) - Provides access to reports developed by AQMG staff as well as a bibliographic listing of journal articles they have authored or co-authored.

[Related Links](#) --- Provides website links of interest to air quality modelers and policy analysts.

Employment Opportunities: AQMG currently has no open positions to fill. As positions become open, AQMG will update this website with details. In addition, job announcements can be found on the internet at the [Office of Personnel Management website](#). The easiest way to find the announcement is to look for openings located in Research Triangle Park, North Carolina.

If you would like to be notified when we have a position for which you may be interested in applying, you may send a resume to Tyler Fox, Group Leader at: Fox.Tyler@epa.gov.

You will need Adobe Acrobat Reader to view the Adobe PDF files on this site. See [EPA's PDF page](#) for more information about getting and using the free Acrobat Reader.

Recent Additions

SCRAM RSS Feed & Archive

12/22/15 Two 2015 Model Clearinghouse concurrence memorandums ([July 16, 2015](#) to Region 2 and [December 22, 2015](#) to Region 4) regarding the use of the beta ARM2 technique as an alternative model have been added to the MCHISRS database.

12/10/15 A [Clarification on the Approval Process for Regulatory Application of the AERMOD Modeling System Beta Options](#) memorandum is now available. This memo discusses the appropriate process for the approval of the AERMOD Modeling System with the use of various beta options for regulatory applications.

10/8/15 An updated version of AERMINUTE, dated 15272, has been posted on the [Meteorological Processors and Accessory Programs webpage](#). Model Change Bulletin #4 (MCB#4) provides a summary of the changes incorporated into version 15272 of AERMINUTE.

9/14/15 The presentations, transcripts, and audio recordings from the [11th Conference on Air Quality Modeling](#) are now available. Additionally, all of the model code, technical support documentation, draft guidance, IWAQM reports, supporting docket material, etc. related to the

www3.epa.gov/ttn/scram/aqmindex.htm



Technology Transfer Network Support Center for Regulatory Atmospheric Modeling

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Air Quality Models

Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Based on inputs of meteorological data and source information like emission rates and stack height, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere. These models are important to our air quality management system because they are widely used by agencies tasked with controlling air pollution to both identify source contributions to air quality problems and assist in the design of effective strategies to reduce harmful air pollutants. For example, air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. In addition, air quality models can also be used to predict future pollutant concentrations from multiple sources after the implementation of a new regulatory program, in order to estimate the effectiveness of the program in reducing harmful exposures to humans and the environment.



The most commonly used air quality models include the following:

[Dispersion Modeling](#) - These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.

[Photochemical Modeling](#) - These models are typically used in regulatory or policy assessments to simulate the impacts from all sources by estimating pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales.

[Receptor Modeling](#) - These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations.

Additional Information about air quality models can be found at [Related Links](#).

[Office of Air and Radiation](#) | [Office of Air Quality Planning and Standards](#)

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<http://www3.epa.gov/ttn/scram/aqmindex.htm>
[Print As-Is](#)

Last updated on 9/10/2015

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Air Quality Models

Modeling Applications
& Tools

Modeling Guidance &
Support

Meteorological Data &
Processors

Conferences &
Workshops

Reports & Journal
Articles

Related Links

About AQMG



Summary of Input Data Requirements

Program Controls

Run options

Output options

Receptor Locations

Highway Configurations

Vehicle Emissions

Meteorology



Summary of Input Data Requirements

Program Controls

Receptor Locations

Highway Configurations

Vehicle Emissions

Meteorology

Location coordinates
Height of breathing zone



Summary of Input Data Requirements

Program Controls

Receptor Locations

Highway Configurations

Vehicle Emissions

Meteorology

Location coordinates

Source height

Source width



Summary of Input Data Requirements

Program Controls

Receptor Locations

Highway Configurations

Vehicle Emissions

Meteorology

**Traffic volume and
emission factor/rate
or
Total emissions**



Summary of Input Data Requirements

Program Controls

Receptor Locations

Highway Configurations

Vehicle Emissions

Meteorology

Basic parameters:

Wind speed

Wind direction

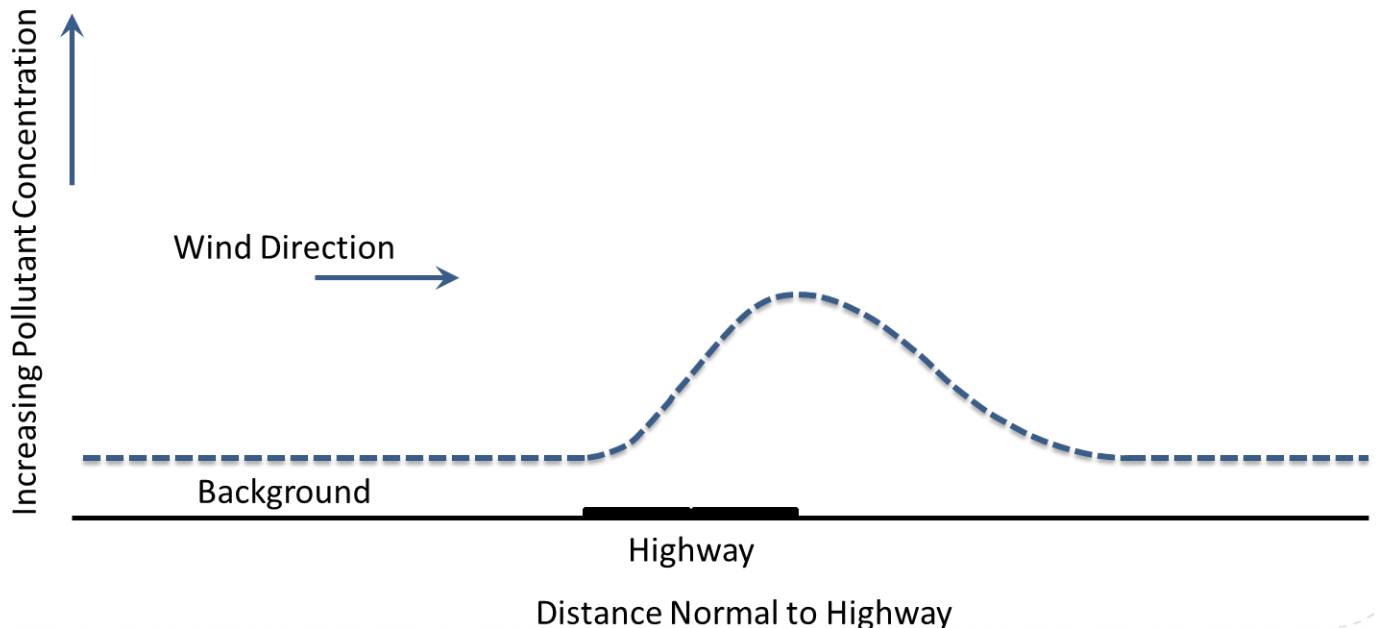
Atmospheric stability

Mixing height

Air Quality Model Results

■ Project scale

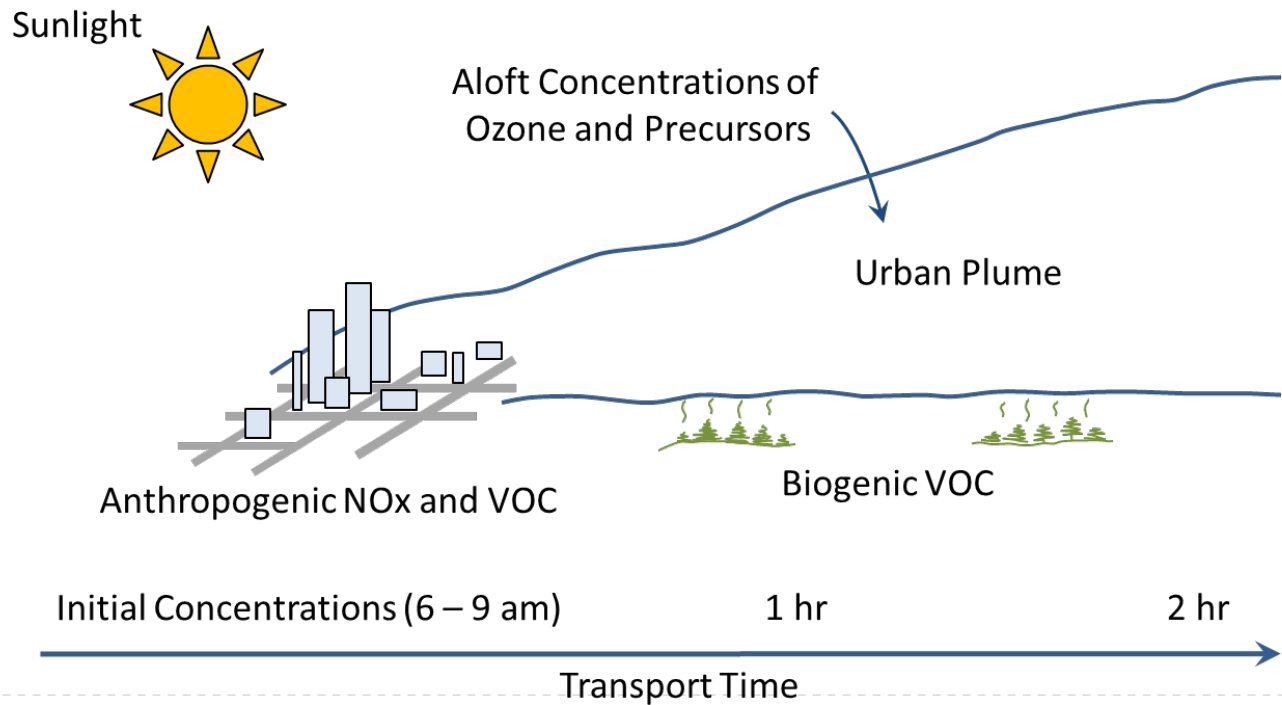
Ambient Concentration = Background + Highway Contribution + Other Nearby Sources Not Reflected in Background



Air Quality Model Results

■ Urban scale

- Ambient concentration
- Background concentration



Air Quality Model Results

- Computing design values
 - Ambient concentration statistic appropriate for comparison to a National Ambient Air Quality Standard (NAAQS)

Design Value \leq NAAQS ?



Training Opportunities

- FHWA Resource Center

<http://www.fhwa.dot.gov/resourcecenter/teams/airquality/courses.cfm>

- Transportation Air Quality Fundamentals
- Air Quality Benefit Estimation Methodologies for TCM Projects
- MOVES2014 (2-days)/User's Group
- NEPA Air Quality Analysis for Highway Projects/Project Mobile Source Air Toxics
- Transportation Conformity 101
- Climate Change Workshop



Training Opportunities

- National Highway Institute

 - <http://www.nhi.fhwa.dot.gov/home.aspx>

 - Implications of Air Quality Planning for Transportation

 - Estimating Regional Mobile Source Emissions

- U.S. Environmental Protection Agency

 - <https://www3.epa.gov/otaq/stateresources/transconf/training.htm>

 - MOVES

 - Quantitative PM Hot-spot Analyses



List of Web Resources

- FHWA Resource Center AQ-TST
<http://www.fhwa.dot.gov/resourcecenter/teams/airquality/index.cfm>
- FHWA Air Quality Page
http://www.fhwa.dot.gov/environment/air_quality/
- EPA Office of Transportation and AQ
<https://www3.epa.gov/otaq/>
- TRB Transportation & AQ Committee
<http://www.trbairquality.org>

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